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NON PREFERENCE/ANTIXENOSIS MECHANISM TO BROWN PLANT HOPPER (*Nilaparvata lugens* Stall) IN SELECTED RICE ENTRIES

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ABSTRACT

Non preference/ Antixenosis mechanism of resistance to brown planthopper, *Nilaparvata lugens* were studied in selected resistant, moderately resistant and moderately susceptible NSN-2 entries along with TN1 as susceptible check and Ptb 33 as resistant check. The Resistant entry, IET No. 23620 and moderately resistant entry, IET No. 23665 were exhibited less number of BPH nymphs settled per plant (1.3 nymphs/ plant). Resistant entries like IET No. 23739, IET No. 23620 and IET No. 23660, received more number of probing marks ranging between 22.3–30.8, excretion of less amount of honeydew (26.3- 46.3 mm^2) and exhibited low fecundity (22.0-53.0 eggs/ pair), indicating the non-suitability of the entries for feeding and oviposition by brown planthopper which is a positive factor in including resistance to BPH in rice cultivars.

Rice, one of the world's most important food crops is attacked by about 800 species of insect pests in both field and storage (Barrion and Litsinger, 1994). One of the most economically important insects is the brown planthopper (BPH), *Nilaparvata lugens* (Stall) (Hemiptera: Delphacidae) which can cause huge damage where both nymphs and adults suck the plant sap directly and indirectly transmits virus diseases such as ragged stunt and grassy stunt (Khush and Brar, 1991). Due to the infestation, plants turn yellow and dry up rapidly. At early infestation, round and yellow patches appear, which soon turn brownish due to the drying up of the plants which is called as 'hopper burn', and could result in causing yield loss ranging from 10-75% (Tirumala Rao, 1950). A resistant plant variety that reduces the insect population by 50% in each generation is sufficient to eliminate an insect of economic importance within a few generations (Painter, 1951). The necessity to identify suitable new resistant donors for BPH from different sources is of utmost important once in order to combat the pest and develop material resistant to BPH. It is also necessary to understand the mechanism and factors responsible for manifesting the resistance into the selected cultures with desirable characters, so that these can be utilized effectively in the breeding programme. Keeping this in view the present investigation of identification of resistant sources from the national screening nurseries - 2 entries was carried out.

MATERIAL AND METHODS

Mass rearing of Brown Plant Hopper

BPH was mass reared on the susceptible rice variety, TN1. BPH population was initially collected from rice fields and pure culture was maintained in the glasshouse at a temperature of 30 $\pm$ 5°C with a relative humidity of 60$\pm$5% on 40 -50 day old potted plants of TN1. Mass rearing was done in cages of 70 cm x 62 cm x 75 cm dimension with glass panels on one side and wire mesh on all other sides. Twenty adult gravid female hoppers were collected with an aspirator and were released on pre-cleaned potted plants of TN1 and are placed in oviposition cages. After four days of egg laying, the gravid females were collected and released on fresh batch of TN1 plants for further egg laying. Plants with eggs were taken out of cages and placed in separate cages for the nymphs to hatch. Fresh plants were placed in the cages with nymphs as and when required. The hatched nymphs were utilized for experiments as and when they attained the desired age. Necessary precautions were taken to keep the culture free from predators such as mirid bugs, spiders, other natural

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enemies and other hoppers like WBPH and GLH. Using this technique, a continuous pure culture of BPH was maintained during the period of study.

Non-preference/Antixenosis

Preference/non- preference is used to denote the group of plant characters and insect responses that lead to or away from the use of particular variety or plant for oviposition, for food, or for shelter or for combination of the three. The non-preference/ antixenosis of the BPH to food, shelter and oviposition were studied by orientation/settling of BPH nymphs on different resistant and susceptible entries, probing marks, honeydew excretion and fecundity of BPH.

Studies on preference/non- preference by BPH nymphs

The selected rice entries were sown in a big pot along with resistant and susceptible checks and after 30 days the pots were covered with mylar cage to prevent escape of insects. About hundred nymphs were released in the pot and number of nymphs settled on each entry was counted at 24, 48, 72, 96 and 120 hours after release.

Probing Test

Number of probing marks made by a single one day old female insect during one day feeding on resistant and susceptible rice cultures was recorded. For this purpose, a single one day old adult female insect was allowed to feed on seven day old test entry in a test tube for 24 hours. After 24 hours, the insect was removed and the test plant was stained by dipping in one per cent aqueous Erythrosin-B solution for one hour to distinguish the feeding marks on the test entries (Naito, 1964). The feeding marks were counted by using magnifying hand lens.

Honeydew Excretion

Homopterans such as BPH which are sap feeders suck plant sap containing large quantity of water. To prevent the dilution of digestive enzymes, this excess water is sent out by filter chamber mechanism and this excretory product is called honeydew which is rich in sugars, amino acids etc. The measurement of honeydew indicates the indirect measurement of insect feeding. The preference of the BPH for the selected lines were also tested by observing the amount of honey dew excreted as an indication of the feeding preference and efficiency by utilizing the method modified by Pathak and Heinrichs (1980). Whatman no. 1 filter paper were dipped in an 0.02% bromocresol green solution in ethanol, allowed to dry for one hour and dipped again till the filter paper turned yellowish orange. The filter paper were placed on the wooden plank kept at the base of the of 30 days old plants. A plastic cup was put over the filter paper and five adult insects pre starved for four hours were released into the cup. A cotton plug in the hole prevents the escape of the insects. The insects were allowed to feed for 24 hours at the base of stem. The honey dew droplets excreted by the adults when come in contact with the filter paper turns into blue spots. The relative area (mm^2) of the spots produced by honey dew excreted on bromocresol green treated filter paper was determined. The area of spots were traced on tracing paper and placed in millimeter squarer graph and the squares were counted. Amount of feeding by the insects on the test line were expressed as area of honey dew excreted in mm^2.

Fecundity, Ovicidal Test / Per Cent Egg Hatching

Seeds of the selected test entries were soaked in Petri dishes and the germinated seeds were sown in 1000 ml plastic pots filled with fertilizer enriched puddled soil. Two germinated seeds were planted in each pot and for each test entry seedlings were raised in 8-10 pots. When the plants were 30 days old, they were thoroughly examined and cleaned to make them free from adults and eggs of other hoppers or mirid bugs before the release of adults. They were covered with mylar tubes with ventilating windows. One pair of one day old adults were released with the help of an aspirator in the mylar cage and the open end of the tube was covered with a muslin

cloth and tied with a rubber band. The adults were allowed to lay the eggs till their death. The plants were observed for nymphal hatching after one week of release. The hatched nymphs were counted, number was recorded and later removed from the plant. After hatching of all the eggs, or when nymphs stop coming out, the plants were cut at the base and examined under stereo binocular microscope to count and record number of unhatched eggs. Unhatched eggs were expressed as percentage of total, which is sum of number of nymphs counted and number of unhatched eggs.

$$\text{Percent of unhatched eggs} = \frac{\text{Number of unhatched eggs}}{\text{(Number of nymphs + number of unhatched eggs)}} \times 100$$

RESULTS AND DISCUSSION

Non Preference of BPH nymphs for feeding on resistant and moderately resistant NSN-2 entries

Number of nymphs settled per seedling on resistant and moderately resistant cultures along with susceptible check (TN 1) and resistant check (Ptb 33) at 1, 2, 3, 4 and 5 days after release was recorded as the criteria for determining BPH nymphal feeding preference. Among the tested entries, differences were evident in the nymphal counts during the period of observation with BPH nymphs showing tendency to move away from the resistant and moderately resistant entries compared to susceptible entries.

The number of nymphs settled on resistant and moderately resistant entries one day after release varied on different entries (Table 1.) IET no 23665 had lowest number of nymphs (3.3) per seedling followed by 23391 (5.0 nymphs) and Purnendu (RC) (5.7 nymphs) and 23241 (6.3 nymphs) which were on par with resistant check, Ptb 33 that has recorded 6.0 nymphs per seedling. One day after release, no clear differences in preference were observed between the resistant entries (IET No. 23620) and moderately resistant entries (IET No. 23661 and 23656) compared to the susceptible check TN 1.

Distinct differences were observed in nymphal preference two days after release wherein resistant and moderately resistant entries recorded less number of nymphs per seedling compared to susceptible check. IET 23665 recorded lowest number of nymphs (3.3 nymphs) and the number of nymphs progressively decreased on resistant entry, IET 23620 (6.3 nymphs settled). Decrease in nymphal settling was observed in all the resistant and moderately resistant entries along with resistant check (Ptb 33) except in IET No. Purnendu (RC) that recorded slight increase in number of nymphs settled. The susceptible check (TN 1) has recorded highest number of nymphs 25.7 per seedling.

Significant differences in the varietal preference were observed at five days after release of nymphs based on nymphal settling wherein very less number of nymphs settled on resistant and moderately resistant entries similar to the resistant check Ptb 33. The resistant entry, IET No. 23620 and moderately resistant entry, IET No. 23665 had minimum number of nymphs per seedling that were on par with the resistant check, Ptb 33. Similar trend was maintained at 2, 3, 4 and 5 days after release and the moderately resistant entries recorded significantly low number of nymphs compared to the susceptible check TN1 (31.0 nymphs). In general, non-preference for nymphal feeding was evident in all the resistant and moderately resistant cultures. Orientation response of insects is one of the important factors that determine the preference of food plant (Saxena *et al.,* 1974). Non preference or antixenosis in resistant variety was suggested to be more due to gustatory rather than olfactory or visual influence (Pathak and Saxena, 1980). BPH showed no significant preference in alighting on different varieties, but the insect did not stay on resistant line for sustained feeding. Present results are in conformity with the results of Kalode *et al.* (1978) who reported lowest number of nymphs settling on Ptb 33 followed by Ptb 21, ARC 6650, CR 57-MR 1523 and Leb Muey Nahng. They further stated that presence of more number of insects on TN1 and

least number on Ptb 33 suggesting possibility of some attractants in the susceptible variety and their absence in resistant ones. Present findings are in confirmation with investigations of Bhanu *et al.* (2014) who reported that the resistant and moderately resistant varieties recorded lowest nymphal preference compared to the susceptible check (TN1).

Feeding behaviour of adult BPH on selected NSN-2 entries based on probing marks

NSN-2 entries including resistant, moderately resistant and moderately susceptible entries along with susceptible and resistant checks were selected to find out the feeding behaviour of adult brown planthopper expressed in terms of feeding marks or probing marks on the stems of rice plants. Results presented in the (Table 2.) indicate that there was a significant difference among the entries with regard to probing marks. Among the screened entries, the resistant entry, IET No. 23739 received maximum number of feeding punctures (30.8) while susceptible check TN1 has received minimum number of feeding punctures (5.5). The resistant entries differed significantly from moderately resistant and moderately susceptible entries with regard to number of probing marks. The resistant entries including IET No. 23620 (26.5) and IET No. 23660 (22.3) and moderately resistant entries including IET No. 23661 (25.0), IET No. 23705 (23.3) and IET No. 23702 (23.2) received significantly more number of punctures which were on par with resistant check, Ptb 33 (26.5 feeding punctures). More number of feeding punctures in the resistant and moderately resistant entries might be due to reason that, these resistant and moderately resistant entries did not sustain prolonged feeding due to presence of certain feeding deterrents or toxic chemicals or absence of feeding stimulants. Hence, the insect had to probe more on the resistant genotypes to locate feeding sites (Sogawa, 1982). Our results corroborate with the findings of several workers (Sogawa and Pathak, 1970; Reddy, 1979; Alagar *et al.,* 2007) who reported that resistant varieties received more probing marks than susceptible ones. Udayababu *et al.* (2011) also reported that average probing marks on resistant plants ranged between 30.4 to 42.9 whereas resistant and susceptible check have recorded 22.1 and 6.7 probing marks, respectively.

Honeydew excretion by nymphs and adults of BPH

Results pertaining to honeydew excreted (area in mm^2) by third instar nymphs of BPH on selected NSN-2 entries, the susceptible check (TN1) and the resistant check (Ptb 33) are presented in the Table 3. From the results, it is evident that honeydew excretion by third instar BPH nymphs feeding on selected NSN-2 entries varied significantly amongst the test entries and ranged from 26.3 mm^2 (IET No. 23620) to 125.3 mm^2 (IET No. 23942), where the susceptible check, TN1 has recorded 125.3 mm^2 honeydew excretion and resistance check, Ptb 33 recorded 57.7 mm^2 honeydew excretion. The resistant entry, IET No. 23620 recorded lowest honeydew excretion of 26.3 mm^2 diameter that was on par with other resistant entries, IET No. 23739 (37.0 mm^2), IET No. 23223 (44.7 mm^2), IET No. 23661 (45.0 mm^2), IET No. 23661 (45.0 mm^2), IET No. 23660 (46.3 mm^2) and IET No. 23705 (50.7 mm^2), followed by IET No. 23702 (54.7 mm^2), IET No. 23894 (56.7 mm^2) and Ptb 33 (57.7 mm^2). These were followed in descending order of honeydew excretion as IET Nos Purnendu (RC) (69.7 mm^2) < 23771 (72.0 mm^2) < 23939 (72.3 mm^2) < 23241 (73.4 mm^2) < 23221 (75.0 mm^2) < 23665 (75.3 mm^2) < 23723 (84.3 mm^2) < 23687 (91.3 mm^2) < 21944 (95.7 mm^2) < 23656 (98.7 mm^2) < 23391 (101.3 mm^2) < 23741 (105.0 mm^2) < 23658 (106.7 mm^2) < 23733 (114.7 mm^2).

Results presented in the (Table 3.) indicate that BPH adults fed less on resistant entries, IET No. 23620 (63.3 mm^2) and IET No. 23739 (73.7 mm^2) which remained on par with the resistant check, Ptb 33 (84.3 mm^2) followed by IET No. 23894 (112.7 mm2) and IET No. Purnendu (RC) (117.3 mm2). Among the resistant cultures, maximum honeydew excretion was

observed in IET No. 23771 (255.0 mm^2) which was significantly low compared to the susceptible check, TN1 (326.7 mm^2), followed by IET No. 23741 (236.7 mm^2), IET No. 23733 (231.7 mm^2), IET No. 21944 (229.7 mm^2) and IET No. 23942 (226.7 mm^2) which remained on par with each other. Among all the entries, susceptible check, TN1 has recorded significantly maximum honeydew excretion indicating more feeding by BPH adults. This clearly revealed that difference in the amount of honeydew excretion is mainly attributed to the difference in the relative amount of sap intake. Less intake of sap on resistant varieties, despite successful stylet penetration into the vascular bundle indicates the occurrence of certain undesirable gustatory factors that governed sustained sucking by the insect (Sogawa and Pathak, 1976). Therefore, the amount of honeydew excreted by the insect in unit time when fed on different rice cultures could be considered as an index for its feeding preference. The resistant rice cultivar, MTU IJ 206-7-4-1 has recorded lowest honeydew excretion (25.60 mm^2) followed by NLR 3093 (65.60 mm^2) and RGL 7002 (87.80 mm^2) where susceptible check TN1 has recorded highest of 456.40 mm^2 (Bhanu *et al.,* 2014). Auclair (1958) demonstrated that measurement of honeydew excretion could be a tool for assessing resistance and susceptibility of a variety in the case of pea aphid *Acyrthosiphon pisum* (Harr). For BPH, less honeydew excretion indicated the resistance character of the rice variety Mudgo (Sogawa and Pathak, 1970). BPH has copiously excreted honeydew on the susceptible TN1, but little to significantly low quantities were excreted when the insects were confined to the resistant and moderately resistant cultures.

Fecundity, Ovicidal test / Per cent Egg hatching

The resistant and moderately resistant rice cultures, which served as hosts for BPH, had adverse effect on biology of BPH, while the susceptible check, TN 1 favoured multiplication of the pest. Resistant and moderately resistant entries were proved detrimental to BPH. Effect of different rice entries on fecundity and egg hatching are presented in (Table 4.) that indicated decrease in fecundity of BPH when fed on resistant and moderately resistant entries compared to the susceptible check, TN 1. Among the NSN-2 entries, IET 23739 recorded nine times lower fecundity compared to the susceptible check, TN 1 and the decrease was on par with the resistant check, Ptb 33. This phenomenon was observed among all resistant and moderately resistant entries, where fecundity ranged between 22.0 to 135.3 eggs/ female compared to 213.0 eggs in susceptible TN 1. Among all the NSN-2 entries, IET 23739 has recorded less number of eggs (22.0 eggs) followed by IET 23661 (39.3 eggs), IET 23620 (39.7eggs), IET 23223 (42.7 eggs), IET 23665 (43.0 eggs), IET 23705 (50.7 eggs), IET 23660 (53.0 eggs) and IET 23702 (54.0 eggs) which were on par with the resistant check, Ptb- 33 (42.0 eggs).

Eggs laid by BPH reared on resistant, moderately resistant, susceptible, susceptible check and resistant check were allowed for hatching to assess the possible effect of host plants on hatching, if any. Among different entries, on resistance check, Ptb-33 less hatching percentage of 28.7 was recorded followed by IET 23620 (41.9 %), IET 23223 (43.5 %), IET 23705 (44.8%), IET 23660 (45.4 %) and IET 23739 (48.5 %) which are on par with each other. Per cent egg hatching was more in the susceptible check, TN 1 (88.6 %) and there was a significant reduction in the egg hatching in case of resistant and moderately resistant entries. The per cent egg hatching ranged from 28.7 to 48.5; 43.5 to 67.8; and 65.9 to 75.1 on resistant, moderately resistant and moderately susceptible entries, respectively. Similar results were obtained by Alagar *et al.* (2007) who reported that the number of unhatched eggs was significantly higher in resistant varieties than in susceptible varieties. They also reported that fecundity was more in susceptible varieties than resistant varieties. Karim (1975) reported lower number of egg deposition on resistant varieties due to insufficient feeding.

Table 1. Preference of BPH nymphs to selected NSN-2 entries

S. No	Entry IET No.	DS	Number of nymphs settled				
			1 DAR	2 DAR	3 DAR	4 DAR	5 DAR
1	23620	2.8 (R)	14.0^{abcd}	6.3^{cde}	3.7^{cde}	2.0^{c}	1.3^{d}
2	23661	3.25 (MR)	15.7^{abc}	12.0^{bc}	9.0^{bcde}	9.7^{b}	10.0^{b}
3	23665	3.75 (MR)	3.3^{h}	3.0^{e}	2.0^{e}	2.3^{c}	1.3^{d}
4	23894	4.2 (MR)	7.7^{defgh}	6.7^{cde}	7.3^{bcde}	5.7^{bc}	5.3^{bcd}
5	Purnendu (RC)	4.75 (MR)	5.7^{fgh}	7.7^{cde}	8.7^{bcde}	6.7^{bc}	6.0^{bcd}
6	23656	4.85 (MR)	19.3^{a}	14.7^{b}	10.7^{bc}	8.0^{bc}	3.3^{bcd}
7	23696	5.0 (MR)	8.3^{defgh}	6.3^{cde}	7.7^{bcde}	5.3^{bc}	10.0^{b}
8	23658	5.1 (MS)	13.3^{abcde}	12.0^{bc}	12.3^{b}	9.7^{b}	7.3^{bcd}
9	23391	5.1 (MS)	5.0^{gh}	7.0^{cde}	6.3^{bcde}	2.3^{c}	2.0^{cd}
10	23942	5.15 (MS)	11.0^{bcdefg}	8.3^{cde}	9.3^{bcd}	8.7^{bc}	8.3^{bc}
11	21944	5.2 (MS)	7.7^{defgh}	5.7^{de}	4.3^{cde}	3.0^{bc}	3.3^{bcd}
12	23957	5.4 (MS)	10.3^{cdefgh}	8.3^{cde}	8.7^{bcde}	6.7^{bc}	8.3^{bc}
13	23241	5.45 (MS)	6.3^{efgh}	4.0^{e}	6.3^{bcde}	3.0^{bc}	4.0^{bcd}
14	23687	5.45 (MS)	12.7^{abcdef}	11.7^{bcd}	10.7^{bc}	7.7^{bc}	6.0^{bcd}
15	TN1	9.0 (HS)	18.0^{ab}	25.7^{a}	29.3^{a}	30.3^{a}	31.0^{a}
16	Ptb 33	2.1 (R)	6.0^{fgh}	4.3^{e}	3.3^{de}	2.0^{c}	1.0^{d}
	SEm±		2.5	2.2	2.5	2.0	1.9
	CD at 5%		7.2	6.3	7.1	5.9	5.5

R= Resistant; MR= Moderately Resistant; MS= Moderately Susceptible; HS= Highly Susceptible Means with same letter are not significantly different at 5% level by DMRT

DAR: Days After Release

DS: Damage Score

Table 2. Number of probing marks of adult BPH on selected NSN-2 entries

S.No	Entry IET No.	DS	Probing frequency
1	23739	2.65 (R)	30.8^{a}
2	23620	2.8 (R)	26.5^{b}
3	23660	3.0 (R)	22.3^{b}
4	23661	3.25 (MR)	25.0^{b}
5	23705	3.45 (MR)	23.3^{b}
6	23702	3.5 (MR)	23.2^{b}
7	23665	3.75 (MR)	17.2^{c}
8	23894	4.2 (MR)	15.5^{cd}
9	Purnendu (RC)	4.75 (MR)	14.7^{cde}
10	23656	4.85 (MR)	17.2^{c}
11	23696	5.0 (MR)	12.0^{defg}
12	23658	5.1 (MS)	10.8^{efgh}
13	23686	5.1 (MS)	9.2^{fghi}
14	23391	5.1 (MS)	14.0^{cde}
15	23942	5.15 (MS)	8.3^{ghi}
16	21944	5.2 (MS)	9.5^{fghi}
17	23957	5.4 (MS)	13.2^{cdef}
18	23241	5.45 (MS)	7.0^{hi}
19	23687	5.45 (MS)	11.8^{defg}
20	TN1	9.0 (HS)	5.5^{i}
21	Ptb 33	2.1 (R)	26.5^{b}
	SEm±		1.5
	CD at 5%		4.3

R= Resistant; MR= Moderately Resistant; MS= Moderately Susceptible; HS= Highly Susceptible
Means with same letter are not significantly different at 5% level by DMRT

Table 3. Honeydew excreted by third instar nymphs and one day old females of BPH fed on selected rice NSN-2 entries

S.No	Entry IET No.	DS	Area of honeydew excreted by 5 nymphs in 24 hours (mm^2)	Area of honeydew excreted by 5 females in 24 hours (mm^2)
1	23739	2.65 (R)	37.0^{jk}	73.7^{kl}
2	23620	2.8 (R)	26.3^{k}	63.3^{l}
3	23660	3 (R)	46.3^{ijk}	122.3^{ij}
4	23661	3.25 (MR)	45.0^{jk}	125.0^{hij}
5	23705	3.45 (MR)	50.7^{hijk}	142.3^{ghi}
6	23702	3.5 (MR)	54.7^{ghij}	135.0^{ghi}
7	23665	3.75 (MR)	75.3^{defg}	165.7^{fgh}

8	23223	3.95 (MR)	44.7^{jk}	175.0^{efg}
9	23894	4.2 (MR)	56.7^{ghij}	112.7^{ijk}
10	23939	4.45 (MR)	72.3^{efgh}	150.3^{ghi}
11	Purnendu (RC)	4.75 (MR)	69.7^{fghi}	117.3^{ij}
12	23656	4.85 (MR)	98.7^{bcd}	197.0^{cdef}
13	23658	5.1 (MS)	106.7^{abc}	151.3^{ghi}
14	23391	5.1 (MS)	101.3^{abc}	166.3^{fg}
15	23942	5.15 (MS)	125.3^{a}	226.7^{bcd}
16	23221	5.2 (MS)	75.0^{defgh}	209.0^{cde}
17	21944	5.2 (MS)	95.7^{bcde}	229.7^{bcd}
18	23741	5.25 (MS)	105.0^{abc}	236.7^{bc}
19	23771	5.25 (MS)	72.0^{efgh}	255.0^{b}
20	23241	5.45 (MS)	73.4^{efgh}	146.7^{ghi}
21	23687	5.45 (MS)	91.3^{bcdef}	193.0^{def}
22	23723	5.5 (MS)	84.3^{cdef}	204.0^{cdef}
23	23733	5.5 (MS)	114.7^{ab}	231.7^{bcd}
24	TN1	9 (HS)	125.3^{a}	326.7^{a}
25	Ptb 33	2.1 (R)	57.7^{ghij}	84.3^{jkl}
	SEm±		8.6	14.5
	CD at 5%		24.6	41.3

R= Resistant; MR= Moderately Resistant; MS= Moderately Susceptible; HS= Highly Susceptible
Means with same letter are not significantly different at 5% level by DMRT

Table 4. Fecundity and Hatching of BPH on selected NSN-2 entries

S.No	Entry IET No.	DS	Fecundity*	No. of Unhatched*	Hatching (%)**
1	23739	2.65 (R)	22.0 (4.7)^{g}	11.3 (3.4)^{i}	48.5 (44.1)^{ghi}
2	23620	2.8 (R)	39.7 (6.2)^{f}	23.0 (4.8)^{gh}	41.9 (40.3)^{i}
3	23660	3.0 (R)	53.0 (7.3)^{f}	29.0 (5.4)^{defgh}	45.4 (42.4)^{hi}
4	23661	3.25 (MR)	39.3 (6.2)^{f}	19.0 (4.3)^{hi}	53.2 (46.9)^{fgh}
5	23705	3.45 (MR)	50.7 (7.1)^{f}	28.3 (5.3)^{efgh}	44.8 (41.9)^{hi}
6	23702	3.5 (MR)	54.0 (7.3)^{f}	23.7 (4.8)^{gh}	56.3 (48.6)^{fg}
7	23665	3.75 (MR)	43.0 (6.5)^{f}	17.7 (4.2)^{hi}	58.7 (50.0)^{ef}
8	23223	3.95 (MR)	42.7 (6.4)^{f}	25.3 (4.8)^{gh}	43.5 (41.2)^{i}
9	23894	4.2 (MR)	135.3 (11.6)^{bcde}	52.0 (7.2)^{ab}	61.5 (51.6)^{def}
10	Purnendu (RC)	4.75 (MR)	126.7 (11.2)^{bcde}	56.3 (7.5)^{a}	55.7 (48.3)^{fg}

11	23656	4.85 (MR)	118.0 (10.9)^{e}	46.3 (6.8)^{abc}	60.7 (51.1)^{def}
12	23696	5.0 (MR)	128.7 (11.3)^{bcde}	41.3 (6.4)^{abcde}	67.8 (55.4)^{bcde}
13	23658	5.1 (MS)	122.7 (11.0)^{cde}	42.0 (6.5)^{abcd}	67.6 (55.3)^{bcde}
14	23391	5.1 (MS)	135.0 (11.6)^{bcde}	46.7 (6.8)^{abc}	65.9 (54.4)^{cde}
15	23942	5.15 (MS)	148.3 (12.2)^{bc}	39.3 (6.3) ^{bcde}	73.9 (59.2)^{bc}
16	23221	5.2 (MS)	135.3 (11.6)^{bcde}	34.0 (5.8)^{cdefg}	74.6 (59.8)^{bc}
17	23741	5.25 (MS)	120.7 (11.0)^{de}	30.0 (5.5)^{defg}	75.1 (60.1)^{b}
18	23771	5.25 (MS)	132.0 (11.5)^{bcde}	37.3 (6.1)^{bcdef}	71.8 (58.0)^{bc}
19	23687	5.45 (MS)	150.3 (12.3)^{b}	47.0 (6.8)^{abc}	68.8 (56.1)^{bcd}
20	23723	5.5 (MS)	146.3 (12.1)^{bcd}	38.0 (6.1)^{bcde}	74.3 (59.5)^{bc}
21	TN1	9.0 (HS)	213.0 (14.6)^{a}	24.3 (4.9)^{fgh}	88.6 (70.2)^{a}
22	Ptb 33	2.1 (R)	42.0 (6.5)^{f}	30.0 (5.5)^{defg}	28.7 (32.3)^{j}
	SEm±		0.4	0.4	1.9
	CD at 5%		1.2	1.2	5.5

R= Resistant; MR= Moderately Resistant; MS= Moderately Susceptible; HS= Highly Susceptible

* Figures in parentheses are square root transformed values

**Figures in parentheses are angular transformed values

Means with same letter are not significantly different at 5% level by DMRT

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RESIDUAL EFFECT OF ORGANIC SOURCES AND FERTILIZER LEVELS TO PRECEEDING MAIZE (*Zea mays* L.) ON THE PHYSIOLOGICAL PARAMETERS OF SUCCEEDING GROUNDNUT (*Arachis hypogea* L.)

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ABSTRACT

Direct and residual effect of integrated nutrient management in Maize-Groundnut crop sequence in Southern Telangana region" was conducted during *kharif* and rabi seasons of 2014-15 and 2015-16 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Southern Telangana.The soil of experimental site was sandy clay loam with pH of 7.6, Electrical conductivity 0.86 dSm^{-1}, low in organic carbon (0.73 %), low in available nitrogen (217 kg ha^{-1}) and medium in phosphorus (64 kg ha^{-1}) and high in potassium (402 kg ha^{-1}).The physiological parameters *viz.,* leaf area index, leaf area duration and radiation use efficiency recorded significantly higher with integration of residual 50% RDF+50% RDN through urban compost (M_5) and 100% RDF (S_1) for succeeding groundnut on par with residual 50% RDF+50% RDN through FYM (M_3) and 100% RDF (S_1) for succeeding groundnut, while growth analysis *viz.,* LAI, LAD and RUE were not significantly influenced at 30 days after sowing during both the years.

One of the most important challenges bring faced by agricultural scientists today is to conserve/ sustain natural resources, including soil and water, for increasing food production while protecting the environment. As the world population grows, stress on natural resources increases, making it difficult to maintain food security. Long term food security requires a balance between increasing crop production, maintaining soil health and environmental sustainability. In India, effective nutrient management has played a major role in accomplishing the enormous increase in food production from 52 million tonnes in 1951-52 to 264 million tonnes during 2014-15. However, application of imbalanced and excessive nutrients led to declining nutrient-use efficiency making fertilizer consumption un economical and producing adverse effects on atmosphere (Aulakh and Adhya, 2005) and groundwater quality (Aulakh *et al.*, 2009) causing health hazards and climate change.

Groundnut, a premier oilseed crop of India, occupies an area of about 6.7 million ha and contributes 7.3 million tonnes in the oilseed production. India stands first in area and second in production, and fifth in productivity (1,000 kg ha^{-1}) after USA, China Indonesia and Nigeria. The productivity of groundnut is low in India when compared with other countries mainly due to rain dependency (85%), monoculture (60%) and cultivation on marginal soils of low fertility. Groundnut is an energy rich crop and needs sufficient quantities of nutrients and moisture to meet its requirement for growth development and for high yields. Sustainable groundnut production is possible by diversifying the groundnut cropping system and nutrient management practices (Dudhatra *et al.*, 2002, and Balaguravaiah *et al.*, 2005). Integration and incorporation of organic manure (FYM/urban compost) in the agricultural systems helps to improve soil structure, soil microbial activity and moisture conservation and which in turn helps to stabilize the production and productivity of the crops. Integrated nutrient management is also important for marginal farmers who cannot afford to supply crop nutrients through costly chemical fertilizers.

MATERIAL AND METHODS

A field experiment entitled "Direct and residual effect of integrated nutrient management in Maize-Groundnut crop sequence in Southern Telangana region" was conducted during *kharif* and *rabi* 2014-15 and 2015-16 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Southern

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Telangana Zone. The soil of experimental site was sandy clay loam with pH of 7.6, Electrical conductivity 0.86 dSm^{-1}, low in organic carbon (0.73 %), low in available nitrogen (217 kg ha^{-1}) and medium in phosphorus (64 kg ha^{-1}) and high in potassium (402 kg ha^{-1}). The experiment was laid out in a randomized block design for maize during *kharif* 2014 and 2015 with six treatments comprising a combinations of three fertilizer levels 100,75 and 50 per cent RDF through inorganic fertilizer and 25 and 50 per cent RDN through two manures (FYM, Urban compost) with four replications. In succeeding *rabi* season, the experiment was laid out in split- plot design by taking five residual treatments from preceding maize as main plots and each at 50, 75 and 100 per cent RDF as three sub-treatments with 3 replications for groundnut during *rabi* 2014-15 and 2015-16. Succeeding rabi Groundnut (Kadiri-6) was sown on 26th November during first year and 16th October during second year adopting a spacing of 30 x 10 cm. In general the climatic conditions were congenial during crop growth period and incidence of pest and disease was noticed to a some extent. The data on physiological parameters included leaf area index, leaf area duration and radiation use efficiency were recorded at 30,60,90DAS and at harvest in groundnut during both years of study.

RESULTS AND DISCUSSION

Leaf Area Index

During first year of study, the LAI(table 1-4) was highest in 50% RDF+50% RDN through urban compost (M_5) followed by 50% RDF+50% RDN through farmyard manure (M_3) and 100% RDF (M_1), with significant disparity between rest of the treatments 1 at 60,90 days after sowing and at harvest, while during second year, the highest LAI was obtained with 50% RDF+50% RDN through urban compost (M_5), which was however, on par with 50% RDF+50% RDN through farmyard manure (M_3) and 100% RDF (M_1) and significantly superior to rest of the treatments at 60,90 days after sowing and at harvest. 75% RDF+25% RDN through farmyard manure (M_2) recorded the lowest LAI during both the years of study at 60, 90 days after sowing and at harvest. The increase in LAI could be attributed to significant increase in leaf expansion (length and breadth), high rate of cell division and cell enlargement, rapid growth and there by improved quality of vegetative growth due to applied organic manures along with RDF, which corroborates with the results of Jaliya *et al.* (2008), Jat *et al.* (2010) and Bisht *et al.* (2012).

During both the years of study, fertilizer levels exerted a significant influence on LAI of groundnut and it was the highest with 100% RDF (S_1), which was however, comparable with 75% RDF (S_2) and significantly superior to 50% RDF (S_3).

With regard to interaction between residual treatments and fertilizer levels, combination of residual 50% RDF+50% RDN through urban compost (M_5) and 100% RDF (S_1) recorded the highest LAI, which was on par with residual 50% RDF+50% RDN through FYM (M_3) and 100% RDF (S_1) during both years of study at 60 days after sowing.

Leaf Area Duration

During first year of study, the LAD(table 5-7) was highest in 50% RDF+50% RDN through urban compost (M_5) followed by 50% RDF+50% RDN through farmyard manure (M_3) and 100% RDF (M_1), with significant disparity between rest of the treatments tried, while during second year, the highest leaf area duration was obtained with 50% RDF+50% RDN through urban compost (M_5), which was however, on par with 50% RDF+50% RDN through farmyard manure (M_3) and 100% RDF (M_1) which was significantly superior over rest of the treatments between 30-60 DAS, 61- 90 DAS and 91 days after sowing- to harvest. 75% RDF+25% RDN through

farmyard manure (M_2) were recorded the lowest leaf area duration during both the years of study at 30-60 DAS, 61- 90 DAS and 91 days after sowing - to harvest. Leaf area duration is a function of leaf area index which indicates persistence of photosynthetic activity in the plant. It indicates the maintenance of assimilatory surface area over a period of time, which is prerequisite for prolonged photosynthetic activity and the ultimate productivity in crop plants. Increased availability of soil moisture content at all the stages of crop growth and available N, P_2O_5 and K_2O at different stages ,especially nitrogen might have resulted in development of required efficient photosynthetic system as reflected by higher LA and LAI and its retention for longer period of time as evidenced by higher LAD. Surkod (1993) and Patil *et al.* (2000) also recorded increased LAD with integrated nutrient management in maize-groundnut cropping system.

During both the years of study, fertilizer levels exerted a significant influence on leaf area duration of groundnut and it was the highest with 100% RDF (S_1), which was however, comparable with 75% RDF (S_2) and significantly superior to 50% RDF (S_3) at 30-60 DAS, 61- 90 DAS and 91 days after sowing- to harvest.

With regard to interaction between residual treatments and fertilizer levels, combination of M_5S_1 recorded the highest leaf area duration, which was on par with M_3S_1 and M_1S_1, during both the years of study at 61-90 days after sowing.

Radiation Use Efficiency

A significant influence of different nitrogen levels and their integration with 25 and 50 per cent RDN through FYM or Urban compost on RUE was observed at all growth stages in both the seasons.

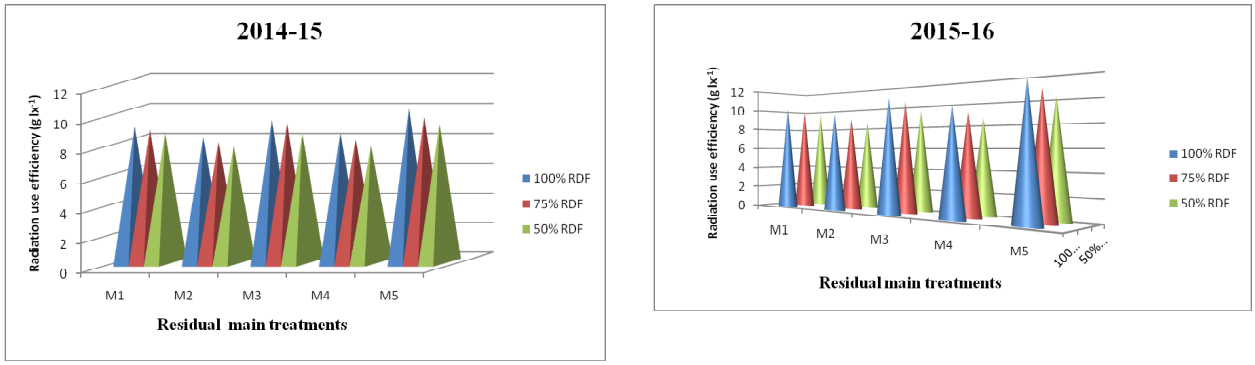
The values of RUE(table 8-11) increased following the tendency of canopy expansion and varied from 4.40 to 11.94 g lx^{-1} during first year and 4.84 to 13.13 g lx^{-1} during second year. RUE was not significantly different with treatments at 30 days after sowing in both years of study. Significantly high RUE was recorded for groundnut with application of 50% RDF+50% RDN through urban compost (M_5) followed by 50% RDF+50% RDN through FYM (M_3) and 100% RDF (M_1) which was on par with each other.

Radiation use efficiency was significantly influenced due to fertilizer levels at all growth stages during both seasons. The values of RUE increased following growth of groundnut and varied from 3.86 to 11.14 g lx^{-1} during first year and 4.24 to 12.26 g lx^{-1} during second year. Beneficial effects of fertilizer application over RUE were not noticed at 30 days after sowing. Significantly higher RUE was observed for groundnut with 100% RDF. The amount of RUE recorded with 100% RDF (S_1) was on par with 75% RDF (S_2) and significantly superior to 50% RDF (S_3) at 60, 90 DAS and at harvest.

The results suggested the benefit of nitrogen levels and their integration with 25 and 50 per cent RDN through FYM or Urban compost due to early canopy growth and increase the leaf area for increased intercepted solar radiation and conversion efficiency into chemical energy by the photosynthetic processes. Similar findings were also reported by Otegui *et al*. (1995) and Gardner and Auma (2003).Further, Whitelam and Halliday (2007) discussed carbon metabolism of plants was extremely sensitive to change in environmental conditions, especially light.

With regard to interaction between residual treatments and fertilizer levels, combination of M_5S_1 recorded the highest RUE, which was on par with M_3S_1 and M_1S_1, during both year of study at 60 days after sowing.

Fig 1. Radiation use efficiency (g lx^{-1}) at 60 DAS of *rabi* groundnut after *kharif* maize as influenced by different treatments



The physiological parameters *viz.,* significantly higher leaf area index, leaf area duration and radiation use efficiency recorded with integration of residual 50% RDF+50% RDN through urban compost (M_5) and 100% RDF (S_1) for succeeding groundnut which was on par with residual 50% RDF+50% RDN through FYM (M_3) and 100% RDF (S_1) for succeeding groundnut, while growth parameters *viz.,* LAI, LAD and RUE were not significantly influenced at 30 days after sowing during both the years.

1. Leaf Area Index at harvest of *rabi* Groundnut after *kharif* Maize as influenced by different treatments

Treatments given to *kharif* Maize(M)	Treatments given to rabi Groundnut(S)							
	2014-15				2015-16			
	Recommended Dose of Fertilizer (%)				Recommended Dose of Fertilizer (%)			
	100(S_1)	75(S_2)	50(S_3)	Mean	100 (S_1)	75 (S_2)	50 (S_3)	Mean
M_1- 100% RDF of NPK	4.10	3.76	3.62	3.83	4.51	4.14	3.98	4.21
M_2- 75% RDF of NPK +25% N-FYM	3.74	3.49	3.36	3.54	4.13	3.83	3.69	3.88
M_3- 50% RDF of NPK +50% N-FYM	4.32	4.20	4.04	4.19	4.75	4.62	4.44	4.60
M_4- 75% RDF of NPK +25% N-Urban Compost	3.94	3.77	3.57	3.76	4.34	4.15	3.93	4.14
M_5- 50% RDF of NPK +50% N-Urban Compost	4.76	4.49	4.26	4.50	5.22	4.94	4.69	4.95
Mean	4.18	3.94	3.77		4.59	4.34	4.15	
	S.Em ±	CD at 5%				S.Em±	CD at 5%	
M	0.39	0.84			M	0.34	0.79	
S	0.10	0.24			S	0.12	0.31	
M at S	0.24	NS			M at S	0.26	NS	
S at M	0.54	NS			S at M	0.59	NS	

2. Leaf Area Duration (dm^2 days) at 91 DAS-at harvest of *rabi* Groundnut after *kharif* Maize as influenced by different treatments

Treatments given to *kharif* Maize(M)	Treatments given to rabi Groundnut(S)							
	2014-15				2015-16			
	Recommended Dose of Fertilizer (%)				Recommended Dose of Fertilizer (%)			
	100(S_1)	75(S_2)	50(S_3)	Mean	100(S_1)	75(S_2)	50(S_3)	Mean
M_1- 100% RDF of NPK	155.93	148.90	143.53	149.45	171.50	163.80	157.83	164.38
M_2- 75% RDF of NPK +25% N-FYM	149.40	144.03	140.40	144.61	164.27	158.40	154.40	159.02
M_3- 50% RDF of NPK +50% N-FYM	162.53	157.87	152.80	157.73	178.77	173.60	168.07	173.48
M_4- 75% RDF of NPK +25% N-Urban Compost	153.13	148.90	143.13	148.39	168.80	163.57	157.43	163.21
M_5- 50% RDF of NPK +50% N-Urban Compost	174.43	165.20	158.47	166.03	191.83	181.70	174.30	182.60
Mean	159.08	152.98	147.67		174.95	168.26	162.41	
	S.Em ±	CD at 5%				S.Em ±	CD at 5%	
M	6.37	17.42			M	9.24	19.34	
S	2.9	6.31			S	3.54	7.53	
M at S	7.19	NS			M at S	8.10	NS	
S at M	5.1	NS			S at M	6.8	NS	

3. Radiation Use Efficiency (g Ix^{-1}) at harvest of *rabi* Groundnut after *kharif* Maize as influenced by different treatments

Treatments given to *kharif* Maize(M)	Treatments given to rabi Groundnut(S)							
	2014-15				2015-16			
	Recommended Dose of Fertilizer (%)				Recommended Dose of Fertilizer (%)			
	100(S_1)	75(S_2)	50(S_3)	Mean	100(S_1)	75(S_2)	50(S_3)	Mean
M_1- 100% RDF of NPK	7.12	6.54	6.29	6.65	7.84	7.19	6.92	7.32
M_2- 75% RDF of NPK +25% N-FYM	6.50	6.02	5.80	6.11	7.15	6.63	6.39	6.72
M_3- 50% RDF of NPK +50% N-FYM	7.51	7.30	7.01	7.27	8.25	8.03	7.71	8.00
M_4- 75% RDF of NPK +25% N-Urban Compost	6.84	6.56	6.23	6.54	7.53	7.22	6.85	7.20
M_5- 50% RDF of NPK +50% N-Urban Compost	8.25	7.80	7.40	7.82	9.08	8.58	8.13	8.60
Mean	7.24	6.84	6.55		7.97	7.53	7.20	
	S.Em ±	CD at 5%				S.Em ±	CD at 5%	
M	0.48	1.34			M	0.85	1.72	
S	0.33	0.68			S	0.36	0.74	
M at S	0.73	NS			M at S	0.80	NS	
S at M	0.18	NS			S at M	0.20	NS	

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ATTITUDE OF RURAL WOMEN TOWARDS HOMESTEAD TECHNOLOGIES OF RAJENDRA AGRICULTURAL UNIVERSITY (RAU)

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ABSTRACT

A number of technologies are developed for rural women. Unfortunately these technologies are not widely adopted by them. This could be due to low awareness about these technologies, lack of proper knowledge about them and unfavourable attitude of rural women towards these technologies. Hence it is important to assess the attitude of rural women towards the technologies developed for them. A study was conducted in three districts of Bihar- Vaishali, Samastipur and Muzaffarpur in 2013 to develop and standardise attitude scale using Likert method of summated rating to measure the attitude of rural women towards homestead technologies of RAU and to know the attitude level of the respondents towards theses technologies. Following Likert method, 22 statements constituted the final attitude scale to measure the attitude of rural women towards homestead technologies of RAU. It was found that 65.78 per cent of the respondents had favourable attitude towards homestead technologies of RAU. It was followed by 18.67 per cent respondents with neutral and 15.55 per cent respondents with unfavourable attitude towards homestead technologies of RAU respectively.

It is said that 'the fundamental problem of agricultural growth is of education' (Wharton, 1965). There is a need of education for rural development, in general, and agricultural development in particular. In this context, education has two components: a) research in agriculture and allied areas to develop newer technologies and new inputs of production and b) educating rural women to improve their skills, replace their traditional attitudes with modern ones and improve their innovative abilities etc. Attitude is the degree of positive or negative effect associated with psychological objects. It is universally accepted that the attitude of an in-dividual plays an important role in determining his/her behaviour with respect to a particular object. Attitude of rural women affects the knowledge and adoption of technologies of rural women. It is important to develop an attitude scale and standardise it to measure precisely the attitude of rural women towards a particular object so that it suits to the given subject and the psychological object under study. A no. of techniques were developed by scientists to measure attitude like Thurstone, Kilpatrick, Likert etc. Hence an attempt was made to develop and standardise attitude scale using Likert method to measure rural women's attitude towards homestead technologies.

MATERIAL AND METHODS

A set of positive and negative attitude statements were framed in consultation with the concerned research scientists and thorough study of relevant literature that represent attitude of rural women towards the selected homestead technologies. These statements were administered to 80 respondents in non-sample area to elicit their response on a three point continuum i.e. 'agree', 'undecided' and 'disagree' with a score of 3,2 and 1 for positive statements and reverse for negative statements. Based on the total scores of the respondents, they were arranged in descending order and 25 per cent respondents were selected from the high group and low group. These responses were subjected to item analysis for selection of the items and all statements with t-values greater than 1.75 was selected for final attitude scale. The selected statements were subjected to reliability and validity tests. The final attitude scale was administered to 225 respondents on a three point continuum with the same scoring pattern. The total score of the respondents was calculated and the respondents were put into three categories based on the computed Mean and Standard Deviation.

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RESULTS AND DISCUSSION

Construction and Standardisation of Attitude Scale

For measuring attitude, different types of scales developed by Thurstone, Likert, Bogardus and several others were observed. Finally the Likert Method of Summated Ratings was used to develop and measure the attitude of respondents towards homestead technologies of Rajendra Agricultural University (RAU) for the following reasons-

(i) Attitude scale with greater reliability can be developed by this technique in comparison with the Thurstone's technique. Likert (1934) have shown that more satisfactory reliability coefficients could be obtained when each item in a Thurstone type scale was assigned five alternative choices and the points were checked in all items to obtain a total score. Hall (1934) indicated that the Likert type scale with even fewer statements will give high reliability coefficients. Reliability coefficients for his scale of 10 statements measuring attitude towards religion ranged from 0.91 to 0.93.

(ii) In this scale each item was judged on a three point continuum rather than mere rejection of the items as in Thurstone scale. By this method, we get more information about the items than Thurstone's scale.

(iii) No judges are required to rank the items as in the case of Thurstone's scale. This saves time, labour, money and also simplifies the procedure.

(iv) The items on a Likert scale provide data on the individual's attitude about the specific issue covered by the single item as well as a total score on the attitude dimension being studied.

(v) By using the scale with a new group, the internal consistency and spilt-half reliability of Likert scale could be quickly checked. Non- discriminating items could be eliminated and scores can be calculated from the remaining items. New items could also be added and tested with ease.

A. Collection of Statements

One hundred and sixteen statements representing the attitude of rural women of Bihar towards ten (10) selected homestead technologies of Rajendra Agricultural University (RAU) were collected initially from various sources such as published literatures of the University and in discussion with the concerned Scientists of the University.

The selected technologies were- fruit & vegetable preservation, value added quality protein maize products, value added products from cereals & pulses, stitching & embroidery, value addition to garments, arts & craft making, mushroom production, value added mushroom products, vermicompost technology and apiculture. These statements were framed in the form of both positive and negative statements, so as to get accurate response.

One Hundred and sixteen statements were edited based on the criteria suggested by Thurstone and Chave (1929), Likert (1932) and Edwards (1957) and finally eighty statements were included in the scale. Utmost care is taken in formulation of statements.

B. The Procedure of Item Analysis for Selection of Statements

Eighty statements representing the attitude of rural women towards 10 selected homestead technologies of RAU were administered to 80 respondents from non-sampled area who were aware of all nine homestead technologies. The respondents were asked to indicate their degree of agreement or disagreement with each statement on a three point continuum ranging from 'Agree' to 'Disagree'. The scoring pattern adopted was 3 weights for 'Agree', 2 to 'Undecided' and 1 to 'Disagree' for positive statements and 1 weight for 'Agree', 2 to 'Undecided' and 3 to 'Disagree' for negative statements. Their responses were recorded and the summated score for the 80 statements was obtained. The total score

obtained by each respondent was arranged in descending order. Twenty five per cent of the respondents obtaining highest scores and twenty five per cent of the respondents obtaining lowest scores were taken for the item analysis, i.e. 20 respondents from the high group and 20 respondents from the low group. These responses were subjected to item analysis for selection of the items that would constitute the final attitude scale.

The critical ratio, i.e. t-value which is a measure of the extent to which a given statement differentiates between the high and low group of respondents for each statement was calculated by using the formula suggested by Edwards (1959).

$$t = \frac{\overline{X}_H - \overline{X_L}}{\sqrt{\left\{\left(\frac{S_H{}^2}{n_H}\right)+\left(\frac{S_L{}^2}{n_L}\right)\right\}}}$$

Where,

$\overline{X}_H$ = the mean score on a given statement for the high group.

$\overline{X_L}$ = the mean score on a given statement for the low group.

$S_H{}^2$= the variance of the distribution of the responses of the high group to the statement.

$S_L{}^2$= the variance of the distribution of the responses of the low group to the state

n_H= the number of respondents in the high group

n_L= the number of respondents in the low group

As was equal to (20 each) the modified formula for calculating the t-values of the statement was used. The formula is given below:

$$t = \frac{\overline{X}_H - \overline{X_L}}{\sqrt{\frac{\sum(X_H - \overline{X}_H)2+\sum(X_L - \overline{X}_L)2}{n(n-1)}}}$$

Where,

$$\sum(X_H - \overline{X}_H)^2 = \text{“}X_H^2 - (\text{“}X_H)^2/n \text{ and}$$

$$\sum(X_L - \overline{X}_L)^2 = \text{“}X_L^2 - (\text{“}X_L)^2/n$$

After calculating the t-values for all the items of the selected respondents of high and low groups, the values of the statements were arranged in descending order from the highest to the lowest as indicated in (Table 1.) Twenty two statements with t-values greater than 1.75 were selected for inclusion in the scale, with equal number of positive and negative statements which is presented in (Table 2.)

C. Reliability of the Scale Test and Retest Method

A set of 22 statements which were framed to study the attitude of rural women towards homestead technologies of RAU with three point response continuum were administered to a fresh group of 60 rural women who were outside the main sample selected for this study. Their responses for attitude statements were collected and total score was computed. After a period of 15 days the scale was again administered to the same respondents and again responses were recorded and total score was computed. Both set of scores were correlated and the correlation coefficient value obtained was 0.829. The ‘r’ value was significant at 0.01 level of probability indicating that the attitude scale was suitable for administration to rural women as the scale was stable and dependable in its measurement.

Table 1. Attitude statements with their calculated 't' values

Sl. No.	Attitude statements	't' values
General Statements About Homestead Technologies of RAU		
1.	The technologies are transferred only to a few interested women.	0.41
2.	The University should develop more technologies to increase resources for my family.	0.75
3.	The University should develop more technologies on child development.	0.45
4.	*The technologies do not reach remote and backward villages.*	2.55
5.	Low literacy rate is a barrier for rural women in availing maximum benefits from these technologies.	0.26
6.	There is a need to develop more technologies that are purely meant for women.	0.0
7.	The University should develop more low-cost household technologies.	0.0
Attitude of Rural Women About Fruit & Vegetable Preservation		
1.	These technologies are easy to practice.	0.42
2.	*As these products can be prepared at home, I can save family budget.*	1.89
3.	*Price and demand for these products is good.*	2.65
4.	*Preparation of preserved products from fruits & vegetables is a highly profitable enterprise.*	2.29
5.	The preservatives used for preparation of these products are not available in local market.	0.57
6.	As preparation of these products require lot of money, I cannot practice.	1.18
7.	*The training given by Scientists on preparation of these products is sufficient.*	**3.03**
8.	The Scientists provide sufficient literature related to the technologies in local language.	1.39
Attitude of Rural Women About Value Added Quality Protein Maize Products		
1.	Lime water treatment to Quality Protein Maize is complicated and takes considerable time.	0.28
2.	Some of the Quality Protein Maize products are not tasty.	1.0
3.	These technologies have helped to improve nutritional status of my family.	0.86
4.	The technology is low cost.	1.10
5.	Quality Protein Maize is not readily available for use.	0.0
6.	Proper training is given by the Scientists on Quality Protein Maize technologies.	0.0
7.	Due to financial constraints, I cannot prepare it at home.	0.95

Sl. No.	Attitude statements	't' values
	Attitude of Rural Women About Stitching & Embroidery	
1.	The stitches demonstrated by the University are latest and new.	0.58
2.	The different embroideries demonstrated are already known to me.	1.18
3.	Sufficient time is not given by the Scientists to impart the skill.	1.15
4.	*The stitches and embroideries which I have learnt increased the income of my family by taking it up as an enterprise.*	**1.76**
5.	Stitching and embroidery materials are not available locally.	0.87
6.	There is no market demand for the stitched and embroidered products that I make.	1.07
7.	Women still want to learn more about different types of garment stitching and advanced stitches.	1.34
	Attitude of Rural Women About Value Addition to Garments	
1.	The disseminated technologies are useful in enhancing the value of the garments	1.19
2.	Tie & Dye technique is demonstrated in simple & easy to understand way.	0.0
3.	Batik painting is very complicated and difficult to put into practice.	0.0
4.	Mithila Painting has not been popularized much by the University.	0.0
5.	Women & girls look forward to learn more about fabric painting.	0.48
6.	*Due to financial constraints, I am not able to apply value addition techniques to the garments.*	**1.82**
7.	The technologies are useful but unavailability of required materials is a constraint in its adoption.	1.37
8.	*The technology is disseminated only to the interested women.*	**2.69**
9.	Proper training is not given to impart skill.	0.71
10.	These technologies are latest and new to me.	0.56
	Attitude of Rural Women About Arts & Craft Making	
1.	These technologies are low cost.	0.80
2.	*It is easy to follow as it can be made from waste or left over things at home.*	**2.32**
3.	Some of the demonstrated arts & craft items are already known to me.	0.36
4.	*I want to take it up as an enterprise to support family living.*	**2.69**

Sl. No.	Attitude statements	't' values
5.	*These technologies should be further refined so that the products could compete in the market.*	**2.05**
6.	*I want to learn other art and craft products which have high value and good return in the market.*	**3.50**
7.	Some of the disseminated technologies are obsolete.	0.99
	Attitude of Rural Women About Value Added Products from Cereals and Pulses	
1.	I want to learn about new products like pasta, noodles, corn flakes etc. which is highly in demand.	0.48
2.	*I've taken up these technologies to run an enterprise but it is not giving good return.*	**1.87**
3.	*The technologies are low cost and easy to practice at home.*	**2.66**
4.	The University does not organise training programs on packaging and marketing of the products.	0.75
5.	*I am using these technologies only for my home consumption.*	**3.19**
	Attitude of Rural Women About Mushroom Production	
1.	The process of mushroom cultivation is very simple and easy to practice.	0.59
2.	The materials and equipments used in mushroom cultivation are low cost.	0.48
3.	There is no market for the mushroom that we produce.	0.39
4.	*Mushroom consumption is not popular in my region.*	**1.97**
5.	The Scientists do not organise regular training to improve knowledge and skill in mushroom cultivation.	0.78
6.	*The Scientists do not provide timely information about mushroom cultivation.*	**2.65**
7.	The Scientists are very friendly and cooperative during dissemination of the technology.	1.06
	Attitude of Rural Women About Value Added Mushroom Products	
1.	*Preparation of value added products from mushroom is very useful and new technology.*	**5.03**
2.	The technologies introduced by the Scientists are very useful to me in the preservation and processing of mushroom.	0.74
3.	The taste of the products is not good.	0.57
4.	Value added mushroom products have very less demand in the market.	0.87

Sl. No.	Attitude statements	't' values
5.	The technologies have helped in decreasing the wastage of mushrooms as they are highly perishable.	0.0
6.	The method of preparation is very complicated.	0.25
7.	These products have given an additional source of income.	0.46
8.	The products do not fetch good net returns to me.	0.73
	Attitude of Rural Women About Vermicompost Technology	
1.	Use of vermicompost in my field has helped to increase crop yield.	0.39
2.	*Preparation of vermicompost is laborious and involves lot of labour.*	**1.78**
3.	Preparation of vermicompost needs lot of water and cow dung which is not always available.	0.89
4.	The technology is low cost and can be easily adopted.	0.66
5.	There is difficulty in finding the market for sale of vermicompost.	0.74
6.	The technology is easy and simple to understand.	1.47
	Attitude of Rural Women About Apiculture	
1.	Honey bee rearing is suitable to this area.	1.25
2.	Proper training was given to provide hands-on skill in the use of the technologies.	1.16
3.	*The equipments and materials are easily available in the market.*	**3.03**
4.	*It is difficult to control pest and disease in honey bee rearing.*	**3.07**
5.	Honeybee rearing is a costly affair.	0.38
6.	*Labourers cannot understand skills in honey bee rearing easily.*	**1.80**
7.	Apiculture is a laborious procedure.	0.19
8.	Govt. subsidy is needed to promote apiculture.	0.63

Statements in italics are selected for final scale

D. Validity of the Scale Content Validity

One method for determining validity of a scale is to judge whether it measures what it is intended to measure. Scale produced consistent results and is dependable. The statements represent the population and are extensively reviewed by experts. Hence it can be concluded that the scale has content validity.

Table 2. Final attitude statements with calculated't' values 1.75 and above

Sl. No.	Attitude statements	't' values
General Statements About Homestead Technologies Of RAU		
1	The technologies do not reach remote and backward villages.	2.55
	Attitude of Rural Women About Fruit & Vegetable Preservation	
2	As the value added fruits & vegetables products can be prepared at home, I can save family expenses.	1.89
3	Price and demand for these products is good.	2.65
4	Preparation of preserved products from fruits & vegetables is a highly profitable enterprise.	2.29
5	The training given by Scientists on preparation of these products is sufficient.	3.03
	Attitude of Rural Women About Stitching & Embroidery	
6	The stitches and embroideries which I have learnt increased the income of my family by taking it up as an enterprise.	1.76
	Attitude of Rural Women About Value Addition to Garments	
7	Due to financial constraints, I am not able to apply value addition techniques to the garments.	1.82
8	The technology is disseminated only to the interested women.	2.69
	Attitude of Rural Women About Arts & Craft Making	
9	It is easy to follow as it can be made from waste or left over things at home.	2.32
10	I want to take it up as an enterprise to support family living.	2.69
11	These technologies should be further refined so that the products could compete in the market.	2.05
12	I want to learn other art and craft products which have high value and good return in the market.	3.50
	Attitude of Rural Women About Value Added Products from Cereals and Pulses	
13	I've taken up these technologies to run an enterprise but it is not giving good return.	1.87
14	The technologies are low cost and easy to practice at home.	2.66
15	I am using these technologies only for my home consumption.	3.19
	Attitude of Rural Women About Mushroom Production	
16	Mushroom consumption is not popular in my region.	1.97
17	The Scientists do not provide timely information about mushroom cultivation.	2.65
	Attitude of Rural Women About Value Added Mushroom Products	
18	Preparation of value added products from mushroom is very useful and a new technology.	5.03
	Attitude of Rural Women About Vermicompost Technology	
19	Preparation of vermicompost is laborious and involves lot of labour.	1.78
	Attitude of Rural Women About Apiculture	
20	The equipments and materials are easily available in the market.	3.03
21	It is difficult to control pest and disease in honey bee rearing.	3.07
22	Labourers cannot understand skills in honey bee rearing easily.	1.80

A. Administration of the Scale

The final attitude scale with 22 statements were administered to the selected 225 respondents i.e. the main sample of the study to determine the attitude of rural women towards homestead technologies of RAU.

B. Scoring Pattern

Each item of the scale was provided with a three point response continuum. These were 'Agree', 'Undecided' and 'Disagree' with weights of 3, 2 and 1respectively for positive statements and 1, 2 and 3 respectively for negative statements. The total score of the respondent on the scale was obtained by adding the scores of all items in the scale. The minimum and maximum possible scores were 22-66. From the scores obtained by the respondents mean and standard deviation were calculated.

C. Categorisation of Respondents based on their Attitude Scores

The respondents were categorised into three groups based on the calculated mean and standard deviation as below:

Sl. No.	Category	Score
1	Unfavourable attitude	Mean- S.D.
2	Neutral	Mean ±S.D
3	Favourable attitude	Mean +S.D.

Attitude of rural women towards homestead technologies of RAU

Attitude of rural women towards Homestead technologies of RAU was studied and analysed to know the degree of favourableness or unfavourableness on a three point continuum as indicated in table 3. It was found from the data of this table that 65.78 per cent of the respondents had favourable attitude towards homestead technologies of RAU. It was followed by 18.67 per cent respondents with neutral and 15.55 per cent respondents with unfavourable attitude towards homestead technologies of RAU respectively.

Table 3. Distribution of respondents based on their attitude towards homestead technologies

(n=225)

Sl. No.	Category	n	%
1	Unfavourable	35	15.55
2	Neutral	42	18.67
3	Favourable	148	65.78
	Total	225	100.00

Mean= 46.63 Standard Deviation=5.34

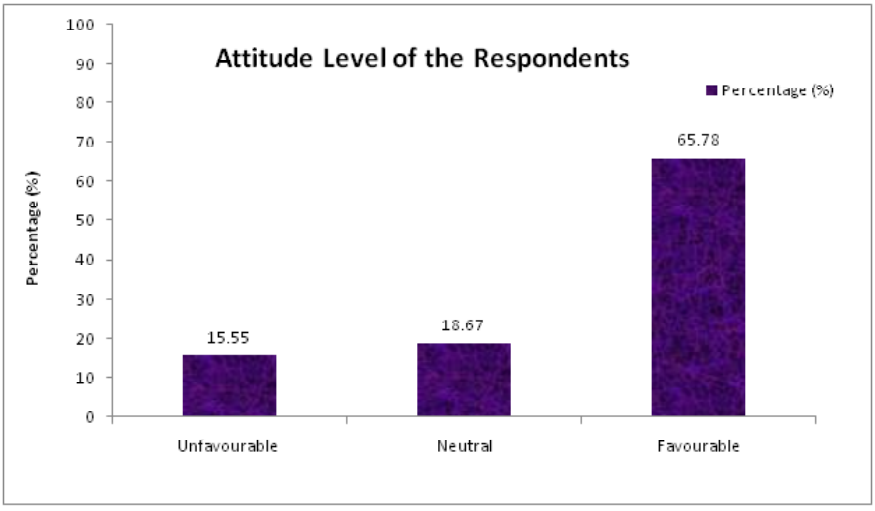

Fig 1. Distribution of respondents based on their attitude towards homestead technologies.

The result could be due to the fact that majority of the respondents had medium level of perception about the attributes of homestead technologies and were exposed to various sources of information in regard to these technologies through different dissemination methods.

It infers that the respondents had positive opinion about the Homestead technologies of RAU and were satisfied with these technologies. They have better ability to understand new ideas & practices. They have rational thinking, evaluation and understanding. The rural women were well acquainted with the homestead technologies of RAU and had good contact with some of the research scientists and extension scientists of the University. Majority of them were satisfied with the services of the University and the prompt and timely reply to their queries through phone. These factors might have been the reason for majority of the rural women to have favourable attitude towards these technologies of RAU.

Similar findings were observed in the study of Sharma (2001) which revealed that majority (57.58%) of the respondents had favourable attitude followed by neutral (24.24%) and unfavourable attitude (18.18%) towards income generating activities.

CONCLUSION

Most of the rural women had favourable attitude towards Homestead technologies of RAU. Research scientists and extension scientists should make more efforts so that they can develop favourable attitude among the rest of the rural women. Attitude of rural women is directly related to the adoption of these technologies. Hence if there is improvement in the attitude of rural women, it will lead to increased adoption of these technologies by rural women.

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APPLICATION OF NONLINEAR GROWTH MODELS FOR ESTIMATION OF ANNUAL COMPOUND GROWTH RATES OF MAJOR PULSE CROPS IN TELANGANA STATE

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ABSTRACT

In the present study nonlinear growth models were applied to estimate the compound annual growth rates of area, production and yield of red gram and green gram in Telangana state for the period from 1979-80 to 2012-13. An attempt was made in this paper to suggest some important nonlinear growth models to overcome the inherent problems of the conventional semi-logarithmic estimation of growth rates. The study revealed that both the Logistic and the Gompertz model gave almost similar results. But in some cases the Logistic model proved to be better fit as compared to the Gompertz model since the calculated mean squared errors were smaller for the Logistic model. The estimated compound annual growth rates revealed that the area, production and yield of arhar has shown an increasing trend over the study period but there was a decreasing trend for moong in Telangana state

Estimation of growth rates in agricultural sector has been one of the most important subject matter of the agricultural economics research. A large number of literature are available in this field of study like Rambabu *et al*. (2014), Datarkar *et al.* (2015) and Pardhi *et al.* (2015) etc. Most of the studies on compound growth rate estimation in agricultural field were based on the application of semi-logarithmic growth model. However this method of computation of growth rates has a number of serious lapses and therefore the conclusions drawn are not statistically sound (Prajneshu and Chandran, 2005). In the present study an attempt was made to apply various nonlinear growth models like the Logistic model and the Gompertz model to estimate the compound annual growth rates of area, production and yield of two major pulse crops viz. red gram (arhar) and green gram (moong) in Telangana state.

MATERIAL AND METHODS

Red gram (arhar) and green gram (moong) were selected for the present study. The district wise data pertaining to the area, production and productivity of the two selected crops for the period from 1979-80 to 2012-13 were collected from the Directorate of Economics and Statistics, Government of Telangana, Hyderabad and the official website of the Directorate of Economics and Statistics, Department of Agriculture, Co-operation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, GOI (http://eands. dacnet.nic.in/). The entire state of Telangana was classified into three different sub-divisions each comprising of three districts. These three sub-divisions are as follows, Northern Telangana (Adilabad, Nizamabad and Karimnagar), Central Telangana (Medak, Rangareddy and Warangal) and Southern Telangana (Khammam, Mahaboobnagar and Nalgonda).

The trend of the response variable has to be identified properly in order to fit a growth model into it (Prajneshu and Chandran, 2005). The growth models should be mechanistic in nature rather than empirical in which the parameters should have some meaningful biological interpretation. The main utility of such models is that they help in getting an insight of the underlying mechanism of the system and thereby a proper management of it. Some of the important non-linear growth models that can be applied in the

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analysis of growth rate of area, production and yield of agricultural outputs are discussed below.

A. Logistic growth model

The logistic model can be expressed in its differential form as,

$dY/dt = r Y (1 – Y/k)$ 1

Integrating the above equation we get,

$Y(t) = K / [1 + (K / Y_0 – 1) \exp (– r t)]$ 2

Where,

K = Carrying capacity of the system

r = Intrinsic growth rate

Y_0 = value of Y(t) at t= 0.

When Y(t) is fitted against time it gives a S shaped curve kinked at the carrying capacity of the system and symmetric. The model postulates that the variable grows at an exponential rate in the beginning and then an internal force comes into play which limits the increase of the variable beyond certain limits.

B. Gompertz growth model

This model has found an important place in the biological work which has a sigmoid behaviour. Unlike the logistic model, this model is not symmetric at its point of inflexion. The model is expressed in its differential form as

$dY/dt = rY \ln (K / Y)$.....3

Integrating the equation 3.6 we get

$Y(t) = K \exp [\ln (Y_0 / K) \exp (– r t)]$..... 4

The above deterministic models are made statistical non-linear model by adding an error term with each of the models. The most widely used method for estimating the non-linear least square estimators of the above models is the Levenberg-Marquardt's method. This method is discussed briefly below.

$Y_i = f(X_i, è) + å_i$, i= 1, 2,..., n.....5

Where, Y_i is the i^{th} observation of the dependent variable, X_i is the i^{th} independent variable, è= $(è_1, è_2, \ldots, è_p)'$ are parameters, $å_i$ are the error terms which are independent and follows $N(0, ó^2)$. The residual sum of square is,

$$S(\theta) = \sum_{i=1}^{n} [Y_i - f(X_i, \theta)]^2 \quad \text{.....6.}$$

Let $è_0 = (è_{10}, è_{20}, \ldots, è_{p0})'$ is the vector of initial parameter values, then the algorithm for obtaining successive estimates is given by

$(H+ôI)(è_0-è_1)= g$, ...7

Where,

$$g = \frac{\partial S(\theta)}{\partial \theta}\Big| \theta = \theta_0 \ , \ H = \frac{\partial^2 S(\theta)}{\partial \theta \partial \theta'}\Big| \theta = \theta_0,$$

I is the identity matrix and ô is the suitable multiplier.

For logistic, and Gompertz models, the annual growth rates pertaining to the period (t_i , t_{i+1}) [i = 0, 1, ..., n-1, where n denotes the number of data points], on using Equations 8 and 9 respectively are:

$R_t^L = r [1 – Y(t) / K]$ 8

$R_t^G = r \ln [K / Y (t)]$ 9

Goodness of fit of the model

This is generally assessed by the coefficient of determination, R^2. Kvalseth (1985) pointed out that, although R_1^2 is given by,

$$R_1^2 = 1 - \sum\left(Y_i - \hat{Y}_i\right)^2 / \sum (Y_i - \bar{Y})^2 \quad \text{.....10}$$

is quite appropriate even for the nonlinear models. Some other summary statistics can also be applied to test the goodness of fit of the models like,

Mean absolute error (MAE) = $\sum|Y_i - \hat{Y}_i|/n$ 11

Mean squared error (MSE) = $\sum(Y_i - \hat{Y}_i)^2/(n-p)$ 12

Where n is the total number of observed values and p denotes the number of parameters in the model.

The assumption of independence of the error terms in the above three models are tested by the non-parametric test Run's test. Normality of the error term is tested by the Shapiro- Wilk test.

RESULTS AND DISCUSSION

Nonlinear estimation of compound annual growth rates of area, production and yield of arhar

In an attempt to calculate the compound annual growth rates of area, production and yield of arhar (red gram) in Telangana state and its region, nonlinear growth models were applied to the data of 34 years from 1979-80 to 2012-13. The results obtained from the Logistic and the Gompertz models were tabulated in table 1. The tables revealed that the performance of the Logistic model was slightly better over the Gompertz model, except in some cases. This was because the estimates of the MAE and MSE were smaller for the Logistic model than the Gompertz model for arhar in Telangana state and its regions. The estimates of the intrinsic growth rates and the carrying capacity of the system were in accordance with the estimated values of the growth rates. These estimates also appeared with minimum standard errors.

The crop arhar had registered a positive growth trend in all its parameters in the state as confirmed by both the traditional and the nonlinear estimation of compound growth rates. The compound growth rates of area, production and yield of the crop in the Telangana state over the study period were 1.6 per cent, 6.25 per cent and 3.2 per cent respectively as per the Logistic model. Using the Gompertz model the estimates of these parameters were 2.4 per cent, 5.5 per cent and 3.4 per cent respectively. For the estimation of the CAGR of area in the Telangana state the Gompertz model was found to be better over the Logistic model since the value of the MSE was 999.779 and 569.051 for Logistic and Gompertz models respectively. The estimate of the intrinsic growth rate was also much closer to the actual rate in case of Gompertz model as compared to the Logistic model. In all other cases in the state performance of Logistic model was better than the Gompertz model.

The region wise analysis of the growth rates revealed that the growth of area under arhar was highest in Southern Telangana region (3.0 per cent) followed by Central Telangana (2.7 per cent) and Northern Telangana (0.80 per cent). But in Northern Telangana the growth of the production of the crop was comparatively higher than the other two regions of the state since its growth of the area under the crop was least among others. This led to the highest growth in the yield of arhar in Northern Telangana region. The CAGR of yield was 5.3 per cent in Northern Telangana, 2.6 per cent in Central Telangana and 2.5 per cent in Southern Telangana region

Table 1. Nonlinear growth models for Arhar (Red Gram) in Telangana State (1979-80 to 20112-13)

		Area		Production		Yield	
		L	G	L	G	L	G
Northern Telangana	**R**	0.032 (0.075)	0.019 (0.050)	0.115 (0.064)	0.071 (0.046)	0.077 (0.045)	0.046 (0.056)
	K	62.836 (42.386)	71.983 (56.650)	30.719 (8.791)	36.015 (15.895)	0.984 (0.528)	0.746 (0.652)
	CAGR (%)	0.8	0.8	5.8	8.0	5.3	5.1
	MAE	3.981	3.855	6.675	6.851	0.092	0.108
	MSE	27.197	26.887	67.033	91.335	0.013	0.019
Central Telangana	**R**	0.045 (0.026)	0.042 (0.028)	0.106 (0.044)	0.033 (0.036)	0.037 (0.057)	0.070 (0.109)
	K	155.845 (127.135)	113.788 (43.951)	56.922 (24.676)	126.752 (222.018)	1.183 (4.254)	0.449 (0.117)
	CAGR (%)	2.7	2.8	6.4	6.4	2.6	2.5
	MAE	7.326	7.469	6.178	6.355	0.090	0.093
	MSE	97.105	103.607	73.156	75.578	0.014	0.017
Southern Telangana	**R**	0.073 (0.027)	0.055 (0.025)	0.100 (0.40)	0.041 (0.034)	0.084 (0.061)	0.056 (0.057)
	K	168.714 (24.003)	166.305 (37.590)	73.194 (27.412)	113.702 (108.982)	0.437 (0.116)	0.468 (0.190)
	CAGR (%)	3.0	3.1	5.7	5.9	2.5	2.7
	MAE	11.488	11.632	7.115	7.154	0.059	0.059
	MSE	229.890	252.775	112.139	113.957	0.007	0.007
Telangana	**R**	0.049 (0.070)	0.024 (0.018)	0.089 (0.031)	0.044 (0.033)	0.046 (0.041)	0.029 (0.036)
	K	313.420 (44.550)	559.379 (312.196)	226.637 (131.462)	206.607 (139.654)	1.023 (1.892)	0.940 (1.229)
	CAGR (%)	1.6	2.4	6.2	5.5	3.2	3.4
	MAE	24.567	18.596	13.673	17.143	0.056	0.056
	MSE	999.779	569.051	393.057	569.967	0.007	0.007

Figures within the brackets indicate corresponding standard errors.
R = Intrinsic growth rate of the system,
K= Carrying capacity of the system,
CAGR= Compound annual growth rate,
MAE= Mean absolute error,
MSE= Mean squared error

Nonlinear estimation of compound annual growth rates of area, production and yield of moong

Nonlinear growth models were applied to the data from 1979-80 to 2012-13 of area, production and yield of moong (green gram) in Telangana state and its three regions to estimate compound annual growth rates (CAGR). The results are presented in the (Table 2.) The (Table 2.) revealed that the Logistic model produced a slightly better fit to the data than that of the Gompertz model in the sense that the calculated MAE and MSE were smaller in the former model in almost all cases. The intrinsic growth rate and the carrying capacity estimates of the system appeared with minimum standard errors implying the good fit of the models. The normality of the residuals was tested applying the Shapiro-Wilk test.

The results revealed that the area and production of the crop in the state registered a negative trend over the years under study. But the fall in the area under cultivation was steeper than the fall in the production due to which the yield of the crop witnessed an increasing trend over the years. The CAGRs calculated by using the Logistic and the Gompertz models for area, production and yield were -2.4 per cent and -2.5 per cent, 1.8 per cent and -2.2 per cent and 1.1 per cent and 0.90 per cent respectively. This clearly indicates that despite the fall in the area and production the yield of the crop was almost stable over the years mainly due to the fact that the fall in area was more as compared to the fall in the production. The trend of the area, production and yield in all three regions of the state were similar to the state level performance over the study period. The area and production registered declining trend in all three regions whereas the growth trend of the yield was positive. The fall in the area and production was highest in Northern Telangana region followed by the Southern Telangana and Central Telangana. The yield of the crop registered a positive trend in all the regions of the state. In Southern Telangana, the rate of increase in the yield was the highest compared to the other two regions.

The estimation of compound growth rates by using nonlinear growth models proved to be an improvement over the conventional semi-logarithmic estimation since these models gave a better insight about the working of the process of growth. Along with the estimates of annual compound growth rates, these models gave the estimates of the carrying capacity of the system and the intrinsic growth rates. Using these two models the CAGR of area, production and yield of arhar were 1.60 percent and 2.4 per cent, 6.2 per cent and 5.5 per cent and 3.2 per cent and 3.4 per cent respectively in Telangana state. The same estimates for moong were -2.4 per cent and -2.5 per cent, -1.8 per cent and -2.2 per cent and 1.10 per cent and 0.90 per cent respectively in the state during the study period.

Table 2. Nonlinear growth models for Moong(Green Gram) in Telangana State(1979-80 to 2012-13)

		Area		Production		Yield	
		L	G	L	G	L	G
Northern Telangana	R	0.032 (0.075)	0.019 (0.050)	0.115 (0.064)	0.071 (0.046)	0.077 (0.045)	0.046 (0.056)
	K	62.836 (42.386)	71.983 (56.650)	30.719 (8.791)	36.015 (15.895)	0.984 (0.528)	0.746 (0.652)
	CAGR (%)	0.8	0.8	5.8	8.0	5.3	5.1
	MAE	3.981	3.855	6.675	6.851	0.092	0.108
	MSE	27.197	26.887	67.033	91.335	0.013	0.019
Central Telangana	R	0.045 (0.026)	0.042 (0.028)	0.106 (0.044)	0.033 (0.036)	0.037 (0.057)	0.070 (0.109)
	K	155.845 (127.135)	113.788 (43.951)	56.922 (24.676)	126.752 (222.018)	1.183 (4.254)	0.449 (0.117)
	CAGR (%)	2.7	2.8	6.4	6.4	2.6	2.5
	MAE	7.326	7.469	6.178	6.355	0.090	0.093
	MSE	97.105	103.607	73.156	75.578	0.014	0.017
Southern Telangana	R	0.073 (0.027)	0.055 (0.025)	0.100 (0.40)	0.041 (0.034)	0.084 (0.061)	0.056 (0.057)
	K	168.714 (24.003)	166.305 (37.590)	73.194 (27.412)	113.702 (108.982)	0.437 (0.116)	0.468 (0.190)
	CAGR (%)	3.0	3.1	5.7	5.9	2.5	2.7
	MAE	11.488	11.632	7.115	7.154	0.059	0.059
	MSE	229.890	252.775	112.139	113.957	0.007	0.007
Telangana	R	0.049 (0.070)	0.024 (0.018)	0.089 (0.031)	0.044 (0.033)	0.046 (0.041)	0.029 (0.036)
	K	313.420 (44.550)	559.379 (312.196)	226.637 (131.462)	206.607 (139.654)	1.023 (1.892)	0.940 (1.229)
	CAGR (%)	1.6	2.4	6.2	5.5	3.2	3.4
	MAE	24.567	18.596	13.673	17.143	0.056	0.056
	MSE	999.779	569.051	393.057	569.967	0.007	0.007

Figures within the brackets indicate corresponding standard errors.
R = Intrinsic growth rate of the system,
K= Carrying capacity of the system,
CAGR= Compound annual growth rate,
MAE= Mean absolute error,
MSE= Mean squared error

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ESTIMATION OF DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY OF RICE IN TELANGANA STATE : APPLICATION OF PARAMETRIC APPROACH

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ABSTRACT

The present study was conducted in the state of Telangana for the period 2000-01 to 2012-13. Tornqvist Total Factor Productivity (TFP) indices of rice and its determinants were calculated. The data on the quantity and price of the output and various inputs were collected from the published documents of the "Cost of Cultivation of Principal Crops" scheme of Government of India. The data on the variables like government expenditure on agricultural research, extension and education was collected from the Office of the Accountant General of the Government of Telangana, Hyderabad. Other required data were collected from various published documents of the Directorate of Economics and Statistics, Hyderabad. The study revealed that over the study period the TFP of rice increased by 36 per cent in Telangana state. The lowest value of the TFP index in Telangana was recorded in the year 2002-03 largely because of the drought conditions in the state. The most the low values of TFP of rice recorded in the years when the state experienced drought conditions. Release of the variety BPT-5204 (Sambamahsuri) significantly helped in productivity gain of rice. The study revealed that the productivity growth of rice in Telangana state was mainly driven by the government investment in agricultural research, education and extension, average rainfall in the state, irrigated area under the crop and rural literacy rate with regression coefficients 0.076, 0.792, 0.005 and 0.026 respectively.

Rice is the main foodgrain crop cultivated in the state of Telangana with 30 to 35 per cent share in the total cultivated land of the state. India got self-sufficiency in foodgrains production largely due to the contribution of green revolution in 1960s, primarily through increasing the production of rice and wheat. This achievement was brought out through the faster spread of modern varieties (MVs) and inputs intensification (Suresh, 2013). But the green revolution did not come without problems. The Indian agriculture has also suffered due to the negative impacts of the green revolution. The high yielding production technologies recommended during the period of green revolution created some serious problems like nutrient imbalances caused by huge application of nitrogenous fertilisers, depletion of soil micro-nutrients, over-exploitation of groundwater, degradation of land, more frequent emergence of pests and diseases, and diminishing returns to inputs (Chand *et al.,* 2011). It was felt that the potential of green revolution technologies has reached its limits and it was not able to sustain the future growth in Indian agriculture (Chand *et al.,* 2012). In this background the productivity growth of agriculture in the country is facing some serious concerns and raises the question whether the productivity slowdown is due to technology failure or policy fatigue (Narayanamoorthy, 2007). The debate is stretched to question the efficacy and contribution of research to the agricultural growth process (Chand *et al.,* 2012). Under this backdrop, it was important to estimate the Total Factor Productivity (TFP) growth of rice in Telangana state and determine the factors affecting the TFP growth.

MATERIAL AND METHODS

Estimation of total factor productivity for the state of Telangana was based on 13 years data (2000-01 to 2012-13). The entire state of Telangana was classified into three different sub-divisions each comprising of three districts. These three sub-divisions are as follows, Nforthern Telangana (Adilabad, Nizamabad and Karimnagar), Central Telangana (Medak, Rangareddy and Warangal) and Southern Telangana (Khammam, Mahaboobnagar and Nalgonda). The total value of output of rice was derived by summing up the values of main product and the by-product in Rupees. The gross value of the output was divided by the area under the rice crop to get the price of the product. The selected inputs of production for the present study were family human labour (in hours), paid human labour (in hours), animal labour (in hours), machine hours, seed (in Kg.), nitrogenous fertiliser (in Kgs.), phosphatic fertilises (in Kgs.), potassic fertiliser (in Kgs.), farm yard manure (FYM) (in quintals), insecticide and irrigation machine (in

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hours). The data was collected for the period of 2000-01 to 2012-13 from the published documents of Comprehensive Scheme on Cost of Cultivation of Principal Crops in India. The district, as well the state level data were compiled from the unit level data from Cost of Cultivation Scheme. The time series data from 2000-01 to 2012-13 on the variables like average rainfall in the state, crop wise irrigated area in the state and rural literacy rate (per cent) were collected from various statistical year books published by the Directorate of Economics and Statistics, Government of Telangana, Hyderabad. Data on the government expenditure on agricultural research, education and extension was collected from the office of the Accountants General, Government of Andhra Pradesh and Telangana.

The Divisia-Tornqvist Index or Translog Index was used in this study for computing the total output, total input, and TFP indices. The total output, total input and TFP indices have been calculated as under,

Total Output Index (TOI)

$$\frac{TOI_t}{TOI_{t-1}} = \Pi_j \left(\frac{Q_{jt}}{Q_{jt-1}}\right)^{\left(R_{jt}+R_{jt-1}\right)^{\frac{1}{2}}} = A_t \quad \text{.....1}$$

Or,

$$ln\left(\frac{TOI_t}{TOI_{t-1}}\right) - 1/2\sum_j \left(R_{jt}+R_{jt-1}\right) ln\left(\frac{Q_{jt}}{Q_{jt-1}}\right) \quad \text{.....2}$$

Total Input Index (TII)

$$\frac{TII_t}{TII_{t-1}} = \Pi_i \left(\frac{X_{it}}{X_{it-1}}\right)^{(S_{it}+S_{it-1})^{1/2}} = B_t \quad \text{.....3}$$

Or,

$$\ln\left(\frac{TII_t}{TII_{t-1}}\right) = 1/2\sum_i (S_{it}+S_{it-1}) ln\left(\frac{X_{it}}{X_{it-1}}\right) \quad \text{.....4}$$

Where,

R_{jt} is the share of j^{th} crop output in total revenue in year t,

Q_{jt} is the output of j^{th} crop in year t,

S_{it} is the share of input i^{th} the total input cost in year t, and

X_{it} is the quantity of input i in year t.

X_{IT} is the quantity of input i in year t.

Total Output Index (TOI) and Total Input Index (TII) for the year t computed from Equations (2) and (4) as follows:

$$TOI\ (t) = A_1\ A_2\ \ldots\ldots\ldots A_t \quad \text{.....5}$$

$$TII\ (t) = B_1\ B_2\ \ldots\ldots\ldots B_t \quad \text{.....6}$$

The Total Factor Productivity (TFP) index is given as

$$TFP_t = \{TOI\ (t) / TII\ (t)\}$$

$$=1/2\sum_j \left(R_{jt}+R_{jt-1}\right) ln\left(\frac{Q_{jt}}{Q_{jt-1}}\right) - 1/2\sum_i (S_{it}+S_{it-1}) ln\left(\frac{X_{it}}{X_{it-1}}\right) \quad \text{.....7}$$

For constructing TFP index, chain index is preferred to fixed base index (Coelli *et al.* 2005). Chain index combines annual changes in productivity to measure changes in productivity over a period of time. In other words, let I (t+1, t) be an index for the period t+1 with the base period t. This index is applied to time series t=0 to T. A comparison between period t and fixed base 0 is made by following chain indexing of successive periods.

I(0,t) = I(0,1) x I(1,2) x I(2, 3) x……x I(t -1, t) ……..8

Multiple regression analysis was carried out in order to detect the main factors that were influencing the Total Factor Productivity (TFP) growth in Telangana agriculture. For this purpose, the crop wise indices of TFP in Telangana state was regressed on various identified variables that affect the TFP growth. Natural logarithm of all the variables including the TFP were taken for the regression analysis except those variables represented as ratios and percentages. The basic model for this purpose is as follows,

$\ln (TFP_{crop})$ = f{ln(Government expenditure on agricultural research, education and extension per hectare of cultivated land), ln(Average rainfall in the state in millimetre), Percent irrigated area of the crop, Rural literacy in percentage}

After running the regression analysis, the tests of regression analysis were applied. The final selection of the variables to be included in the analysis was done based on no multicollinearity assumption, i.e., the variables having high multicollinearity problem were dropped from the model. Then the selected models were tested for the presence of heteroskedasticity and autocorrelation problems. All the analyses for this purpose were carried out in R software package.

RESULTS AND DISCUSSION

Tornqvist Total Factor Productivity Indices of Rice

The Tornqvist Total Output Index (TOI), Total Input Index (TII) and Total Factor Productivity Index (TFP) of rice in the state of Telangana were estimated for a period of 13 years from 2000-01 to 2012-13. These indices were transitive and relative to the first observation of the study. The results have been presented in (Table 1.) The three indices of TOI, TII and TFP for the state Telangana as well as the three regions were presented graphically in illustration 1. In the state, the values of TOI for the first four years were less than the values of TII, and thus the TFP indices in these years were less than hundred. TFP index was lowest in the 2002-03 (64.20) when TOI (45.5) was much less as compared to the TII (70.9). Since the year 2005-06 the TOI started to rise above the TII and thereby raising the TFP index above 100 and continued to grow over the period of time. The growth of TOI was much more than the TII in the state during these years and therefore resulted in higher level of Total Factor Productivity (TFP) index. The value of TFP index in the state was highest in the year 2012-13 with the value of 136.10. The average values of TOI. TII and TFP index over the years were 92.6, 87.5 and 104.2 respectively in Telangana. The Compound Annual Growth Rate (CAGR) of TOI, TII and TFP index in the state over the period of time were 5.0 per cent (significant at 1 per cent level), 1 per cent and 4.4 (significant at 1 per cent level) respectively. This implied that the growth of TOI in the state was much higher as compared to the growth of TII.

The region wise estimation of the indices revealed that Central Telangana had performed better than the other two regions of the state. The CAGR of TFP index in Northern Telangana was 5.40 per cent (significant at 1 per cent level). Average values of TOI, TII and TFP index were 98.80, 92.80 and 103.90 respectively over the period of time. The lowest estimate of TFP index in his region was observed in the year 2004-05 with TFP index value of 58.70 when the TOI reached its lowest level. After this year the TOI started growing faster than that of TII resulting in TFP index to be more than 100. The highest value of TFP index was observed in the year 2010-11 in Northern Telangana. The CAGR of TFP index over the period of time in Central Telangana was 3.00 per cent (Significant at 5 per cent level). The average values of TOI, TII and TFP index were 83.7, 81.4 and 101.6 respectively. The growth of TOI (3.30 per cent per annum) was much higher as compared to TII (0.30 per cent per annum). The lowest value of the TFP index in this region was observed in the year 2002-03 when the TOI was 44.90. The year 2010-11, witnessed the highest value of TFP index in Central Telangana. The performance of Southern Telangana was on par with the state level performance. The growth of TOI, TII and TFP index in Southern Telangana over the study period were 4.80 per cent (significant at 10 per cent level), 0.30 per cent and 4.40 per cent (significant at 1 per cent level) respectively. The average values of the indices were 92.90, 90.10 and 102.3 for TOI, TII and TFP Index respectively. In this region, the TOI reached its lowest value in the year 2002-03 (40.50) resulting in lowest TFP estimate in the same year. The highest value of the TOI was observed in the year 2010-11 but the TFP index in this region was recorded in the year 2012-13 (137.60) when the TII reached its lowest value of 64.50. The value of TII was higher than the TOI in this region up to the year 2006-07 resulting in the TFP Index to be lower than hundred, since then the growth of TOI was higher as compared to that of TII.

It is seen from the results that the TFP indices of rice were below 100 in the initial four years. This was mainly due to the deficiency in the average rainfall in the state in those years. The state observed severe drought situation in the years 2001-02, 2002-03 and 2004-05 when the TFP of rice was severely affected since it was revealed that average rainfall had significant positive impact on the TFP of rice in Telangana. The higher values of the TFP of rice were associated with the higher rainfall years of 2010-11 and 2012-13. Percentage irrigated area under rice was another major source of productivity gain of rice in the state since more than 95 per cent of the rice cultivated land was under irrigation Government investment in agricultural research and education was also found to be another major source of TFP growth in Telangana. The introduction of rice variety BPT 5204 (Sambamahsuri) significantly helped in productivity gain of rice.

Table 1. Tornqvist Total Factor Productivity Indices of Rice in Telangana (Indices Relative to First Observation) from 1979-80 to 2012-13

Year	Northern Telangana			Central Telangana			Southern Telangana			Telangana State		
	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP
2000-01	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2001-02	86.1	94.0	91.6	80.7	77.0	104.8	75.9	80.7	94.1	80.7	83.5	96.7
2002-03	51.6	79.6	64.9	44.9	66.7	67.4	40.5	66.3	61.1	45.5	70.9	64.2
2003-04	70.0	86.7	80.7	71.6	82.9	86.4	57.8	71.3	81.1	65.6	79.5	82.5
2004-05	27.8	47.3	58.7	49.3	64.4	76.5	70.4	81.7	86.2	50.0	66.2	75.6
2005-06	104.4	103.5	100.9	88.7	77.3	114.6	103.4	110.2	93.8	100.0	99.1	100.9
2006-07	115.2	131.0	88.0	83.5	98.9	84.4	87.9	105.7	83.1	96.3	95.3	101.2
2007-08	100.8	94.5	106.6	80.9	77.9	103.9	113.3	109.2	103.8	100.6	96.1	104.7
2008-09	132.5	106.2	124.7	100.4	83.8	119.9	125.1	104.1	120.2	121.4	99.5	122.0
2009-10	64.6	56.6	114.0	56.6	55.6	101.7	93.9	79.8	117.8	74.0	65.7	112.7
2010-11	158.1	111.9	141.2	133.2	105.7	126.0	148.6	113.4	131.0	148.0	111.7	132.5
2011-12	147.8	105.6	140.0	95.6	85.2	112.2	102.3	85.1	120.3	116.5	92.9	125.4
2012-13	125.8	90.0	139.8	102.3	83.0	123.3	88.7	64.5	137.6	105.2	77.3	136.1
Average	98.8	92.8	103.9	83.7	81.4	101.6	92.9	90.1	102.3	92.6	87.5	104.2
CAGR (%)	6.00***	1.00	5.40*	3.30	0.30	3.00**	4.8***	0.30	4.40*	5.0**	1.0	4.4*

TOI= Total output index

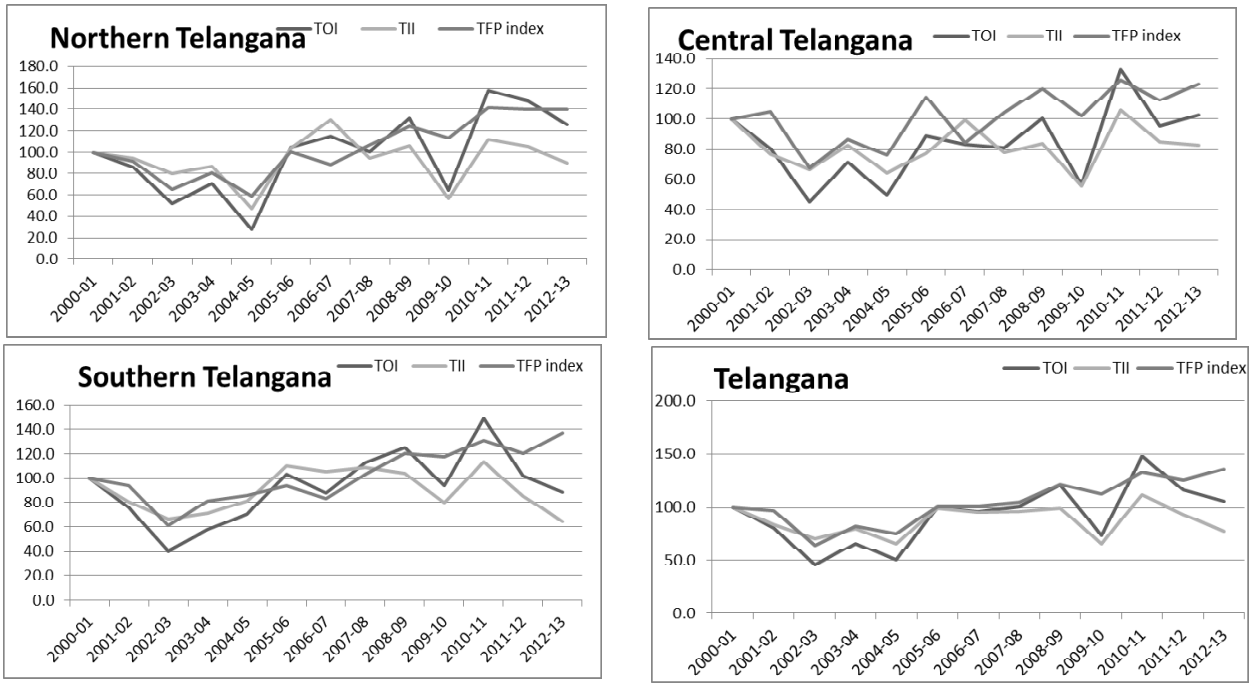
TII= Total input index

TFP= Total factor productivity

AAGR= Average annual growth rate

* 1%, ** 5% and *** 10% level of significance

Illustration 1. Tornqvist Total Factor Productivity Indices of Rice in Telangana (indices are transitive and relative to first observation)



Determinants of TFP of rice in Telangana state from 2000-01 to 2012-13

The natural logarithm of Total Factor Productivity (TFP) Index of rice in Telangana state was regressed with the above mentioned variables. After testing for the multicollinearity, heteroskedasticity and autocorrelation the variables Government expenditure on Agricultural research, education and extension per ha, average rainfall in mm, percentage of irrigated rice area, and rural literacy percentage were identified as the factors influencing the total factor productivity of rice in Telangana state. The results of the regression analysis are presented in the (Table 2.) The 72.0 per cent variation in the TFP index of rice in Telangana was explained by the chosen independent variables in the model. The value of the Durbin-Watson (D-W) statistics was 2.529 which was not significant implying that there was no autocorrelation among the residuals in the regression analysis.

The results revealed that the coefficient of average rainfall in the state was 0.792 (significant at 5 per cent level) implying every 1 per cent increase in rainfall increased the TFP of rice by 0.792 per cent in Telangana state. Other variables also influenced the TFP positively but were not significant. This indicated that the productivity of rice had reached a stagnation which could not be increased significantly by the variables except average rainfall. Since rainfall is beyond our control, its positive influence on the productivity cannot be taken for granted. In order to capitalise the positive impact of the rainfall, appropriate steps should be taken to harvest the surplus rain water and use the same during deficit rain. Further, providing irrigation facilities will boost up the total factor productivity. In order to overcome the stagnation of the productivity of rice the government investment also needs to be enhanced.

Table 2. Determinants of TFP of Rice in Telangana State (2000-01 to 2012-13)

Variable	Regression coefficient	Standard error	t- ratio	p-value
Constant	-2.86	3.705	-0.773	0.4617
Government expenditure on agricultural research, education and extension (per Ha)	0.076	0.110	0.685	0.5128
Average rainfall (mm)	0.792**	0.254	3.116	0.0143
Percentage irrigated area	0.005	0.045	0.104	0.92
Rural literacy (%)	0.026	0.017	1.526	0.166
R^2	0.72**			
D-W statistics	2.529			

Dependant variable: TFP Index of rice in Telangana state (expressed in natural logarithm)All the variables are expressed in natural logarithms expect those calculated as percentages

** Significant at 5% level

The average values of Tornqvist TFP index in Telangana for the study period was 104.2 indicating 4.20 per cent improvement over the base year. The average values of TOI and TII were 92.60 and 87.50 in Telangana. The CAGR of TFP index, TOI and TII were 4.4 per cent, 5.0 per cent and 1.0 per cent respectively. The highest average value of TFP index was noted in Northern Telangana region (103.9) among all the regions. In Northern Telangana, the CAGR of TFP index was 5.4 per cent, highest among the regions. The TFP index of rice in Telangana state remained over 100 for most of the years indicating improvement in the performance of the crop. The regression analysis revealed that the main determinants of TFP of rice in Telangana were government expenditure on agricultural research, education and extension (per Ha), average rainfall (mm), percentage irrigated area, rural literacy (per cent). Average rainfall was found to affect the TFP significantly with regression coefficient 0.792 (significant at 5 per cent level). Based on the findings of the study, it can be suggested that the state can plan massive investment in the field of agricultural research, education and extension. The creation of water harvesting technologies and better storage of excess rain water during the good rainfall years need to be promoted.

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FARMERS PERCEPTIONS ON RICE MECHANIZATION IN THE KOLE LANDS OF THRISSUR DISTRICT, KERALA, INDIA

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ABSTRACT

The *Kole* lands of Kerala are unique agro ecosystems where rice cultivation is taken up for food security as well as ecosystem sustainability. Mechanization in the rice fields of Kole lands has been a successful step to solve the problem of labor shortage, high wages and drudgery while using the resources efficiently. The present study was conducted to understand the perception of the *Kole* farmers of Puzhakkal and Mullassery block panchayats of Thrissur district on the different implications of rice mechanization. While expressing the need for mechanization highlighting its advantages, the farmers also reported the constraints that demand urgent addressal, which included setting up of an effective system to ensure the availability of agro machinery in a timely manner and at affordable rents, facilities for agro machinery servicing as well as more number of skill-oriented training in the farm mechanization sector.

Labor shortage is one of the major problem faced by the agrarian economy of Kerala. The seasonal shortage of labor due to the migration of the work force from agriculture to non-agriculture occupations has serious implications on the paddy cultivation of the state. The human labor employment in paddy farming is exhibiting a steady decline over the years. According to the various report of Economic Review, Government of Kerala, there were 19.2 lakh farm workers in the year 1981.During the decade from 1991 to 2001, this number dropped to 10.2 lakh. However, the recent census estimate (2011) has shown a slight improvement in the number to 16.5 lakh. This decline has been to the tune of 1.63 per cent per annum in the autumn season, 1.92 per cent in winter and 1.98 per cent in summer. On an average, the decline rate was 1.84 per cent per annum. The rate of decline was highest in the summer season when the use level was highest. Overall, the rate of decline in human labor employment from 1980-2013 is - 2.30 per cent per annum (Devi, 2012). This shrinking labor supply calls for labor substitution with technologies like agricultural mechanization, which is being adopted by the rice cultivators of Kerala. In this context, the study tried to analyze the perceptions of rice farmers regarding mechanization in the *Kole* lands, while identifying the constraints faced by them in this regard.

The *Kole* lands of Thrissur and Malappuram districts of Kerala, which cover an area of 13,632 ha, are unique wetland agro ecosystems, internationally recognized under Ramsar sites. They are below Mean Sea Level and remain flooded for nearly half of the year. The main crop of this area is paddy and the single crop a year gives a bumper yield, which in the local language is termed as 'The *Kole*'. Though mechanization started in the *Kole* lands from 1960s, it was intensified in the past decades due to the acute labor shortage and increased wages prevalent in the state. Farm mechanization is identified as the only solution that helps to increase the production and productivity while optimizing the human resource quality in the *Kole* lands.

MATERIAL AND METHODS

The study was conducted in the *Kole* wetlands of Thrissur district. The *Kole* lands of Thrissur come under eight blocks panchayats. Out of these Puzhakkal and Mullassery blocks were randomly selected for sample selection. Ninety rice farmers were randomly selected from these two blocks. Focussed group discussions and structured, open-ended questionnaires were used to collect data.

The questionnaires included basic details of the rice area possessed by the farmers, comparison between mechanized and minimally mechanized rice farming, and statements regarding perceptions of farmers on mechanization in the *Kole* lands. The 15 statements regarding social, economic and environmental impacts, and skill, gender and resource utilization in rice mechanization were selected after relevancy rating by four experts in the field. The

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respondents were asked to either agree or disagree to the statements; an option for 'don't know' was also given.

The basic details and comparisons are represented using percentage and range mode. Percentage analysis was used to interpret the agreement of the farmers to the statements.

RESULTS AND DISCUSSION

Basic details of the respondents

Traditionally rice has been cultivated using family labor which involved contribution by both men and women of the family, though the ownership of the rice fields were generally entrusted to the male members. The women's role in the rice farming as cultivators has been usually ignored and is reduced to just laborers. Here, out of the 90 respondents, 83 were male farmers. The female farmers reported that they found it difficult to carry on the rice farming due to personal, social and economic reasons. All farmers had an experience of more than 20 years in rice farming. All of them owned the land used for the rice cultivation.

Table 1. Operational area under rice farming

No	Area of rice field (ha) possessed	Percentage(%) of farmers
1	0.2 – 0.4	45.56
2	0.4-0.81	31.11
3	0.81-1.62	23.33

The area of rice fields of the individual farmers ranged from 0.2 ha to 1.62 ha. All of them have been depending on animal and human labor for rice production until they started adopting intensive mechanization procedures ten to fifteen years back.

(Table 2) shows the comparative analysis of conventional and current rice farming systems in the study area. It compared the old system with limited mechanization (using only tractor for land preparation) and the present system where agro machineries are used from land preparation to harvesting.

Table 2. Comparison of labor use in conventional and current rice farming (man days per ha)

Particulars	Conventional	Current
Laborers required (Number/ha)	50 -65	30-40
Cost of production (Rupees/ha)	62500-70000	40000-45000
Productivity (Tonnes/ha)	5.0-8.75	11.0-15.0

(Source: Primary data)

Labor input is considered necessary for dewatering the fields, using *Petti and Para* system (the indigenous system for drainage), and making bunds. The scarcity in supply of skilled labour and resultant high wages are reported as the major reason for the shift to use of machines. Mechanization helped them to save a considerable amount of money and time, along with the increased yield and profit.

According to the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, the human labor hours per hectare of rice reduced from 1200 (1988-89) to 800 (2009-2010). On

the same hand, the animal labor hours per hectare of rice reduced from 160 to 20 for the same time period. The sharp declining trends in animal and human labor indicate the fast growing mechanization of rice cultivation.

Similar is the case with the female labor. Female labor is a crucial part of the rice cultivation especially for transplanting, weeding and harvesting. Increasing mechanization of female labor intense operations has led to the declining share of female labor in rice cultivation. According to State Agriculture University, Andhra Pradesh, female labor hours per hectare of rice declined from 600 to 400 from 2005 to 2011.

The most important problems faced by the *Kole* farmers with respect to rice mechanization are the unavailability of agro machineries in time, the increased rent of the machineries and absence of service facilities, and skilled work force for the specific farm machineries.

The *Kole* farmers' perceptions about the multidimensional implications of rice mechanization are given as below.

Social, economic and environmental impacts

The perceptions of farmers on social, economic and environmental impacts of agriculture mechanization are shown in (Table 3). All the farmers unanimously agreed that efficient mechanization in rice cultivation reduced the cost of production, solved the problem of labor shortage, and there by increased the profit, through saving time and money.This supports the finding of Department of Agriculture, Philippines (2014) that with the right interventions on farm mechanization in rice, the production and labor costs could be lessened. Kamboj *et al.* (2013) has conducted a large number of on-farm trials at farmers' fields in Haryana, India, from 2006 to 2010 to evaluate the performance of the mechanical transplanted rice (MTR) and conventional puddled transplant rice (CPTR). They have found that mechanical transplantation helped in reducing labor requirement and ultimately, overall profits to farmers were increased. Further, all farmers reported that mechanization improved the yield by reducing loss and the value of crop by providing quality grains. This is in tune with Chi (2010) study results that harvesters and dryers are labor and time-saving technologies, reducing rice loss and increasing rice quality.

Table 3. Perceptions of farmers on social, economic and environmental impacts

S.No	Statement	% of farmers agreed	% of farmers disagreed	% of farmers who responded 'don't know'
1.	Mechanization reduced the cost of production.	100		
2.	Mechanization solved the problem of labour shortage.	100		
3.	Mechanization increased the profit.	100		
4.	Mechanization saved time and money.	100		
5.	Mechanization improved the quality of the crop.	100		
6.	The reduction in the use of draught animals showed agricultural development.	86	14	
7.	Use of draught animals increased the cost of production	100		
8.	Draught animals are unsuitable for vast areas.	100		
9.	Extensive mechanization causes environmental pollution.			100
10.	Mechanization can attract more people to rice farming.	90	10	
11.	Agriculture mechanization industry created off-farm employment opportunities.	74	5	21
12.	Mechanization improved the cooperation among the rice farmers.	100		

A few decades ago, it was the human laborers and draught animals which did all the farming operations in rice fields. Whereas considering the present agricultural scenario of the state, every farmer opined that draught animals increased the cost of production and were unsuitable for the vast area under rice in the *Kole* lands. But only 86 per cent of the farmers believed that reduction in the use of draught animals showed agricultural development. The rest of the farmers were stressing on the soil enrichment provided by the cattle manure, the ability of draught animals to support the small rice holdings and their suitability when the fuel prices go up or when the agro machineries become unavailable. The planning Commission (2013) had reminded that the shift from animal to mechanical power has also indirectly affected soil health. The difficulty in adopting mechanization in the small and fragmented farm holdings were highlighted by Mehta *et al.* (2014). Discuss the small and marginal farmers problems to adopt for mechanization in rice cultivation.

Japan Association for International Collaboration of Agriculture and Forestry (2014) recommended development of small sized agricultural machineries, implements and tools affordable to the farmers of small land holdings. Many farm machineries and implements for small scale holdings of rice are already generated by Kelappaji College of Agricultural Engineering and Technology (KCAET) of Kerala Agricultural University (KAU).

Environment pollution, particularly air and noise pollution, caused by the agro machineries were mentioned by Aneja *et al.* (2008). Apart from that, Punjab State Council for Science & Technology (2015) reminded of the increased soil compaction and resultant resistance to plant root and seedlings penetration. Burning of the stubbles produced by the agro machineries raised the soil temperature which negatively affected the equilibrium of Carbon: Nitrogen ratio and, the bacterial and fungal population. Excessive use of agro machineries leading to rapid changes in the physico–chemical characteristics of soils were reported by Singh (2011). Surprisingly, the responses of the farmers showed that none of them were aware of any environmental implications of extensive mechanization in rice.

Ninety percent of the *Kole* farmers believed that mechanization would attract more people to rice farming. Department of Agriculture, Philippine Center for Postharvest Development and Mechanization (PhilMech) (2014) reported that they are already on the way to attract younger generation into rice and corn farming by achieving the farm mechanization threshold of 3.0 hp ha^{-1} by 2016. *Mada and Mahai* (2013) had identified that agriculture mechanization industry created off-farm employment opportunities and improved socio economic status of rural farmers along with increased productivity and profit. However, only 74 per cent of farmers agreed with that. Twenty one percent of respondents were unaware to make a response on it, whereas, five percent of farmers feared of the labor displacement due to agricultural mechanization.

The *Kole* land rice fields come under institutional arrangements called as *Padasekhara Samithis* which are actually local rice farmer associations that take leadership to carry out the farming operations. All farmers agreed that mechanization improved the co-operation among the rice farmers.

Skill, gender and resource utilization in rice mechanization

The perceptions of farmers on skill, gender and resource utilization in rice mechanization is presented in (Table 4.) All farmers had the clear understanding about mechanization demands skilled laborers. The lack of skilled laborers led to the dumping of costly agro machineries as useless which later got rusted out. This calls for more number of training sessions that would create skilled personnel to handle the farm machineries.

Table 4. Perceptions on skill, gender and resource utilization in rice mechanization.

No.	Statements	% of farmers agreed	% of farmers disagreed	% of farmers who didn't know
1.	Mechanization required skilled labourers.	100		
2.	Mechanization can be handled only by male labourers.	84	16	
3.	Mechanization helped in optimum use of resources.	100		

The gender discrimination in the labor market included differential wages and restriction of females to low paid, unskilled works (Devi, 2012). As a reflection of this view, 84 per cent of farmers believed that only male laborers possessed necessary skills to use agro machineries in rice fields of the *Kole* lands, especially the combined harvester. The rest told that the gender of the workers didn't matter as far as they are skilled. They also pointed out that, trained female workers were as good as male laborers and could use mini rice reapers / harvesters. This gender disparity in paddy farming is slowly disappearing owing to institutional and social factors. Currently, female wage rate is 72 per cent (2013-14) of their counterparts (Devi, 2012). At this point, it is worthy to remember about the green army training given to the rural women on farm mechanization by the Agricultural Research Station, Mannuthy, and the gender friendly farm machineries devised by Krishi Vigyan Kendra (KVK), Malappuram of Kerala Agricultural University (KAU). Meanwhile, the skilled women under *Mahila Kisan Sashaktikaran Pariyojana* (MKSP), a sub component of the National Livelihood Rural Mission (NRLM), are getting ready to take up mechanized rice cultivation in 5000 acres of the *Kole* lands in Malappuram district by August 2015.

According to the respondents, rice mechanization helped in optimum use of resources. Suleiman and Ibrahim (2014) had analyzed the economic efficiency of resources used in rice production among mechanized and non mechanized farmers. They have found that mechanized rice farms used inputs like labor, land and seed, close to economic optimum than the non mechanized farms. Hence the mechanized rice production was judged more efficient in resource utilization and subsequently more profitable than the non-mechanized rice production.

It is well comprehensible that rice mechanization is essential with the increasing trend of non availability of skilled laborers, high wage rates and increased cost of production of conventional farming methods. Apart from reducing the drudgery in farming operations, mechanization helps in effective utilization of inputs leading to increased productivity and profit of farming community. The study suggested that effective mechanization in the *Kole* lands would help to remove uncertainties in the rice production situation of this agro ecosystem. This study exposed the perceptions of the *Kole* farmers on the impacts of rice mechanization on different levels viz., social, economical, environmental, and those related to gender, skill and resource utilization. All farmers had expressed positive perceptions on rice mechanization, though they strongly suggested having a system that would ensure timely availability of agro machineries at reasonable rents, facilities for repair cum servicing and, training to create more skilled personnel to use farm machineries.

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ASSESSMENT OF NUTRIENT COMPOSITION IN SHEANUT CAKE A AGRO-INDUTRIAL BY-PRODUCT FOR LIVESTOCK FEEDING

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ABSTRACT

Three representative samples of Shea nut cake were collected M/s. Foods, Fats and Fertilizers Pvt. Ltd which is Multi National Company located in West Godavari District A.P for analysis.Analysed for proximate and cell wall constituents. Further, analyzed for mineral profile. It contains 92.42 % Organic matter, 93.26 % dry matter, 13.19% crude protein, 9.84% crude fibre, 2.43% ether extract, and 7.58% total ash content. The mineral content of shea nut cake analyzed and found that it contains calcium (Ca) 0.69, phosphorus (P) 0.34, magnesium (Mg) 0.16, sodium (Na) 0.19, potassium (K) 0.02, (% on dry matter basis) Copper (Cu) 4.39, Zinc (Zn) 37.30, Iron (Fe) 1062.00, Manganese (Mn) 28.87, Cobalt (Co) 3.85, Chromium (Cr) 11.30 (ppm). The findings of this research highlight the potential uses of he Shea Nut Cake as one of the agro-industrial by-product and it can used as feed ingredient for the feeding of livestock after proper screening for Anti nutritional factors.

Sheanut cake is the residue that remains after the extraction of shea butter from the nut. It is estimated that about 500,000 tons of shea nut cake is produced annually by the shea industry in the savanna zones of Ghana (Okai *et al.*,1989). It is estimated that for every metric tonne nuts processed, 450–600 kg of shea nut cake is produced and about 60,000 metric tonnes of shea kernels are consumed locally in a year (Ofosu 2009). Thus, about 30,300,000 kg sheanut cake is generated locally in a year in Ghana. Meanwhile the industry has been projected to equalize the cocoa industry in future as shea butter gradually becomes the best substitute for the cocoa butter industries (Ofosu 1997 and Moore 2008). Unfortunately, the sheanut cake which is produced abundantly in Northern Ghana as a by-product is currently being disposed of or being used marginally as fuel Sheanut is a deciduous, small to medium-sized tree up to 15-25 m tall. Leaves are caducous and arranged spirally, mostly in dense clusters at the tips of branches. Fruit is a 1 or 2-seeded ellipsoid berry (4-8 cm), weight 10-50 g, initially green but turning yellowish green or brown on maturity.Sheanut fruits are a source of energy during the dry season. The large fleshy seeds yield about 45% edible lardlike fat, the sheanut butter, used for food and cosmetics. A by-product of the butter extraction is sheanut cake or meal, which can be used as feedstuff.

MATERIAL AND METHODS

The production of Sheanut cake is approximately 18,000 tons per year from M/s. Foods, Fats and Fertilizers Pvt. Ltd which is Multi National Company located in West Godavari District A.P. It is the only industry that is importing Sheanut cake in Andhra Pradesh. On enquiry it is found that, it is not possible to determine the seasonal and

varietal differences in their nutrient composition, as the collection of Sheanut seeds is done in African countries and supplied to India.

The Sheanut cake collected is subjected to the chemical analysis for its nutrient composition viz., proximate principles, cell wall constituents, mineral composition and amino acid composition The Sheanut cake samples was evaluated for proximate constituents (moisture, crude protein, crude fibre, ether extract, ash, nitrogen free extract) as per the AOAC (1997). The fibre fractions (Neutral detergent fibre, Acid detergent fibre, Lignin, Cellulose, Hemicellulose, silica) in the Sheanut cake were estimated by the analytical procedure of Van Soest *et.al.* (1991).

The calcium and phosphorus was estimated by methods described by Talapatra *et.al.* (1940) and Fiske and Subbarao (1925). The Sheanut cake samples were processed and digested with double acid (one part 70% perchloric acid and three parts with conc. HNO_3 acid) for mineral analysis. The Cu,

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Fe, Zn, Co, K, Mg, Ni, were analyzed by Atomic Absorption Spectrophotometer (Varian).

RESULTS AND DISCUSSION

The chemical composition of Sheanut cake is presented in Table 1. 92.42±3.24 % Organic matter, 93.26± 2.84 % dry matter, 13.19±0.56% crude protein, 9.84± 0.89% crude fibre, 2.43± 0.08% ether extract, and 7.58± 0.67% total ash content.

Table 1. Chemical composition of experimental feed ingredients (% DM basis)

Proximate Constituent	**Percentage Shea nut cake**
Moisture	6.74 ± 0.34
Dry matter	93.26 ± 2.84
Organic matter	92.42 ±3.24
Crude protein	13.19 ±0.56
Crude fibre	9.84 ± 0.89
Ether extract	2.43 ± 0.08
Nitrogen free extract	66.96 ±8.98
Total ash	7.58 ± 0.67
Acid insoluble ash	2.03 ± 0.09
Cell wall constituents	**Percentage**
NDF	60.27 ±2.87
ADF	33.96 ±1.09
ADL	1.99 ±0.08
Hemi cellulose	26.31 ±1.23
Cellulose	28.29 ±1.08
Silica	1.68 ±0.06

Above values were mean average of 3 observations

Mineral composition of Sheanut cake

The mineral content of shea nut cake analysed and found that it contains calcium (Ca) 0.69, phosphorus (P) 0.34, magnesium (Mg) 0.16, sodium (Na) 0.19, potassium (K) 0.02, (% on dry matter basis) Copper (Cu) 4.39, Zinc (Zn) 37.30, Iron (Fe) 1062.00, Manganese (Mn) 28.87, Cobalt (Co) 3.85, Chromium (Cr) 11.30 (ppm).

Table 2. Mineral composition of Sheanut cake

Sl.No	Element	Content
	Major elements	**% on DM basis**
1	Calcium (Ca)	0.69±0.01
2	Phosphorus (P)	0.34±0.02
3	Magnesium (Mg)	0.16±0.01
4	Sodium (Na)	0.19±0.02
5	Potassium (K)	0.02±0.00
	Trace elements	**Ppm**
6	Copper (Cu)	4.39±0.12
7	Zinc (Zn)	37.30±1.02
8	Iron (Fe)	1062.00±32.84
9	Manganese (Mn)	28.87±2.76
10	Cobalt (Co)	3.85±0.12
11	Chromium (Cr)	11.30±0.18

Above values were mean average of 3 observations

This research investigated the proximate and mineral compositions and phytochemical constituents to fill the academic and economic gaps created by inadequate research into the shea nut cake. This could offer scientific support for the use of the cake as feedstuff in the poultry and animal industries as well as in the fertilizer industries. The proximate composition of the shea nut cake is comparable to works of other researchers. Differences in fat content of shea cake across the industries do not agree with findings by Pousga *et al*., 2007 who found fat content to vary across two climatic zones of Burkina Faso. The present findings of crude fat levels (2.43%) were higher than 5.3%–9.6% recorded. The differences in fat levels could be attributed to the differences in approach (the pre-treatment, the care and attention at every stage of the process) of oil extraction and the level of efficiencies reached. This was also likely indicative of the differences in fat levels of the shea trees due to their genetic disparities or probably due to their different geographical and ecological zones.

Ugese *et al*., 2010 also reported similar low figures (2.8%–4.0%) of crude fat levels for shea nut cake. The crude protein (13.19±0.56) from our study of the shea cake was different from what was reported by Pousga Pousga *et al*., 2007 (2.5–10.3%) and Ugese *et al*., 2010 (7.6–10.1%). The fibre content 9.84± 0.89 of Shea nut cake as reported in the present study (Table 1) appeared to be within the range (7.8–11.0%) to what was reported by Pousga *et al*.,2007 but was lower than values (9.9–19.3%) recorded by Ugese *et al*.,2010

The mineral content of the shea cake is promising and presented in (Table 2.) These are all useful minerals for supporting the life of plants in the agricultural sector. In addition to other qualities, the heavy metal load of the cake was fairly reasonable for use in compost development for agricultural purposes. William (2000) reported that the recommended metal limits for heavy metal use of compost is 75, 50 and 0.5 mg/kg for lead (Pb), copper (Cu) and mercury (Hg) respectively. This present study found 4.39±0.12, 37.30±1.02, 1062.00±32.84 28.87±2.76, 3.85±0.12 and 11.30±0.18 ppm/kg for Cu, Zn, Fe, Mn, Co and Cr respectively (Table 2).The major minerals analyzed in Shea nut cake was 0.69±0.01% Ca, 0.34±0.02% P, 0.16±0.01% Mg, 0.19±0.02% Na

and 0.02±0.00% K. Sodium is known to facilitate and maintain the fluid balance of the body and promotes the normal functioning of the body nerves and muscles (Mohammad, 2009).

The sodium content found in this present study is higher than what (0.05 mg kg^{-1}) was reported by Pousga et al.,2007 for shea nut cake. Among other by-products, the sodium content of shea nut cake compares well with that of cotton seed cake (0.35 mg kg^{-1}) but higher than that of sorghum beer residue (0.06 mg kg^{-1}).The potassium content in shea nut cake across the industries was generally high and comparatively higher (4.05 mg kg^{-1}) than the mean value (0.54 mg kg^{-1}) determined.. The present findings also indicate that shea nut cake has higher potassium content than cotton seed (1.8 mg kg^{-1}) and sorghum beer residue (0.11 mg kg^{-1}). Potassium plays a significant role in protein synthesis in addition to its involvement in the functioning of cell organelles Muhammad 2009 and it is also noted for the life supporting role it plays for plants. Magnesium is generally required for healthy bones and muscles and the functioning of many enzymes in living systems (Holistic 2009).

The present study reveals that shea nut cake has high magnesium content (1.43 ± 0.65 mg kg^{-1}) as compared to (0.15 mg kg^{-1}) observed by Pousga et al., 2007. The calcium and phosphorus contents of shea nut cake according to the findings of the present research (0.51 mg kg^{-1} and 0.22 mg kg^{-1} respectively) are concordant with the findings of Pousga *et al.*, 2007. Whereas the calcium content was comparatively high compared to values for both cotton seed cake (0.34 mg kg^{-1}) and sorghum beer residue (0.14 mg kg^{-1}), phosphorus in the shea nut cake was lower than cotton seed cake (1.3 mg kg^{-1}) and sorghum beer residue (0.25 mg kg^{-1}). The high nitrogen (2.96 mg kg^{-1}), potassium (4.05 mg kg^{-1}) and magnesium (1.43 mg kg^{-1}) contents make shea nut cake ideal for use as manure and for fertilizer production.

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ESTIMATION OF AMINO ACID PROFILE IN SHEANUT CAKE BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

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ABSTRACT

Three modes of samples of Shea nut cake were collected M/s. Foods, Fats and Fertilizers Pvt. Ltd which is Multi National Company located in West Godavari District A.P for analysis. The amino acid values of Sheanut cake on the per cent DM basis, per cent CP basis and on fresh basis are Amino acid values on DM, CP and fresh basis (%) for Methionine 0.27, 1.80 and 0.28; Cystine 0.20, 0.37 and 0.21; Methionine + cystine 0.47, 3.17 and 0.48; Lysine 0.48,3.24 and 0.48; Threonine 0.50,3.37 and 0.52; Arginine 1.49, 10.10 and 1.54; Isoleucine 0.61,4.15 and 0.63; Leucine 1.03,7.03 and 1.07; Valine 0,78, 5.27 and 0.80; Histidine 0.40, 2.71 and 0.41; Phenylalanine 0.47,3.20 and 0.49; Glycine 0.64,4.34 and 0.66; Serine 0.54, 3.65 and 0.56; Proline 0.71, 4.82 and 0.74; Alanine 0.72, 4.87 and 0.74, Asparatic acid 1.41, 9.58 and 1.46; Glutamic acid 2.14, 14.50 and 2.22, respectively. The findings of this research highlight the protein values and potential uses of the Shea Nut Cake as one of the agro-industrial by-product and it can used as feed ingredient for the feeding of livestock after proper screening for Anti nutritional factors.

Shea nut cake is the residue that remains after the extraction of shea butter from the nut. It is estimated that about 500,000 tons of shea nut cake is produced annually by the shea industry in the savanna zones of Ghana Okai *et al.,* (1989). It is estimated that for every metric tonne nuts processed, 450–600 kg of shea nut cake is produced and about 60,000 metric tonnes of shea kernels are consumed locally in a year Ofusu *et al.,* (2009). Thus, about 30,300,000 kg shea nut cake is generated locally in a year in Ghana. Meanwhile the industry has been projected to equalize the cocoa industry in future as shea butter gradually becomes the best substitute for the cocoa butter industries Moore S (2008) and De Muelenaere (1997). Shea nut fruits are a source of energy during the dry season. The large fleshy seeds yield about 45% edible lardlike fat, the shea nut butter, used for food and cosmetics. A by-product of the butter extraction is shea nut cake or meal, which can be used as feedstuff. The green fruit of Shea (*Butryospermum parkii*) tree has a pulp that covers the seed or nut.

The harvest follows 3 to 5 years cycle and yields 80 kg of nuts and from these nuts, oil will be extracted and leaving the residue Abidemi et al., (2009) and Kumar et al., (2010). Sheanut meal is now receiving increased attention as a potential feed ingredient due to the increased amounts that are available as a result of high demand for shea fat for cosmetics and as a cocoa butter substitute in chocolate Lipp and Anklam, (1998). The protein component potential of sheanut products has not yet been fully explored. The present amino acid analysis study was therefore undertaken to analyze the amino acid content in the sheanut cake expeller and solvent extractions for their suitability source of as poultry and animal feed.

MATERIAL AND METHODS

Three modes of samples of Shea nut cake were collected M/s. Foods, Fats and Fertilizers Pvt. Ltd which is Multi National Company located in West Godavari District A.P for analysis.

The amino acid composition in the Sheanut cake was estimated by using the High Performance Liquid Chromatography (HPLC).

The Sheanut cake sample was first hydrolyzed by heating in 6N HCL and then amino acids are derivatized by using solution methanol, water, triethylamine, phenyl isothiocyanate in the ratio of 7:1:1:1 and the derivatized sample was added to phosphate buffer and acetonitrile buffer and vortexed.

The obtained sample was analyzed using the HPLC (Varian), containing the column Pico-Tago column and UV detector set at 257nm. Amino acids content were provided by the standard method described by VDLUFA IV ed. Naumann and Bassler (1997).

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RESULTS AND DISCUSSION

The amino acid values of Sheanut cake on the per cent DM basis, per cent CP basis and on fresh basis are presented in the (Table 1.) Amino acid values on DM, CP and fresh basis (%) for Methionine 0.27, 1.80 and 0.28; Cystine 0.20, 0.37 and 0.21; Methionine + cystine 0.47, 3.17 and 0.48; Lysine 0.48,3.24 and 0.48; Threonine 0.50,3.37 and 0.52; Arginine 1.49, 10.10 and 1.54; Isoleucine 0.61,4.15 and 0.63; Leucine 1.03,7.03 and 1.07; Valine 0,78, 5.27 and 0.80; Histidine 0.40, 2.71 and 0.41; Phenylalanine 0.47,3.20 and 0.49; Glycine 0.64,4.34 and 0.66; Serine 0.54, 3.65 and 0.56; Proline 0.71, 4.82 and 0.74; Alanine 0.72, 4.87 and 0.74, Asparatic acid 1.41, 9.58 and 1.46; Glutamic acid 2.14, 14.50 and 2.22, respectively.

The levels of other amino acids of non-conventional and local feed resources in Sudan. Methionine and lysine for poultry concentrates which increase the feeding cost of the sesame cake were higher than those reported by the poultry Agunbiadi *et al*. (2010) concluded that NRC (1994) by 5% and 17%, respectively. The shea nut cake amino acids Methionine (0.27%) and Lysine (0.48%) composition is comparable with Ground nut cake(GNC),Sesame cake, Sunflower cake, Cotton seed cake, Baobab seed cake, Moringa shows that the methionine and lysine were relatively low for baobab seed cake and Moringa seeds 0.49,1.82;1.29,1.09;0.63,1.07;0.38,1.10;0.19,0.66 and 0.55,0.60 per cent respectively. Babikar (2012).

Table 1. Amino acid composition of Sheanut cake

Amino acid	AA Content (%) on DM	AA (%) in CP	AA Content (% basis)
Methionine	0.27	1.80	0.28
Cystine	0.20	0.37	0.21
Methionine + Cystine	0.47	3.17	0.48
Lysine	0.48	3.24	0.50
Threonine	0.50	3.37	0.52
Arginine	1.49	10.10	1.54
Isoleucine	0.61	4.15	0.63
Leucine	1.03	7.03	1.07
Valine	0.78	5.27	0.80
Histidine	0.40	2.71	0.41
Phenylalanine	0.47	3.20	0.49
Glycine	0.64	4.34	0.66
Serine	0.54	3.65	0.56
Proline	0.71	4.82	0.74
Alanine	0.72	4.87	0.74
Aspartic acid	1.41	9.58	1.46
Glutamic acid	2.14	14.50	2.22

The real prospects for effective utilization of non-conventional feed resources are associated with their nutritive value and the cost of collection, detoxification and processing that increase their benefits. The current study revealed that the amino acid contents of shea nut cake as non-conventional feed resources. So, research is needed to determine the effect of these tested feeds as protein source in poultry and livestock diets in India.

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INVESTMENT VIABILITY OF COLD STORAGE INFRASTRUCTURE FOR AGRICULTURAL PRODUCE IN TELANGANA STATE

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The eradication of poverty and hunger is the most important of the United Nations' Millennium Development Goals. Post harvest storage solutions that could enable the deferred sale of horticultural produce would provide farmers with options to tide them over the crisis of low market prices during the harvest season and spread product supply in market over a wider period, thus, enabling remunerative returns.

India is the largest producer of fruits and second largest producer of vegetables and milk in the world. In spite of that, per capita availability of fruits and vegetables is quite low. Although India has the potential to become one of the world's major food suppliers, the country's inefficient cold chain network results in spoilage of almost 40 per cent of its total agricultural production. The total value of the cold chain industry is estimated to be as high as USD 3 billion and growing at 20-25 per cent a year. India has surpassed the United States as the country having the greatest amount of refrigerated warehouse space of 130 million cubic meters capacity in 2014 against 105 million cubic meters in 2012. About 5 per cent of that space is owned by the Government of India (Victoria, 2014). In India, Uttar Pradesh, Maharashtra, West Bengal, Punjab and Gujarat accounts for about 60 per cent of the cold storage capacity followed by Andhra Pradesh, Haryana and Madhya Pradesh. The growth of cold stores in, North region, South region, East region, West region and Central region increased by 47 per cent, 33 per cent, 7 per cent, 7 per cent and 6 per cent respectively during the period from 1955 to 2008 which is not uniform both region wise and state wise (Gundewadi, 2013.

Thus, the study has been undertaken to work out the economics of cold storage units and determine its feasibility in Hyderabad and Ranga Reddy districts of Telangana State.

Cold storage capacity created in the state of Telangana is mainly concentrated in Hyderabad and Ranga Reddy districts which together accounts for 62 per cent of the total capacity in the state. There are around 82 cold storage units in the state which are predominantly owned (91 per cent) by the private entrepreneurs, only 6 per cent and 2 per cent are under the cooperative and public ownerships respectively. The business viability of the cold storage units depends upon its optimum utilization, regular and continuous supply of power.

Hyderabad and Ranga Reddy district was selected for the study as the district has maximum number of cold storage units in Telangana. About 8 large units with capacity of more than 70000 MT, 18 medium units with capacity 3500-7000 MT and 14 small units with capacity less than 1500 MT per year were selected randomly for this study. Primary data was collected directly by interview with the help of schedule. Secondary data was collected from the office of the Commissioner of Industries, National Horticulture Mission etc. Apart from the simple tabular analysis, the discounting techniques like Net Present Value (NPV), Internal Rate of Return (IRR), Benefit Cost Ratio (BCR) are also used to assess the investment decisions.

$$NPV = \sum_{i=1}^{n} Y_i (1 + r) - i - 1$$

Y_i = Net cash inflows in the year n, r = Discount factor, I = Initial investment and i = Year of life period 1, 2, ……n

IRR =

Lower discount rate+(Difference between the two) discount rates $\times$ $\frac{\text{Present worth of cash flows at lower discount rate}}{\text{Absolute difference between present worth of cash flows at the two discount rates}}$

BCR= $\frac{\text{Discounted net cash}}{\text{Initial investment}}$

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The investment details of the cold storage units are shown in the (Table 1). The investment on land was Rs. 3.9 crores, Rs. 1.5 crores and Rs. 65 lakhs for large, medium and small units respectively. Similarly, the investment on building was Rs. 132 lakhs, Rs. 60.9 lakhs and Rs. 25.2 lakhs respectively, where as the investment on machinery was Rs. 84.7 lakhs, Rs. 33.9 lakhs and Rs. 12.7 lakhs in the same order. The total fixed capital worked out to Rs. 621.8 lakhs, Rs. 265.2 lakhs and Rs. 110.8 lakhs for large, medium and small cold storage units respectively.

The details of the storage cost of the cold storage units are given in the (Table 2). The total storage cost of large, medium and small cold storage units is Rs. 78.01 lakh, Rs. 55.9 lakh and Rs. 40.4 lakh of which the fixed cost contributed Rs. 37.56 lakh, Rs. 25.3 lakh and Rs. 20.7 lakh and the variable cost was Rs. 40.4 lakh, Rs. 30.6 lakh and Rs. 19.6 lakh respectively. The study indicated that the highest share in variable cost was due to electricity charges which comprised about 16.09 per cent, 17.33 per cent, and 13.87 per cent for large, medium and small sized units respectively. When units size is small, electricity consumption is less and for bigger and medium units consumption is more. The next major cost was on repair and maintenance having a share of 11.03 per cent, 11.03 per cent and 12 per cent for big, medium and small sized units respectively. (Singh *et al* 1998). The details of the cost and returns of the cold storage units are shown in the (Table 3). The cost per MT was Rs. 1114.59, Rs. 1599.75 and RS. 2693.95 in the large, medium and small cold storage units respectively. The returns per MT were Rs. 2909.24 and the total returns per year accounted to Rs. 203 lakh, Rs. 156 lakh and Rs. 102 lakh for the large, medium and small units in the same order. The gross returns per MT were Rs. 1794.68, Rs. 2873.90 and Rs. 4165.33 whereas the gross returns per year were Rs.12562749.40, Rs. 10058637.10 and Rs. 6247995 respectively. This clearly shows that all the three different capacities of cold storage units have a good economic feasibility.

The (Table 4) shows the results of the financial feasibility analysis such as Net Present Value, Benefit – Cost Ratio, Internal Rate of Return conducted. The Net Present Value (NPV) of large, medium and small cold storage units at 14 per cent discount rate was Rs. 25739295.04, Rs. 17699041.84 and Rs. 12294846.65 respectively thus showing the present value of the future business of cold storage units. The Benefit Cost Ratio (BCR) was 1.61 for large cold storage unit, 1.79 for medium cold storage unit and 1.55 for small cold storage unit which is more than unity indicating the worthiness of investment on these units. The Internal Rate of Return (IRR) was 96 per cent, 93 per cent and 90 per cent for large, medium and small cold storage units respectively. Since IRR was more than the opportunity cost of capital, it clearly indicated that investment on cold storage units is financially feasible and economically viable. (Ashwini *et al*, 2005).

Table 1. Investment details of the cold storage units (in Rupees)

S. No.	Particulars	Large	Medium	Small
1	Land	39000000	15000000	6500500
2	Building	13203900	6099600	2527494
3	Machineries & equipment	8476000	3394560	1274850
4	Other fixtures	1505000	901680	354736
Total Fixed Capital		**62184900**	**26520000**	**11085500**

Table 2. Details of the storage cost of the cold storage units (in Rupees)

S. No	Particulars	Large	Medium	Small
FIXED COST				
1	Depreciation on building	140550 (1.80)	140550 (2.25)	100550 (2.49)
2	Depreciation on Machinery	90330 (1.16)	90330 (1.61)	82600 (2.04)
3	Payment to permanent employees	1400000 (17.94)	1000500 (11.87)	790000 (19.55)
4	License fees	10000 (0.13)	10000 (0.18)	10000 (0.25)
5	Insurance premium	1550000 (19.87)	1000000 (17.86)	857000 (21.21)
6	Others	200000 (2.56)	100000 (1.79)	62500 (1.55)
7	Interest on fixed capital @ 10 %	365750 (4.69)	191350 (3.41)	170000 (4.21)
TOTAL FIXED COST		**3756630 (48.15)**	**2532730 (45.23)**	**2072650 (51.29)**
VARIABLE COST				
1	Electricity charges	1255000 (16.09)	970280 (17.33)	560500 (13.87)
2	Water and fuel charges	300000 (3.85)	210000 (3.75)	100900 (2.5)
3	Wages for labour	700000 (8.97)	585000 (10.45)	390500 (9.66)
4	Repairs & maintenance	860700 (11.03)	625000 (11.16)	485000 (12)
5	Telephone charges	26000 (0.33)	15000 (0.21)	12000 (0.3)
6	Stationery	15000 (0.19)	12000 (0.22)	9000 (0.22)
7	Taxes	50000 (0.64)	38000 (0.68)	28000 (0.69)
8	Spoilage costs	400000 (5.13)	315000 (5.63)	249750 (6.18)
9	Interest on working capital @ 12.5 %	438650 (5.62)	295550 (5.28)	132620 (3.28)
TOTAL VARIABLE COST		**4045350 (51.85)**	**3066380 (54.77)**	**1968270 (48.71)**
TOTAL STORAGE COST		**7801980 (100.00)**	**5599110 (100.00)**	**4040920 (100.00)**

Table 3. Cost & returns structure of cold storage units

S.No.	Particulars	Unit	Large	Medium	Small
1	Quantity stored	MT	7000	3500	1500
2	Total cost	Rs/yr	7801980	5599110	4040920
3	Total cost/MT	Rs/MT	1115	1600	2694
4	Total return	Rs/yr	20364730	15657747	10288915
5	Total return	Rs/MT	2909	4474	6859
6	Gross return	Rs/yr	12562750	10058637	6247995
7	Gross return	Rs/MT	1795	2874	4165
8	Benefit Cost Ratio		1.61	1.79	1.55

Table 4. Financial feasibility analysis of cold storage units

S.No	Particulars	Units	Large	Medium	Small
1	Net Present Value (NPV)	Rupees	25739295.04	17699041.84	12294846.65
2	Benefit Cost Ratio (BCR)	-	1.61	1.79	1.55
3	Internal Rate of Return (IRR)	Per cent	96	93	90

According to 2012 statistics for united Andhra Pradesh, the total cold storage capacity requirement was 23.24 lakh MT whereas the availability was only about 9.01 lakh MT. Thus there is a gap of 14.23 lakh MT. This gap clearly shows that there is an immense scope for the establishment and growth of the cold storage units. With the increase in the number of cold storages, there will be more scope for the producers to increase production and area under the crop. Establishment of cold storage requires huge initial capital investment and also the maintenance cost is very high, therefore a lot of precision in handling each and every activity involved in the unit is essential to keep the cost of storage in control to encourage farmers to store their produce in the cold storage units. In the case of storage pattern, measures should be taken to encourage more and more storage of multi commodities as it will not make cold storage units seasonal in nature and round the year they would be functional irrespective of the peak and lean seasons, thereby giving a steady income to cold storage unit owners. The other constraints can be rectified by adapting innovative technology in storage, proper forecast of the market situation and strategic location of the cold storage units along with government intervention.

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GROWTH AND YIELD OF FODDER PEARL MILLET (*Pennisetum glacum* L.) GENOTYPES AS INFLUENCED BY NITROGEN LEVELS UNDER RAINFED CONDITION

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Area under fodder crops in India is around 8.6 m ha and to meet the fodder shortage for growing animal population, the fodder growing area should ideally be 20 m ha, by 2020 AD. However, this appears to be rather difficult to achieve because of preferential food need for human beings(Hazra and Tripathi, 1998).Therefore productivity is to be through agronomic manipulation. Pearlmillet (Pennisetum glaucum L.) is one of the most widely adopted cereal forage crops under rainfed condition and gaining more popularity due to its quick growing habit, high quality forage and better palatability. Nitrogen is an essential primary nutrient for profuse plant growth and plays a pivotal role in production of forage crops. The application of nitrogen at various growth stages is one of the ways to increase the productivity of forage crops. Recently many new improved varieties of pearlmillet are coming up as forage varieties and need to standardize the dose of nitrogen for better forage yield and quality. Therefore, a field trial was conducted to find out the fodder production potential and nutritional quality of different fodder pearlmillet genotypes grown under different levels of nitrogen application in rainfed condition.

The field experiment was conducted at Forage Crops Research Project, PJTSAU (formerly ANGRAU), Hyderabad under rainfed condition during *Kharif,* 2012-13 (August to October) . The soil of the experimental field was low in organic carbon (0.2%) and available nitrogen (180 kg ha^{-1}), medium in available phosphorus (35.2 kg ha^{-1}) and high in available potassium (330 kg ha^{-1}).

The experiment was laid out in randomized block design (factorial) with sixteen treatment combinations formulated with four varieties (RBB-1, PAC-981, Raj bajra chari) and four nitrogen levels of 0, 30 , 60 and 90 kg N ha^{-1} replicated thrice. The crop was fertilized with 40 kg P_2O_5 and 30 kg K_2O ha^{-1} in the form of single super phosphate and muriate of potash respectively as basal at the time of sowing and half of the nitrogen at the time of sowing and remaining half quantity was top dressed at 30 days after sowing in the form of urea as per treatments. The crop was sown on August 3rd 2012 and all agronomic practices were uniform to all treatments. The crop was harvested at 50 percent flowering. There was well distributed rainfall of 263 mm during crop growing period. The crude protein content was determined on dry weight basis according to standard A.O. A.C. (1990) method.

The green forage and dry matter yields differed significantly among different fodder pearlmillet genotypes (Table 1). Giant bajra significantly out yielded all other cultivars and recorded highest green fodder yield of 510.9 q $ha^{-1}$and dry matter yield of 76.4 q ha^{-1} followed by the PAC-981 i.e. 331.5 and 62.5 kg ha^{-1} of green fodder and dry matter yields respectively.This is due to the superiority of the genotype to produce higher plant height and comparatively higher leaf/stem ratio which is a desirable character for fodder crops. The higher green fodder and dry fodder yields by Giant bajra were also reported by Desale *et al.* (2000) and Tiwana and Puri (2005). Crude protein content was also varied significantly among genotypes. The highest crude protein content of 10.04 per cent recorded with Giant bajra was statistically on par with Raj bajra chari (9.60%) and both were significantly higher than other g two genotypes i.e. RBB-1 and PAC-981. Highest crude protein yield of 7.74 q ha^{-1} was recorded by

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Giant bajra and was significantly superior to all other genotypes. This might be due to higher protein content and dry matter yield of Giant bajra. The results are in tune with Bhilare *et al. (*2010) and Phogat *et al. (*2012). Shashikala *et al.* (2013) also reported significant variations among the multicut pearlmillet genotypes for green fodder, dry matter and crude protein yields.

Growth parameters, green fodder, dry matter and crude protein yields responded significantly with increase in nitrogen levels up to 90 kg ha^{-1} (Table 1). The maximum plant height (159.8 cm) and leaf stem/ ratio (0.42) were recorded at 90 kg N ha^{-1} which was significantly higher than lower doses of nitrogen. Application of 90 kg N ha^{-1} recorded significantly higher green fodder yield (419.9 q ha^{-1}) and dry matter yield (76.9 q ha^{-1}) than other levels of nitrogen. Similar results were also reported by Pathan and Bhilare (2009).The vegetative growth of the plant positively correlated with higher green forage yield and dry matter accumulation (Sharma *et al.* 2003, Mitra *et al* 2001). The application of nitrogen at 90 kg ha^{-1} produced 68.9, 24.7 and 13.2 per cent of higher green fodder yield 62.3, 27.5 and 17.4 per cent of higher dry matter yields over 0, 30, 60 kg N ha^{-1} respectively. The protein content and protein yields were also increased with increasing levels of nitrogen up to 90 kg N ha^{-1}. The interaction of genotypes and nitrogen levels had significant effect on green fodder and dry matter yields. The highest green fodder, dry matter and crude protein yields at higher levels of nitrogen were also reported by Tiwana and Puri (2005), Bhilare *et al.* (2010) and Shahin *et al.* (2013).

It can be inferred from the above study that Pearlmillet variety Giant bajra recorded significantly higher dry matter, crude protein and green fodder yields followed by PAC-981 compared to other pearlmillet genotypes (RBB-1, and Raj bajra chari) and responded up to 90 kg N ha^{-1} under rain fed conditions in Telangana region.

Table 1. Growth, green forage yield(q ha^{-1}), dry matter yield (q ha^{-1}), crude protein content (%)and crude protein yield (q ha^{-1})in Pearlmillet genotypes as influenced by nitrogen levels

Treatments	Plant Height (cm)	Leaf/ stem ratio	Green forage yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Crude protein (%)	Crude protein yield (q ha^{-1})
Genotypes						
RBB-1	140.5	0.30	281.8	57.3	9.00	5.5
PAC-981	128.8	0.33	331.5	62.4	8.52	4.4
Raj bajra chari	138.2	0.33	250.4	53.8	9.60	5.3
Giant bajra	145.8	0.35	510.9	76.4	10.04	7.7
SEM ±	4.70	0.02	9.1	1.1	0.17	0.4
CD at 5%	NS	NS	26.2	3.1	0.50	1.0
Nitrogen Levels (kg ha^{-1})						
0	121.8	0.28	248.4	47.4	8.10	4.6
30	128.1	0.29	336.1	60.3	8.73	5.1
60	143.6	0.37	370.2	65.5	9.61	6.1
90	159.8	0.42	419.9	76.9	10.74	7.8
SEM ±	4.7	0.02	9.1	1.1	0.17	0.4
CD at 5%	13.7	0.05	26.3	3.2	0.50	1.0
Interaction						
SEM ±	9.50	0.04	18.2	2.2	0.35	0.7
CD at 5%	NS	NS	58.2	7.0	NS	NS
CV %	11.9	18.25	9.2	6.1	6.47	20.9

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FACTORS INFLUENCING CONSUMER SATISFACTION WITH SOLAR WATER HEATERS

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India is a sunny country with a solar energy potential of 20 mw every square km. At present, only a tiny fraction was being tapped. Solar energy can be used directly in two forms –producing heat or light. Production of light and electric current from the sun's rays users' photovoltaic technology', which involves direct conversion of sunlight into electricity. The thermal form of solar energy is used for cooking, water heating or purification, drying and fruit ripening, lighting, distillation or producing steam for power generation. Apart from cooking, heating water dominates the energy needs of households. For households in developing nations, heating water was often the most energy intensive process, and therefore the most expensive or time-intensive. In communities throughout the developing world, poor households struggle to meet their hot water needs.

Solar water heating technology was used in many parts of the world including the U.S., China, India, and the Middle East. Systems have been adopted for a wide range of use patterns and climate conditions (Praveena and Kumaresh, 2011).

The objective of the study is to analyse the factors influencing consumer satisfaction with solar water heaters. A standard questionnaire was framed for data collection. One hundred samples were taken in Hyderabad city for this study.

Thilagawathi and Mownica (2014) had explored on customer satisfaction towards solar water heater with reference to Erode city. Majority of the respondents were satisfied about the solar water heater.

This was because of its no electricity charges and environment safety and some kind of promotional activities.

The age of the head of the family showed that 47 per cent of the respondents belonged to young age group. More or less an equal proportion of the respondents belonged to middle age group (29%) and above middle age group (24%). Education of head of the family showed that 47 per cent of the respondents were post graduates i.e. M.Sc, M.Tech & M.B.A followed by professional degree holders (32%). Nearly one-fifth (19%) of the respondents were graduates i.e. B.Sc, B.Com & polytechnic and negligible proportion of the respondents were doctorates (2%

A negligible percentage (3%) of the respondents had chosen semi-professional occupation. Income of head of the family found that sixty per cent of the families were earning Rs.50,000-1,00,000 and 30 per cent of the families were earning Rs.1,00,000-1,50,000 while negligible proportion of the families were earning Rs.1,50,000-2,00,000 (7%), Rs.d" 50,000 (2%), and Rs.d" 2,00,000 (1%). Majority (85%) of the respondents belonged to nuclear families followed by 15 per cent respondents belonging to joint families. Type of building showed that 81 per cent of the respondents were living in independent buildings out of which half (50%) of the respondents were living in duplex building followed by single storeyed building (29%), while 19 per cent of the respondents were living in apartments. A negligible

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Table 1. Distribution of respondents according to the factors for satisfaction with SWH

(n=100)

Factors	5(HS)	4(S)	3(U)	2(D)	1(HD)	Total Score	Rank	Mean	S.D
1.Operational factors: 1.1.Easy to operate	43	39	16	1	1	422	7	4.22	1.59
1.2.There is no switch off/on Required	41	45	12	2	0	425	5	4.25	0.89
1.3.It is easy to operate by children	51	31	12	3	3	424	6	4.24	0.96
1.4.There is no short-circuit problem by solar water heater while operating it	45	31	21	1	2	416	9	4.16	0.95
1.5.It does not require much skill to operate it	51	33	16	0	0	435	3	4.35	0.73
1.6.Instructions to use are clear	49	31	11	7	2	418	8	4.18	1.00
Total						**2540**	**2**	**4.23**	**1.02**
2.Maintainance factors 2.1.Require very little maintenance	13	21	57	8	1	337	16	3.37	0.83
2.2.Low cost for maintenance	18	20	53	7	2	345	15	3.45	0.93
2.3.Easy to maintain	40	35	15	6	4	401	12	4.01	1.06
Total						**1083**	**4**	**3.61**	**0.94**
3.Performance factors: 3.1.Time saving	51	34	10	3	2	429	4	4.29	0.90
3.2.Getting hot water daily	45	31	12	3	3	424	5	4.24	0.95
3.3.In winter and rainy season also getting hot water properly	31	27	35	6	1	381	14	3.81	0.96
3.4.Environmental friendly	28	62	7	2	1	414	10	4.14	0.69
Total						**1648**	**3**	**4.12**	**0.87**
4.Financial factors: 4.1.Cost effectiveness	47	53	0	0	0	447	2	4.47	0.60
4.2.Reduction in electricity bill	59	38	3	0	0	456	1	4.56	0.61
4.3.Government subsidy	9	86	3	2	0	402	11	4.02	0.43
4.4.Loan availability	6	89	2	2	1	397	13	3.97	0.48
Total						**1702**	**1**	**4.25**	**0.53**

(Table 1.) refers to the factors influencing the customer's satisfaction with SWH. Respondents were asked to report on a 5 point continuum scale i.e. highly satisfied (5), satisfied (4), undecided (3), dissatisfied (2) and highly dissatisfied (1). Each point on the scale carries a score. These score values were not printed on the instrument but are shown here just to indicate the scoring pattern. Each statement was scored by 100 respondents on a 5 point scale. The maximum score earned on that statement was 100X5=500 i.e. highly satisfied and minimum score earned on each statement was 1X100=100 i.e. highly dissatisfied.

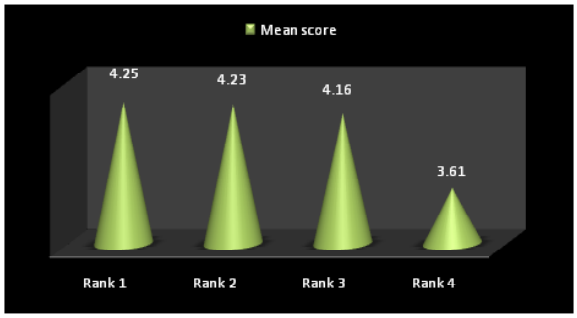
Ranking was given to each statement based on the total score of that statement. The total score was calculated on each statement separately by multiplying the score with the number of responses on all 5 categories and adding up. The results revealed that financial factor was ranked high in giving satisfaction to the user followed by operational factor (2^{nd} rank) and performance factor (3^{rd} rank).

Each statement's mean and S.D also score was calculated by dividing the total score with 100 respondents. Same method was followed for each statement. For all 17 statements mean and S.D was calculated. Based on the mean score calculated, it was found that under operational factor the most important reasons that had contributed satisfaction with SWH were not requiring much skill to operate (mean score 4.35), no need to switch Off/On for operating SWH (mean score 4.25) and easy to operate by children (mean score 4.24). Easy to maintain the SWH (mean score 4.01) was most important maintenance factor quoted by the respondents.

Under performance factor the most important reasons that had contributed satisfaction with SWH were time saving (mean score 4.29),getting hot water daily(mean score 4.24) and environmental friendly(mean score 4.14).

Reduction in electricity bill SWH (mean score 4.56) was the most important financial factor quoted by the respondents. While Baliga and Rodrigues (2015) reported in their study that majority of the respondents have perceived customer satisfaction as good followed by very good and average.

Figure 1. Distribution of respondents according to the factors for satisfaction with SWH by mean score



Based on the mean score calculated, it was found that financial factor (mean score 4.25) was the high in giving satisfaction to the user SWH followed by operational factor (mean score 4.23), performance factor (4.12) and maintenance factor (mean score 3.61).

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VARK LEARNING STYLE PROFILE OF ADULT LEARNERS OF KRISHI VIGYAN KENDRA

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Learning styles is a term used to refer to the methods of gathering, processing, interpreting, organizing and thinking about information. Individual learning style refers to style or learning methods used in the process of learning. There are various views on learning style concepts and definitions among researchers and each investigates and observes from various aspects such as psychological and environmental aspects. These learning styles' concepts and definitions show that learning has a cognitive, affective and behavioralcharacteristics, based on seeing, interacting and responding to methods in learning.

Fleming (2001) proposed VARK Model, a sensory model that is an extension of the neuro-linguistic model proposed by Eicher in 1987. The acronym VARK stands for Visual (V), Aural (A), Read/ Write (R), and Kinesthetic (K). He defined learning style as an individual's characteristics and preferred ways of gathering, organizing, and thinking about information. VARK is in the category of instructional preference because it deals with perceptual modesAccording to him every learner would possess a learning style, through which they learn. The visual learners have a preference for seeing visual aids that represent ideas using methods other than words, such as graphs, charts, diagrams, symbols, etc., auditory learners best learn through listening lectures, discussions, tapes, etc. Kinesthetic learners prefer to learn via experience — moving, touching, and doing active exploration of the world, science projects, experiments, etc. and Read/write learners prefer to learn by reading text or writing down things.

Hence, the ability of teachers and computer's capability in integrating multimedia technology would be able to diversify teaching strategies to fulfill different learners' demands. Ismail (2008), in the context of preferred sensory modality theory, stated that each learner has different acceptance abilities based on certain senses.There are learners with better reception ability through stimulation process of the brain compared to visual sense, and there are learners who can receive better information through contrast stimulation, such as, combination of the visual and hearing senses. Therefore, VARK learning style model can illustrate and strengthen the multimedia courseware application's role during teaching andlearning process, as an instructional material.

The study was conducted in five adopted villagesviz.,Beerkur, Kistapur, Malkapur, Ranampally, Timmapurof KVK by randomly selecting 150 sample from among the clientele.The clientele were those who visit KVK either to seek information or to avail any service and these clientele were termed as adult learners. The VARK questionnaire 7.0 version, developed by Flemming (2006) to study the learning styles profile of adult learners as whether they are visual, auditory, read and kinesthetic, was adopted for the study to develop inventory on identification of learning style preferences of to identify the learning styles of present sample.

The inventory consisted of 12 questions with four options viz., a, b, c, d for each item. Option 'a' reflects visual learning style, 'b' auditory, 'c' reading and 'd' kinesthetic. The order of options is non linear and differed from question to question. Each response of the sample to the corresponding item was tabulated as 'a' or 'b' or 'c' or 'd'. Based on the dominating style the individual was recognized as visual, auditory, read or kinesthetic learner. Since the questionnaire was translated to local language for the convenience of the sample, the reliability of the inventory was measured using test retest method, to confirm its suitability for execution. The 'r' value was found as 0.89, proving the instrument as a reliable one.

The learning preferences of the respondents were analysedand found the learning style profile as indicated below

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Table 1. VARK profile of the respondents

n1= 30, n2=30, n3=30, n4=30, n5=30

Learning style	Beerkur	Kistapur	Malkapur	Ranampally	Timmapur	Total
Unimodal Visual	6 (20.00)	6 (20.00)	4 (13.33)	3 (10.00)	8 (26.66)	27 (18.00)
Auditory	7 (23.33)	8 (26.66)	8 (26.66)	12 (40.00)	5 (16.66)	40 (26.67)
Read	3 (10.00)	1 (3.33)	2 (6.66)	2 (6.66)	6 (20.00)	14 (9.33)
Kinesthetic	4 (13.33)	4 (13.33)	5 (16.66)	6 (20.00)	5 (16.66)	24 (16.00)
Total Unimodal	**20 (66.67)**	**19 (63.33)**	**19 (63.31)**	**23 (76.67)**	**24 (80.00)**	**105 (70.00)**
Bimodal	10 (33.33)	11 (36.66)	9 (30.00)	6 (20.00)	5 (16.66)	41 (27.33)
Trimodal	--	--	1 (3.33)	--	1 (3.33)	2 (1.33)
Multimodal	--	--	1 (3.33)	1 (3.33)	--	2 (1.33)
Total	30 (99.99)	30 (99.98)	30 (99.97)	30 (99.99)	30 (99.97)	150 (99.99)

Figures in parentheses are percentages n1Beerkur, n2 Kistapur, n3 Malkapur, n4Ranampally, n5 Timmapur

All four types of learning styles, viz., uni, bi, tri and multiple modals were evident among the respondents in all the villages. Unimodal were more (70%), followed by bimodal (27%) and equal proportion of tri and multi modal (1.33% each). Among uni, auditory learners (26.67%) were more, followed by visual (18.00%), kinesthetic (16.00%) and read (9.33%). The data with regard to other types where there were combination of learning style was analyzed to find out the dominating learning style and data was presented below.

Combination learning styles in bi modal respondents

Very unique combination was found among bimodal learners. Equal respondents with combination of VA and AR (21.95%) learning styles were there. Followed by them were AK (19.51%), RK (14.63%), VR (12.20%) and VK (9.76%) learning styles could be observed. High percentage of combinations has auditory learning style. Even among uni modal learning style auditory learning style was high. Hence it may be inferred that in the present research, the predominant learning style is auditory.

Table 2.Combination learning styles in bi modal respondents

n1= 10, n2=11, n3=9, n4=6, n5=5

Composition	Beerkur	Kistapur	Malkapur	Ranampally	Timmapur	Total
VA	2 (6.66)	4 (13.33)	1 (3.33)	--	2 (6.66)	9 (21.95)
VR	2 (6.66)	2 (6.66)	--	1 (3.33)	--	5 (12.20)
VK	1 (3.33)	--	2 (6.66)	--	1 (3.33)	4 (9.76)

AR	2 (6.66)	2 (6.66)	1 (3.33)	3 (10.00)	1 (3.33)	9 (21.95)
AK	1 (3.33)	3 (10.00)	2 (6.66)	2 (6.66)	--	8 (19.51)
RK	2 (6.66)	--	3 (10.00)	--	1 (3.33)	6 (14.63)
Total	10 (33.30)	11 (36.65)	9 (29.98)	6 (19.99)	5 (16.65)	41 (100.00)

Figures in parentheses are percentages n1Beerkur, n2 Kistapur, n3 Malkapur, n4Ranampally, n5 Timmapur

Respondents with tri and multiple were equal (1.33% each). The combinations of styles in tri modal were VAK and VRK, visual and kinesthetic were common and audio or read were alternate. All the four styles are equally dominant in multi modal. The gender wise learning style preferences were also computed and presented in Table 3.

Table 3. Gender wise learning style preferences

Learning style	Male	Female	Total
Unimodal	59 (17.70)	46 (13.80)	105 (70.00)
Bimodal	28 (8.40)	13 (3.90)	41 (27.33)
Trimodal	--	2 (0.60)	2 (1.33)
Multimodal	1 (0.30)	1 (0.30)	2 (1.33)
Total	88	62	150

Figures in parentheses are percentages

The data reveals that uniform trend between female and male could be inferred from the above table. Among unimodal learners male (17, 70%) were more, followed by bimodal (8.40), also. However there were trimodal only in female, whereas multi modal was equal.

The profile of the adult learners of KVK, Rudrur, Nizambad district revealed that all the four modals viz., unimodal, bimodal, trimodal and multimodal were existing. But amajoritypreferred unimodallearning style, among which highly preferred style was auditory. Auditory was also found as common style among different combinations of styles in bi and trimodals. While organizing programmes for adult learners, a very congenial environment for effective hearing should be taken care of by KVK.

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EXTENT OF LEARNING BY ADULT LEARNERS WITH DIFFERENT LEARNING STYLES FROM ICT MODULES

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ICT provides productive learning through the use of audio, video text, multicolor images, graphics and motion. ICT gives ample and exceptional opportunities to the learners to develop capacities for high quality learning and to increase their ability to innovate.

The term ICTs refers to forms of technologies that are used to transmit, store, create, share or exchange information. This broad definition of ICTs includes such as radio, television, DVD, telephone (both fixed and mobile), satellite systems, computer and network hardware and software; as well as the equipment and services associated with these technologies, such as videoconferencing and electronic mail. ICTs can enable the rapid and cost-effective creation and distribution of socially, culturally and linguistically appropriate learning content.

Kirkwood and Price (2006) examined the relationship between the use of information and communication technologies (ICT) and learning and teaching, particularly in distance education contexts and found that there is a significant relationship between ICT and learning and teaching. Kambouri *et al.* (2006) did a study to develop effective ICT based teaching strategies through a series of trials using theoretically grounded ICT task designs targeted at specific adult literacy. Both the development of literacy skills through the use of ICT and the acquisition and development of ICT skills were examined. Findings supported hypotheses that use of ICT boosts adult learners' confidence in learning as well as rapidly gain ICT skills and double the value of study time by acquiring two sets of skills.

The objective of the study was to find out the extent of learning by adult learners with different learning styles from ICT modules on environment education. Exploratory research design was used to carry out the study. The sample was 150 and they were randomly selected from five adopted villages of KVK, Warangal district of Telangana state.

ICT module on environment education was operationalized as a digital lesson consisting of textual content with images, presented orally to enable seeing, reading and hearing, related to different aspects of environment prepared for uploading in www.vigyanasaadthitha.com, a vernacular website for dissemination of information for life style management. The web portal is in operation from 2013-14 onwards providing information in the form of articles, quizzes. ICT modules were prepared on environmental education to enhance the interactivity of web portal. Before uploading the content, the present study was carried out to study the extent of learning from ICT modules on environment education for all types of learners. The selected topics of ICT modules on environment education consisted viz., Global warming (*Bhougolika vechchadanam*), Home gardening (*Intipanta*) and Carriers of communicable diseases (*Antuvyadula vahakala nirmulana).* These topics were selected to produce ICT modules as the articles relevant to these were clicked by a good number of visitors on www.vigyanasaadhitha.com at the time of selecting the topics for research study.

The length of each ICT module ranges from 9 minutes 30 seconds to 11 minutes 55 seconds. Content was presented in textual and oral forms with relevant images and videos, and images and text were animated wherever necessitated. At the end of each lesson, objective questions were given. Learning through ICT module was operationalized as the understanding gained by the respondents after watching the ICT module. Objective test was carried out to measure the learning.

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The respondents as a group viewed these modules one per day and soon after watching, an objective test was carried out to understand their extent of learning. There was one objective test for each ICT module, which consisted of ten questions. The questions were in the form of multiple choice or matching sets or true or false questions or blanks. Irrespective of the type of question, each correct answer was assigned '2' and wrong answer '1', so that the maximum score would be 20 and minimum 10. The score thus obtained was considered as the extent of learning of the respective ICT module. This activity was carried out in all the villages. ICT module wise and learning style wise mean scores obtained by the respondents from each village were computed and presented in the following table.

Impact of ICT modules of extent of learning by adult learners

The following table indicated the mean scores obtained by the respondents after watching ICT modules on Global warming, Home arming and Carriers of communicable diseases. To understand the overall impact, the total mean scores obtained by the respondents were tabulated.

Table 1. ICT module wise learning by adult learners

n=150

Learning style	Global warming	Home gardening	Carriers of communicable diseases	Learning style over all mean score
Visual	18.75	18.12	18.12	18.33
Aural	18.11	17.31	17.62	17.68
Reading	17.67	17.46	17.32	17.48
Kinesthetic	17.50	16.62	17.12	17.08
Unimodal	18.00	17.37	17.54	17.64
Bimodal	18.47	17.32	17.61	17.80
Trimodal	18.50	18.00	18.00	18.16
Multimodal	16.00	16.00	19.00	17.00
Over all mean score	17.74	17.17	18.03	

The duration of ICT modules ranged from 9 minutes 13 seconds to 11 minutes 53 seconds, the shortest being Global warming and the longest is Home farming. Extent of learning from the three modules is evident from the above table. So, in total all the ICT modules could engage the learner in learning. When analysed the overall mean scores, the highest mean score is for Global warming (17.85) followed by Carriers of communicable diseases (17.83) and Home farming (17.26) respectively. To empirically satisfy that the ICT modules are supporting the VARK learning styles, the compatibility of the ICT modules was also computed.

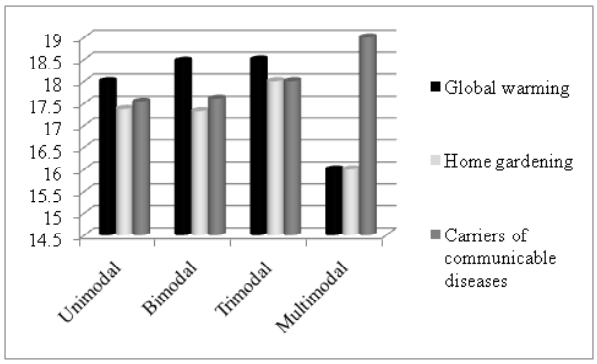

Figure 1. ICT module wise extent of learning by adult learners

This table indicates that highest mean score of ICT module on Global warming in trimodal is (18.50), followed by bimodal (18.47), unimodal (18.00) and multimodal (16.00) learners. For ICT module on Home gardening, the highest mean score for tri modal was 18.00 followed by unimodal (17.37), bimodal (17.32) and multi modal (16.00). The highest mean score of ICT module on Carriers of communicable diseases is in multimodal (19.00), followed by trimodal (18.00), bimodal (17.61) and unimodal (17.54). Hence, it could be inferred that the three ICT modules supported all the learning styles and resulted in learning.

Among unimodal learners, the extent of learning for visual learners was high for all the three ICT modules because of visual effectiveness of ICT module with relevant video clippings, images and animation. Apart from this, the language, the font type, size of the text and voice and its modulation, clarity in concept explanation also contributed for the high score of learning among aural, reading and kinaesthetic learners.

Learning with ICT modules on Global warming, Home gardening, Carriers of communicable diseases occurred was more or less similar among all selected adult learners of KVK, Warangal district. The results are in conformity with the study done by Turky (2015). The results of his study indicated that 43% of medical students at King Saud University in Riyadh, Kingdom of Saudi Arabia preferred to learn using all VARK learning styles and the learning style preferences are not related to a student's academic achievements. In the present study also it was found that learning could happen among all adult learners for all three ICT modules irrespective learning style preferences.

Learners will be motivated and purposefully engaged in the learning process when concepts and skills are embedded with ICTs. So it is substantiated that ICT provides productive learning in order to increase people's creativity and rational thinking especially in today's information society, irrespective of their learning styles.

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PRODUCTION AND EXPORT OF RAISINS FROM AFGHANISTAN

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Afghanistan's climatic and geographical conditions have provided the best ways to produce horticultural products. Afghanistan has various climatic conditions in various provinces and areas but generally Afghan farmers produce apples, pomegranates, apricots, grapes, walnuts, pistachios, almonds, raisins, melons and watermelons. About 78 per cent of human resource of Afghanistan is engaged in agriculture while the contribution of agriculture to the annual GDP (Gross Domestic Product) is only 31.5 per cent.

Raisins have a distinguished history in Afghanistan and remain an important high value horticultural product and Afghanistan's number one agricultural export commodity by value. Grapes are grown widely throughout Afghanistan, most without trellising or other vine support, covering an estimated 60,832 hectares. The area under grape is 34 per cent of the total fruit crop area. The Central provinces (Kabul 22 per cent, Parwan 15 per cent) are the major grape producing areas accounting for 37 per cent of total production. Poor harvest techniques and post harvest handling are responsible for an estimated 15 to 25 per cent post harvest loss annually. Afghanistan produces two main types of raisins. Green raisins (Kishmish) are dried in shaded and ventilated houses while red raisins (Aftabi Kishmish) are sundried on the ground and roofs. Raisin production tends to track grape production closely each year. (Gain Report, 2011).

In 2010, Afghanistan produced world's 3.25 per cent raisins which made Afghanistan one of the 6th major raisins producing country of the world.

In 2009, the total exports of raisins reached 30 million USD and constituted 45 per cent of total exports of the country. In 2014-15 the exports of raisins was 36000 tons. (Miraki, 2015). Looking at the importance of raisins production and exports in Afghanistan's economy, the study was carried out to analyze above mentioned aspects.

Both primary and secondary data were used in the study. Majorly the secondary sources of information about the trends in area, production, productivity of grapes and exports to other countries was gathered from Ministry of Agriculture and Live stock, Ministry of Economy and Ministry of Commerce and industry.

Kabul province was selected for the study. About 50 farmers were selected from 5 districts, Guldara, Paghman, Deh sabz, Qarabagh and Shakardra. From each district, 10 farmers were randomly selected. 20 traders were selected from 2 districts viz., Kabul and Bagrame (10 traders from each district). Primary data with regard to the problems faced by them in production, marketing and exports of raisins, was collected from farmers and traders.

Compound Annual Growth Rate (CAGR) and Rank Based Quotient (RBQ) were used to analyze the data.

To calculate the Compound Growth Rate (CGR) in area, production and productivity of grapes, the data was obtained from the secondary source for a period of fifteen years (2000-01 to 2014-15). The results are presented in (Table.1)

Table 1. Trends in area, production and productivity of grapes in Afghanistan (2000-01 to 2014-15).

Particulars	Area	Productivity	Production
CAGR	1.73 %	3 %	4.7 %

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The data regarding the production, domestic consumption and export of raisins for the period ranging from 2000-2001 to 2014-2015 is presented in the (Table 2.)

The compound annual growth rate for production, domestic consumption an exports worked out to 5.02 per cent, 3.2 per cent and 5.4 per cent respectively indicating a positive growth trend.

Table 2. Trends in production, domestic consumption and export of raisins in Afghanistan (2000-01 to 2014-15)

Particulars	Area	Productivity	Production
CAGR	1.73 %	3 %	4.7 %

Marketing pattern and commodity chains of raisins

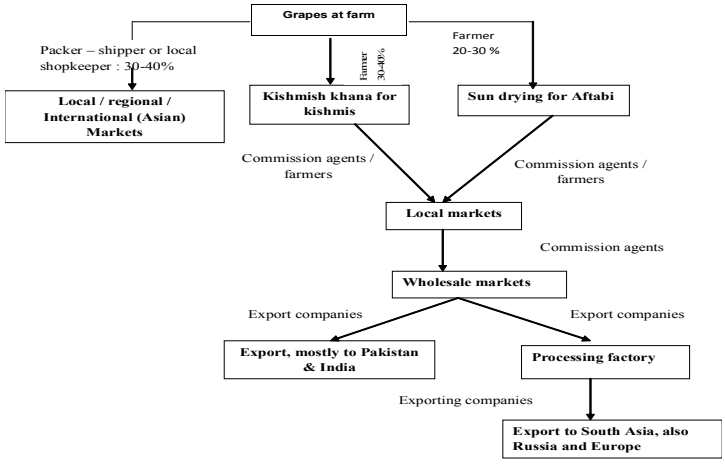
The marketing pattern and the commodity chains of raisins involves the packer / shipper contractor who will meet the grower at the vineyard during the month of August, prior to the harvest. They negotiate the price and the terms of sale. The packer / shipper contractor will gauge the size of the *kishmish khana* and assesses the farmers position with his estimate of the carrying capacity of the *kishmish khana* in relation to the size of the vineyard and accordingly negotiates the price of purchase.

Very often the farmer will agree to sell about 40 per cent of his crop fresh to the harvesting contractor. Since the varieties in the vineyard are usually mixed; the farmer will sell the seeded varieties and the early seedless varieties to the packer / shipper for sale in the fresh market. Once this deal is made, the farmer has the responsibility of maintaining and irrigating the farm.

The normal practice is that the packer / shipper has to pay the farmer 30 per cent of the estimated value of the crop at the time of the deal. Another 30 per cent is paid halfway through the harvest and the final 40 per cent at the end of harvest. It is also common, for the packer shipper to delay payment, misrepresent the weight of the grapes harvested, attempt to re-negotiate the deal halfway through claiming bad market conditions and end up not paying for a portion of the grapes harvested.

In spite of the wrong practices followed by the contractors, growers see these arrangements as preferable since they are not usually well connected to the markets and do not have the downstream contacts themselves. The perishable nature of the grapes heightens the unfavourable nature of many of these transactions for the farmer, since to avoid spoilage the product has to be delivered to markets whether or not cash has changed hands. (Lister *et al.,* 2004).

Figure 1. Commodity chains of raisins in Afghanistan



The eight most important problems encountered by the farmers in the production (Table 3) were listed and the respondents were asked to rank them according to the order of importance. Using the Rank Based Quotient (RBQ), the responses were analyzed. Lack of technical knowledge was identified as the most important problem with an RBQ value of 81.75. Limited water resources was expressed as the second most important constraint with RBQ of 72.

Similarly, poor soil health condition was marked as the third most important problem (RBQ score 66.25) besides lack of availability of quality inputs (RBQ score 54.24), problems of weeds, pests and diseases (RBQ score 51.5) and financial constraints (RBQ score 45.5) which were ranked at fourth, fifth and sixth position amongst the listed problems. Limited government support to the farmers through technical advice, subsides etc were not convincing and therefore was ranked seventh with RBQ Score of 40.75. The eighth rank was allotted by the farmers to the problem of delayed payment by contractors and misrepresenting the weight of the produce. This results in lot of disappointment to the farmers and they feel cheated by the traders. The traders usually buy time to renegotiate with the farmers with regard to the price promised at the time of procurement leaving the farmers in the helpless situation with no alternative left for them.

Table 3. Problems of farmers in raisins production in Afghanistan

Sl.No.	Constraints	R.B.Q (Score)	Over all rank
1	Lack of Technical knowledge	**81.75**	**I**
2	Limited water resources	**72**	**II**
3	Lack of quality inputs	**54.25**	**IV**
4	Problems of weeds, pest and diseases	**51.5**	**V**
5	Poor soil health condition	**66.25**	**III**
6	Delayed payment by contractors and mis representing the weight	**38**	**VIII**
7	Financial constraints	**45.5**	**VI**
8	Limited government support	**40.75**	**VII**

The traders of raisins are encountered by several problems in their trading activities both in domestic and international markets. The results are presented in (Table 4.) Amongst the problems identified, the first ranked was given to the poor harvesting methods (RBQ score 71.94) followed by the farmers which affects the quality and results in more spoilage losses. Further, most of the traders have limited or no knowledge about the export opportunities and the quality standards in the international markets and therefore loose out in making good business and was ranked at second important problem (RBQ score 68.06). Poor packaging, limited government support, many market intermediaries, unskilled labor were positioned at third, fourth, fifth and sixth amongst the various problems faced by the traders. Lack of data base, market research and information with regard to the prices, demand, arrivals etc will make the decision making process more difficult and therefore traders ranked it as seventh important problem with RBQ score of 58.06. Lack of organized marketing and processing (eighth rank), lack of scientific storage facilities leading to increased storage losses (ninth rank), poor roads (tenth rank) and price variability (eleventh rank) were the bottlenecks for trading operations. Further, illegal charges during export of raisins, unscientific and unhygienic drying process resulting in poor quality no marketing subsidies to promote exports and lack of producers associations

to strengthen the linkages were identified as problems by the traders and were occupying twelfth, thirteenth, fourteenth and fifteenth positions. The other problems encountered were post harvest losses, lack of cold chains during transportation and market glut during harvest season.

Table 4. Problems of raisin traders in processing, marketing and exports in Afghanistan

S. No	Constraints	R.B.Q (Score)	Overall rank
1	Poor harvesting methods	71.94	**I**
2	Unscientific drying process.	47.22	**XIII**
3	poor packaging	66.67	**III**
4	Lack of scientific storage facilities	55.00	**IX**
5	No export subsidy	47.22	**XIV**
6	Market glut	29.72	**XVIII**
7	Price variability	47.78	**XI**
8	Unskilled labour	62.22	**VI**
9	Illegal charges in export	47.50	**XII**
10	Many market intermediaries	63.06	**V**
11	Lack of data base for market research and information	58.06	**VII**
12	Lack of knowledge about export procedures and quality standards	68.06	**II**
13	Lack of organized marketing and processing	56.39	**VIII**
14	Limited government support in marketing and export	65.28	**IV**
15	Poor roads	52.22	**X**
16	Lack of cold chains	31.39	**XVII**
17	More post harvest losses	35.28	**XVI**
18	Lack of producers associations	45.00	**XV**

Various international agencies and the Government of Afghanistan are making efforts to encourage export of raisins to non traditional countries through various schemes and policies. Lack of technical knowledge and limited water resource were identified as the most important problems in production whereas poor harvesting method and lack of knowledge about exports are the important marketing problems. The problems can be partly resolved if the Government can also buy some crops at high price from the farmers and store it in their storages and / or cold storage and can resale after due time. This will help the farmers in gaining more income which will in turn lead to improved investment in agricultural sector. Establishment of Farmers Market Association or Co operatives will increase the market awareness and also improve the bargaining strength.

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TRAINING NEED ASSESSMENT IN ADOPTED VILLAGES OF KRISHI VIGYAN KENDRA, UNDI , WEST GODAVARI DIST

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Training plays an important role in the advancement of human performance in a given situation. Training provides a systematic improvement of knowledge and skills which in turn helps the trainees to function effectively and efficiently in their given task on completion of the training. Lynton and Pareek (1990) stated that training consists largely of well organized opportunities for participants to acquire necessary understanding and skill. Farmer training is directed towards improving their job efficiency in farming. As systematic procedure for planning and implementation of training programme, KVKs in general starts with identification of training needs of farmers/rural youth/extension personnel, and hence becomes the most important step in any training programme by KVKs. KVK scientists, as mandatory have to communicate the research findings, new innovations and technologies to the farmers and needy people (Venkatasubramanian *et al.* 2009). Therefore, KVK training is an essential component for the successful dissemination and large scale adoption of latest agricultural technologies in a social system particularly among farming communities. Thus, the gaps identified through assessment of training needs would be of great help in designing future training programmes. In this context a study was planned with an objective of identifying training needs of farmers, extension functionaries and women. An exploratory research design was used to study training needs of farmers, extension functionaries and women of Krishi Vigyan Kendra adopted villages during 2011. From four adopted villages of KVK 120 farmers were randomly selected (30 farmers from each.village), sixty extension functionaries representing whole district including AEOs, AOs were selected. Hundred women i.e., 25 from each adopted village were randomly selected to represent the population. For the present study, a list of 3 major thematic areas viz., crop production, plant protection and horticulture was prepared. The schedules were administered to the indented respondents for data collection. In this regard, the farmers and extension functionaries were requested to give a tick in one of the three response categories (viz. Very Important, Important and Not Important) provided against the identified specific items under each major component based on their perceived needs for providing training to them for further improvement in their farming system and livelihood. Women were asked to give their response against seven training needs expressed by them.

The farmer's responses were collected in a 3 – point continuum scale as Very Important (VI), Important (I) and Not Important (NI) by assigning scores 3, 2 and 1 respectively. The results were calculated as weighted score for each of the thrust area identified for the training

$$\text{Weighted Score (WS)} = \frac{(\text{No. of VI} \times 3) + (\text{No. of I} \times 2) + (\text{No. of NI} \times 1)}{\text{Total No. of VI + I + NI}}$$

Weighted Score will be ranging from 1 to 3. That is,

If all the selected farmers' marks that thrust area X is very important, then the WS will be 3.

If all the selected farmers marks that thrust area X is not important/ no response, then the WS will be 1.

If all the selected marks that thrust area X is important, then the WS will be 2.

The training needs of the farmers, extension functionaries and women are presented in the form of weighted scores in the Tables 1,2 and 3. Training needs were rank ordered under each discipline.

Majority of the farmers of KVK adopted villages expressed trainings as very important are farm

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machinery (71.67%), alternate crops to paddy (65.83%), fertilizer management in maize (62.5%), low cost production technologies (61.67%), management of heavy rain affected paddy fields (57.5%) , new paddy varieties (56.67%). These identified training needs were given more emphasis in planning and implementing crop production training programmes. Great majority of the farmers perceived trainings as very important in plant protection are Integrated Pest Management in paddy (78.33%), fallowed by Integrated Disease management (72.50%), new molecules for pest and disease management in paddy (68.33%), rodent management and YMV in pulses (57.5%) according to weighted scores. This finding is in conformity with Sajeev *et al* (2012). Almost fifty six (55.83%) per cent of the farmers expressed training on coconut management practices as important training need followed by vegetable cultivation on bunds and Weed management in okra and brinjal (48.33%) in horticulture discipline.

Majority of the extension functionaries felt that trainings on alternate crops to paddy (71.67%) with 1st rank, resource conservation technologies (53.33%) with 2nd rank, zero tillage maize cultivation (60.0%) with 3rd rank, low cost production technologies (61.67%) with 4th rank and farm machinery (36.7%) with 5th rank as their very important training needs with regard to crop production. These training needs were addressed by the KVK by organizing on campus trainings to the extension functionaries before starting of the season. New molecules for pest and disease management in paddy (76.67%) with 1st rank was the training need expressed by great majority of the extension functionaries as very important followed by Integrated Pest Management in paddy (73.33%) with 2nd rank, Integrated Disease Management in paddy (70.0%) with 3rd rank, compatibility of agricultural chemicals (65.0%) with 4th rank and bio Control agents for pests and disease management in paddy (58.33%) with 5th rank in plant protection discipline. Indiscriminate use of pesticides and fungicides by the farmers was the basic reason for concern on Integrated Management of Pests and Diseases. With respect to horticulture discipline coconut management practices (48.33%) with 2nd rank and vegetable cultivation on bunds (40.0%) with 1st ranks were expressed as important training needs by the extension functionaries.

From (Table 3) it could be found that women from KVK adopted villages needed training on tailoring (62.0%), Painting and embroidery (58.0%), surf making (47.0%), dining plate preparation (36.00%) and candle making (29.00%) as they have perceived those are the very important training needs. Since school drop out girls were there in these villages in large number majority of the women opted tailoring, painting and embroidery as most preferred training areas as these are the trainings which give them self employment and consistent supplementary income to their families. Thus the training need assessment made the scientists of KVK, Undi in meeting very important training needs of farmers, extension functionaries and women in time further helped them to perform their job effectively and efficiently.

Table 1. Rank ordering of training needs of farmers

n=120

S.No	Training area	VI		I		N I		WS	Rank
		Frq	%	Frq	%	Frq	%		
	Crop production								
1.	Integrated crop management in paddy	29	24.17	78	65.0	13	10.83	2.13	IX
2.	New paddy varieties	68	56.67	43	35.83	9	7.5	2.49	IV
3.	Weed management in paddy	30	25.00	85	70.83	5	4.17	2.21	VIII
4.	Irrigation for major crops	21	17.5	69	57.5	30	25.0	1.93	XIV
5.	Alternate crops to paddy	79	65.83	32	26.67	9	7.5	2.58	II
6.	Resource conservation technologies	23	19.17	76	63.33	21	17.5	2.02	XIII
7.	Low cost production technologies	74	61.67	28	23.33	18	15.0	2.46	VI
8.	Seed production of major crops	28	23.33	73	60.83	19	15.83	2.08	XI
9	Micro nutrient management	22	18.33	81	67.5	17	14.17	2.04	XII
10	Fodder production	10	8.33	76	63.33	34	28.33	1.8	XV
11	Integrated Nutrient Management of major crops	36	30.0	63	52.5	21	17.5	2.12	X
12	Farm machinery	86	71.67	25	20.83	9	7.5	2.64	I
13	Use of Azolla in paddy	13	10.83	34	28.33	73	60.83	1.5	XVII
14	Management of heavy rain affected paddy fields	69	57.5	44	36.67	7	5.83	2.52	III
15	Fertilizer management in Maize	75	62.5	28	23.33	17	14.17	2.48	V
16	Zero tillage maize cultivation	66	55.0	39	32.5	15	12.5	2.42	VII
	Plant Protection								
1.	Integrated Pest Management in Paddy	94	78.33	18	15.0	8	6.67	2.72	I
2.	Integrated Disease Management in paddy	87	72.50	26	21.67	7	5.83	2.54	III
3	New molecules for pest and disease management in paddy	82	68.33	28	23.33	10	8.33	2.6	II
4.	Bio Control agents for pests and disease management in paddy	12	10.0	46	38.33	62	51.67	1.58	XVI
5.	Compatibility of agricultural chemicals	32	26.67	74	61.67	14	11.67	2.15	VII
6.	Rodent management	69	57.5	45	37.5	6	5.0	2.53	IV
7.	Wild boar management	22	18.33	65	54.17	33	27.5	1.91	
8	Pest and disease management in maize	43	35.83	59	49.17	18	15.0	2.21	VI
9	YMV in pulses	69	57.5	34	28.33	17	14.17	2.43	V
	Horticulture								
1.	Coconut management practices	33	27.5	67	55.83	20	16.67	2.11	I
2	Vegetable cultivation on bunds	12	10.0	58	48.33	50	41.67	1.68	IV
3.	Weed management in okra and brinjal	18	15.5	58	48.33	44	36.67	1.78	III
4.	Plant protection in vegetables	20	16.67	55	45.83	45	37.5	1.79	II
5	YVMV in Okra	15	12.5	49	40.83	56	46.67	1.66	V
6.	IPM in Brinjal	21	17.5	35	29.17	64	53.33	1.64	VI

Table 2. Rank ordering of training needs of extension functionaries

n=60

S.No	Training area	VI		I		N I		WS	Rank
		Frq	%	Frq	%	Frq	%		
	Crop production								
1.	Integrated crop management in paddy	6	10.0	39	65.0	15	25.0	1.85	X
2.	New paddy varieties	13	21.67	34	56.67	13	21.67	2.0	IX
3.	Weed management in paddy	3	5.0	44	73.33	13	21.67	1.83	XII
4.	Irrigation for major crops	5	8.33	31	51.67	24	40.0	1.68	XIV
5.	Alternate crops to paddy	43	71.67	14	23.33	3	5.0	2.67	I
6.	Resource conservation technologies	32	53.33	25	41.67	5	4.17	2.52	II
7.	Low cost production technologies	37	61.67	14	23.33	9	15.0	2.47	IV
8.	Seed production of major crops	21	35.0	24	40.0	15	25.0	2.1	VII
9	Micro nutrient management	17	28.33	28	46.67	15	25.0	2.08	VIII
10	Fodder production	14	23.33	23	38.33	23	38.34	1.85	X
11	Integrated Nutrient Management of major crops	19	31.67	33	55.0	8	13.33	2.18	VI
12	Farm machinery	22	36.67	28	46.67	10	16.66	2.2	V
13	Use of Azolla in paddy	6	10.0	32	53.33	22	36.67	1.73	XIII
14	Management of heavy rain affected paddy fields	21	35.00	29	48.33	10	16.67	2.18	VI
15	Fertilizer management in Maize	7	11.67	33	55.0	20	33.33	1.78	XII
16	Zero tillage maize cultivation	36	60.0	18	30.0	6	10.00	2.5	III
	Plant Protection								
1.	Integrated Pest Management in Paddy	44	73.33	10	16.67	6	10.00	2.6	II
2.	Integrated Disease Management in paddy	42	70.0	11	18.33	7	11.67	2.58	III
3	New molecules for pest and disease management in paddy	46	76.67	10	16.67	4	6.66	2.7	I
4.	Bio Control agents for pests and disease management in paddy	35	58.33	19	31.67	6	10.00	2.48	V
5.	Compatibility of agricultural chemicals	39	65.00	14	23.33	7	11.67	2.53	IV
6.	Rodent management	34	56.67	18	30.00	8	13.33	2.43	VII
7.	Wild boar management	20	33.33	22	36.67	18	30.00	2.03	IX
8	Pest and disease management in maize	15	25.0	37	61.67	8	13.33	2.12	VIII
9	YMV in pulses	36	60.0	15	25.0	9	15.0	2.45	VI
	Horticulture								
1.	Coconut management practices	16	26.67	29	48.33	15	25.0	2.02	II
2	Vegetable cultivation on bunds	14	23.33	24	40.00	22	36.67	2.03	I
3.	Weed management in okra and brinjal	18	30.00	22	36.67	20	33.33	1.97	III
4.	Plant protection in vegetables	19	31.67	18	30.00	23	38.33	1.93	IV
5	YVMV in Okra	8	13.33	17	28.33	35	58.34	1.55	VI
6.	IPM in Brinjal	11	18.33	12	20.0	37	61.67	1.57	V

Table 3. Rank ordering of Training needs of women

n=100

S.No	Training area	VI		I		N I		WS	Rank
		Frq	%	Frq	%	Frq	%		VI
1	Agarbatti making	38	38.0	22	22.0	40	40.0	1.98	VII
2	Candle making	29	29.0	44	44.0	27	27.0	2.02	V
3	Paper bag preparation	14	14.0	58	58.0	28	28.0	1.86	VIII
4	Surf making	47	47.0	42	42.0	11	11.0	2.36	III
5	Dining plate preparation	36	36.0	45	45.0	19	19.0	2.17	IV
6.	Tailoring	62	62.0	29	29.0	9	9.0	2.53	I
7.	Painting and embroidery	58	58.0	34	34.0	8	8.0	2.5	II

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A STUDY ON PERSONAL AND PSYCHOLOGICAL PROFILE OF DIABETICS

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Diabetes mellitus is reaching potentially epidemic proportions in India. The level of morbidity and mortality due to diabetes and its potential complications are enormous, and pose significant healthcare burdens on both families and society. Diabetes mellitus is an important public health priority requiring urgent preventive action.

Diabetes is fast gaining the status of a potential epidemic in India with more than 62 million diabetic individuals currently diagnosed with the disease. 422 million adults were living with diabetes in 2014, compared to 108 million in 1980 It is predicted that by 2030 diabetes mellitus may afflict up to 79.4 million individuals in India. India currently faces an uncertain future in relation to the potential burden that diabetes may imposeupon the country.

Diabetes is a metabolic disorder which has reached an epidemic state. No longer is a disease of predominantly rich nations, the prevalence of diabetes steadily increasing everywhere, most markedly in the world's middle-income countries." Diabetes is a serious, chronic disease that occurs either when the pancreas does not produce enough insulin (a hormone that regulates blood sugar, or glucose), or when the body cannot effectively use the insulin it produces. Diabetes is an important public health problem, one of four priorities no communicable diseases (NCDs) targeted for action by world leaders.

Provision of education and information forms a major part of chronic disease management strategies. People with chronic disease who receive education are presumed to be in a better position to take responsibility for their own health, participate in their own health care and management, and thus maximize their health outcomes. Knowledge and information, however, is not necessarily translated into action or better health behaviours.

In view of the above, the study was planned with an objective to understand the personal and psychological profile of diabetic. The study was conducted in Hyderabad city, Telangana State, India.90 diabetic respondents of Hyderabad city were randomly selected for the interview to elicit information on their personal and psychological profile.

The study showed that 62.22% of the respondents were female while 37.77% of the respondents were male. Middle age group i.e. 35 – 60 years washad the highest percentage (66.66%) of incidence of diabetes disorder among the respondents. The data gives clear indication that diabetes disorder is increasing among younger age groups the probable reason can be urbanization. The education level for majority of the respondents (72.22%) was graduation and above which shows high level of education in the urban population. Rayappa*et al*. (1999) pointed that education has a major effect on diabetes prognosis.

Equal percentage of employee and self-employee (31.11%) could be observed, followed by homemakers (25.55%) and software professionals(12.22%). The respondents could be categorized under sedentary category. The study is in line with Shihabudheen *et al*. (2010) where in majority of the diabetic respondents were in middle class (36.66%) and upper middle class (34.44).

Majority of the respondents (64.44 %)in the study were non-vegetarians, followed by vegetarians 30.00%, and ova vegetarians 5.55%. Almost 92% of respondents had a habit of taking junk foods, while 80.00% of respondents regularly consumed desserts and confectionary. The junk foods in diet along with desserts and confectionary may be risk factors for diabetes among the respondents. Cold beverages which included cold drinks as well as sweetened fruit drinks were taken by 84.44% of the respondents.

Majority of diabetes occurrences was to be linked with genetic inheritance. As much as 83% of

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the diabetic respondents indicated that they had inheritance of the disease from parents and grandparents. Out of these 34.44% of them indicated the inheritance from a maternal parent, 28.88% from a paternal parent. Ostovan, (2007) indicated that type 2 diabetes has more. Inheritance from family than type 1 diabetes. Diabetes prevalence increases with increasing family history of diabetes

Majority of respondents (38.88%) said that polyuria was the pre-detective symptom which helped them identify their condition of diabetes. Through doctors' incidental advice 24.44% of the respondent's identified and equal percentage (17.77%) identified due to weight loss and while routine checkup. Up to some extent polydipsia (10%), delayed wound healing (4%) and polyphagia (4%) lead the respondents for diagnosis of diabetes. From the (Table. 1) It is also evident that a very less proportion of population have a habit of undergoing routine health check-up, which is most essential for diabetes management.

Among the list of tests to be undergone, a majority of respondents (88.89%) were found to undergo only fasting and non-fasting glucose tests, only a meagre proportion 27.77% and 22.22%was going for HbA1c test and cholesterol test respectively Overweight category (44.4%) and obese (38.8%) were more than normal weight (16.6%). But, none of the respondents in the study were found underweight.

Table 1. Information seeking behavior of the respondents

n= 90

S.No	Area	Intent 1	Intent 2	Intent 3	Intent 4	Intent 5
1	Clinical information	80.30	4.30	11.30	2.70	1.40
3	Nutrition Information	68.80	19.20	31.80	4.80	2.30
4	Management information	43.30	24.60	29.30	6.50	4.00
Mean score		64.13	16.03	24.13	4.66	2.56

Most of the respondents (64.13%) were seeking information for getting complete picture i.e. intent 1 in almost all the areas, followed by intent 3 for getting a clearer picture (24.13%). According to Erin (2008), the information seekers with intent 1 initiates a search with desire to add new information to an already constructed idea; to link together thoughts or ideas: to remember; to build a more expansive vocabulary in a specific knowledge area. The information seeking process in case of intent 2 seekers are to make change to their ideas upon the information found. For getting a clearer picture i.e. intent 3, the seeker identifies correlation between ideas and views; these ideas with greater definition and understanding. With regard to intent 4, the individual seeks information to relieve existing doubt about an idea, while getting a position in picture intent 5 is to formulate a viewpoint or opinion.

For all sorts of communication with regard to diabetes, the majority respondents were interacting with doctors. Except for dietary information dietician were hardly interacted. Information from friends, relatives, co-diabetics and relatives was also not much.

With regard to daily exposure, to TV was highest (93.33%), followed by mobile SMS (58.88%) and newspaper (55.55%). Magazines were read weekly by a majority (35.55). That might be the reason for exposing to games and puzzles up to 38%. These are usually printed in magazines.

From the above study, it can be concluded that most of the diabetic were of middle aged group with high education level. The respondents had sedentary lifestyle. Respondents had a habit of taking junk foods, respondents regularly consumed desserts and confectionary. The junk foods in diet along with desserts and confectionary may be risk factors for diabetes among the respondents. Cold beverages which included cold drinks as well as sweetened fruit drinks, were taken by majority of the respondents. Majority of respondents were seeking information for getting complete picture i.e. intend 1 in almost all the areas, followed by intend 3 for getting a clearer picture. For all sorts of communication with regard to diabetes, the majority respondents were interacting with doctors

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FAMILY HEALTH CARE COSTS OF LIFESTYLE DISEASES

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Health care has emerged as one of the most progressive and target sector in India, with a GDP spend of 8 per cent in 2012 up from 5.5 per cent in 2009. Health care in India is at an inflection point now and is poised to grow up to US$ 280 billion by 2020 which is a growth of over ten times since 2005 (Source: Indian Hospital Services Market Outlook).

People are predisposed to various diseases based on their way of living and occupational habits (Sharma and Majumdar 2009). These are termed as 'Lifestyle Diseases'. It is only in the last decade that it has become clear that lifestyle diseases are killing more people than communicable ones. Lifestyle diseases are slow progressing, long duration, largely preventable illnesses that result from numerous common modifiable risk factors.

The total family expenditure on medical bills has increased by 317 per cent in urban areas and 363 per cent in rural areas. For institutional care, this increased by as much as 541% in urban areas between 2000 and 2012 (Varma in Times of India, July 13, 2014). He also mentioned that for an urban family of four, average medical expenses would be about Rs.200 per month for normal medical care while it is Rs.120 in rural areas.

The study 'preventative healthcare and corporate female workforce' (2007) reported by ASSOCHAM stated that about 47 per cent spent less than Rs. 500 in a year, 22 per cent spent about Rs.500 - 5,000 and another 29 per cent spent between Rs.5, 000 - 50,000 on health care if hospitalized or with multiple complications. A tremendous effect of this on the family's finance and psycho social aspects is also seen.

This study was done with an objective to investigate the factors associated with the health care costs by the family. The survey was conducted in Hyderabad and Secunderabad. Sample size was limited to 100 families purposively identified based on lifestyle diseases like diabetes, chronic diseases, arteriosclerosis, nephritis, and hypertension experienced by the family members and based on the economic decision making power.

The results of the study revealed that the factors associated with expenditures for healthcare of lifestyle diseases were medicines, diagnostic tests, consultation fess, and transport charges. In addition to these, diet and exercise to control the disease condition /s were also observed as the factors of healthcare costs. The results are presented below;

The results showed that that more than 75% of the respondents choose to visit a private hospital to consult a doctor for treatment rather than a government hospital. The costs of consultation fee revealed that 68% spent Rs.100 to 500 only, 29% spent between Rs.500 to 1,000 and the other 3% spend more than Rs.1,000. For Lifestyle diseases doctor consultation is periodic i.e., for every 15 days / one / two / three months. Out of 100 respondents, 56% visit the hospitals and pay the consultation fees every 15 days while, 27% pay once in three months, once in six months was paid by 11% and once in a year was paid by 6% of the respondents. The amount spent for consultation depends upon the type of hospital they prefer to visit. Opinion scores about the consultation fees showed that only 22% of the respondents felt the amount paid for consultation fee was expensive. A little more than 50 per cent felt it as neither expensive nor cheap, 27% felt the consultation fees as cheap.

Out of 100 respondents, 42 pay Rs.100 to 500, each time they need to undergo a test, 34% spent between Rs.500 to 1,000, and the other 24% spent more than Rs.1000. Respondents who pay once in every month were 41%, 34% pay once in every three months, 22% pay for every six months and other 3% pay once in a year. Opinion scores about the

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payment on diagnostics tests showed that, 75% felt it was expensive, 21% felt as neither expensive nor cheap and the other 4% felt it as cheap.

The results showed that out of 100 respondents, 62% spend between Rs.100 to 500, 24% spend between Rs.500 – 1,000, and 14% spent more than Rs.1,000. Total respondents who spent transport charges frequently, (once in a month) were 89%, 6% pay once in three months 3% were spending once in six months and 2% were spending once in a year. Opinion scores revealed that only 37% felt expensive about these costs, 24% felt as neither expensive nor cheap and 39% felt it as cheap.

The results showed that most of the respondents preferred allopathic medicines compared to ayurvedic, homeopathic or unani medicines. The healthcare costs of the family on medicines revealed that out of 100, 40% spent between Rs.100 to 500, around 43% spend between Rs.500 to 1000, and 17% spend more than Rs.1000. About 88% of the sample studied spent every month on medicines, 7% spend once in three months, only two spent once in six months and the other three once a year. The opinions about the costs of medicines indicated that 75% respondents felt expensive, 20% felt neither expensive nor cheap and the other five felt the amount spent on medicine as cheap.

Figure 1. Health Care Costs of Family

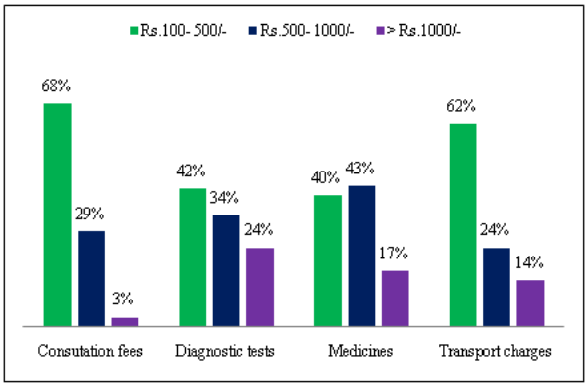
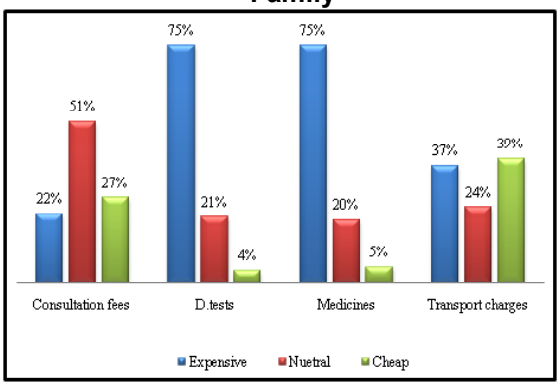


Figure 2. Opinion on Healthcare Costs of The Family



The findings about the dietary costs revealed that most of the respondents (65%) followed regular diet, preceded by diet with modifications like calorie control diet (2) and vegan diet (4), flexitarian (2), fruitarian(1) and supplements . The results about the amount spent on diet revealed that 27% spent between Rs.500 and 1,000, 12% spent from Rs.1,000 to 2,000 while other 35% spent between Rs.2000 and 5,000 and 26% spent more than Rs.5,000. The results about the opinion scores showed that 74% felt the amount spent for diet as expensive, 16% felt neither expensive nor cheap while the other 10% felt it as cheap.

The results showed that 53% of the respondents preferred walking, 30% preferred yoga and the other 17% preferred cycling, Gym and aerobics as a mode of exercise. Majority preferred walking and yoga which are considered as traditional and also scientifically good in controlling lifestyle diseases and these types of exercises do not require much as they spend only for walking aids, yoga mat, etc if required. The results also showed that 69% spent up to Rs.1,000, 20% spent between Rs.1,000 and 2,000 while 7% are spending between Rs.2,000 to 5,000/- and other four per cent spent more than Rs.5,000. Opinion scores on the amount spent on exercise showed that 38% felt it as expensive, 25% felt as neither expensive nor cheap and the other 37% felt it as cheap.

From the above study, it can be concluded that the health care costs of the family depends upon their income. Here the amount paid frequently on health care costs by lower income groups was very less amount which was felt expensive, while the higher income groups are paying more and they felt it as neither expensive nor cheap. It can also be concluded that the mode of transport that they commonly use also points towards less expenditure on transport. But people from higher income categories spend more and rarely and felt it as cheap. A significant association was observed between the health care costs i.e., amount spend for consultation fee, diagnostic tests, medicines and also the transport charges, with regard to income proving that as income increases the comparative expenditure on LSD related health care costs also increases.

The facilitation by the government through ration cards for the supply of essential food grains and other requirements also show the trend towards lesser expenditure by the lower income group. An amount between Rs.2, 000- 5,000 and Rs.5000 was being spent by the highest income quintile and their responses show that that they felt it to be neither expensive nor very cheap. Thus it can be seen that the respondents who preferred walking and yoga, spend less, and those who preferred Gym, Cycling, and Aerobics, spend more. The lower expenditure were attributed to factors such as walking aids, yoga mat, etc and the higher expenditures included trainer's cost, equipment cost, etc so they felt expensive. The result showed a significant association between the income levels in regards to the respondents' opinion on their health care costs where as the income increased their response on amount spent shifted from expensive to cheap.

Action is suggested in educating people to make some minor changes in their life styles to avoid these LSD's in their life because these are preventable. It is in the hands of the people to be free of these diseases and save on the expenditures associated with these LSD's and invest that more meaningfully for the benefit of the family's welfare.

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STATUS OF POTASSIUM IN SOILS OF NALGONDA DISTRICT

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Knowledge about nutrients status of the soil and their interrelationship with physical and chemical propertiesis helpful in understanding the inherent capacity of soil to supply essential plant nutrients for utilization by crops. Potassium (K), a component of several minerals is released in soluble and exchangeable formduring weathering of K bearing minerals at widely differing rates.

Soil K exists in dynamic equilibriumin four forms *viz*., water soluble, exchangeable, non exchangeable and lattice K, of which the first two are very important for the growth of plants and microbes. Different forms of K are in a dynamic equilibrium and any depletion in a given form is likely to shift the equilibrium in the direction to replenish it (Ramamoorthy and Velayutham 1976). Major portion of soil K exists as constituent of mineral structure and in fixed or non-exchangeable forms with minorportion as water soluble and exchangeable K.

Knowledge of different forms of K in soil and their distribution in soils helps in assessing long term K availability and making judicious fertilizer recommendations for efficient crop production.

A survey was conducted in Nalgonda district. Soils were collected from 20 different locations varying in texture, cropping systems and available nutrients. They were analysed for salient soil characteristics such as texture, bulk density, field capacity, pH, EC, OC, CEC, available NPK.

The experimental soils from Nalgonda district were light to medium textured and non saline and slightly acidic to alkaline in reaction. The soils were low to medium in organic carbon content and 50 percent soils are low in available nitrogen content. Majority of the soils were low to medium in available phosphorus. The available potassium in these soils ranged from 102 to 790 kg ha^{-1} with a mean value of 333 kg ha^{-1}. The cation exchange capacity of the soils ranged from 6.95 to 15.70 c mol (p^+) kg^{-1} with a mean value of 12.18. The bulk density of soils under study ranged from 1.46 to 1.82 Mg m^{-3} with a mean value of 1.62 Mg m^{-3}. Field capacity of soils under study ranged from 23.44 to 38.39 percent with a mean value of 32.80 per cent. The physical and chemical properties are presented in (Tables 1(a) and 1(b)).

In the soils of Nalgonda district, these fractions *viz.,* water soluble, exchangeable, non-exchangeable/ fixed potassium and total potassium were analysed and expressed in mg kg^{-1} of soil. The data pertaining to different fractions of potassium was presented in (Table 2).

Water soluble potassium was determined in 1:5 soil : water extract by shaking soil-water suspension for 5 minutes. The available potassium was determined using neutral normal ammonium acetate with 1:5 soil :water extract, after shaking for 5 minutes. The exchangeable potassium was obtained as a difference of the available and water soluble potassium. The non-exchangeable potassium was obtained by deducting the available potassium from 1*N* HNO_3 extractable potassium. The method followed for determination of total potassium is as follows 0.1 g of soil (passed through 0.16 mm sieve)

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was taken in to a platinum crucible and 5 ml of 48% hydrofluoric acid was added.The crucible was placed on a sand bath (maintained at 200 to 225 ^{0}C) for 5 min. The crucible was cooled and 5 mL of 6 *N* HCl was added. Filtered the solution in to a 100 mL volumetric flask and made up the volume with water. The K concentration in this was measured using flame photometer.

The water soluble potassium in the soils ranged from 12.0 to 67.5 mg kg^{-1} with a mean value of 23.0 mg kg^{-1} of soil. The 1 *N* NH_4OAc extractable potassium content ranged from 38 mg kg^{-1} of soil to 294 mg kg^{-1} with an average value of 130.9 mg kg^{-1} of soil.

Lowest exchangeable potassium content of 26 mg kg^{-1} of soil in these soils and the highest value of 239 mg kg^{-1} of soil was recorded with an average of 108 mg kg^{-1} of soil.

1*N* HNO_3 extractable K ranged between 244 mg kg^{-1} of soil to 556 mg kg^{-1} of soil with an average value of 305.7 mg kg^{-1} of soil.

Non – exchangeable/fixed potassium ranged between 140 mg kg^{-1} of soil to 262 mg kg^{-1} of soil with an average value of 194 mg kg^{-1} of soil.

Total potassium content in soils of Nalgonda district ranged between 11,500 to 18,000 mg kg^{-1} of soil with an average value of 14,960 mg kg^{-1} of soil.

On an average, the water soluble, exchangeable and non exchangeable/fixed potassium constituted 0.15, 0.72 and 1.30 per cent, respectively of total potassium. This shows that 0.15 and 0.72 per cent of total potassium is available to plants as water soluble and exchangeable fractions. The fixed potassium constituted only 1.30% of the total K. It indicates that these soils contain relatively less portion of total K in the form of fixed K which would supply K to the growing crops over a long period of time.

Low contribution of water soluble K to the total K in soil was also reported by Sharma *et al.* (2009) and Gurumurthy and Prakasha (2011). Appreciably low levels of water soluble, exchangeable and non exchangeable of K in the soils might be due to continuous cropping without additions of K through fertilizers (Santhy *et al.*, 1998).

The water soluble, exchangeable and non exchangeable potassium constituted only 2.17 per cent of the total K, on an average indicating that the per cent contribution of mineral K (not analysed in this study) to total K in these soils was > 90 per cent, thus indicating the dominance of this form over the other forms of K. Similar observation was made by Sharma *et al.* (2009).

Different forms of potassium were correlated with each other at 5% level of significance and it was found that all fractions were positively correlated with each other. The data is presented in (Table 3).

Water soluble K has shown positive correlation with exchangeable (r= 0.81) and available K (r = 0.8). Jatav and Deewangan (2012) reported positive and significant correlation of water soluble K with exchangeable and available K in inceptisols of Chhattisgarh. Water soluble K has shown significant positive correlation with available, exchangeable and non exchangeable K in soils of Kashmir reported by Uzma *et al.* (2016). This indicates that the removal of water soluble K directly equilibrated with exchangeable K to meet the crop requirement as reported by Ram and Prasad (1984).

Available K has shown positive correlation with Exchangeable K (r = 0.99). The exchangeable K was positively correlated with non exchangeable K. The exchangeable potassium was positively correlated with non- exchangeable potassium that indicated difficulty in replenishment of exchangeable form of potassium from minerals, once available pool of K is depleted these soils may show potassium deficiency if subjected to continuous cultivation reported by Mishra and Srivastava (1991).

Table 1 (a). Physical Properties of selected soil samples in Nalgonda

S. No	Mandal	Village	Soil texture	Bulk density (Mg m^{-3})	pH (1:2.5)	EC (1:2.5) (dS m^{-1})	CEC [c mol ($p^{+}kg^{1}soil$]	Field capcity (%)
1	Bhuvanagiri	Veervally	Clay loam	1.46	7.9	1.10	14.50	37.44
2	Choutuppal	Khairthpur	Clay loam	1.71	8.5	0.25	10.38	27.21
3	Gundala	Anantaram	Clay loam	1.73	8.1	0.75	15.70	30.44
4	Tungathurthy	Reddygudem	Clay	1.52	8.0	0.42	13.64	36.43
5	Yadgirigutta	Kacharam	Clay loam	1.71	8.3	0.27	14.08	32.44
6	Alair	Kolanupaka	Clay	1.75	7.9	0.31	13.71	35.23
7	Bibinagar	Kondamadugu	Clay	1.82	6.4	0.23	13.20	23.44
8	Bibinagar	Jameelapet	Sandy clay loam	1.60	7.9	0.55	11.02	34.20
9	Yadgirigutta	Saidapur	Clay loam	1.63	8.1	0.08	8.80	29.60
10	Alair	Sharmapuram	Clay loam	1.64	7.7	0.25	8.60	31.33
11	Chilkur	Kondapuram	Clay	1.63	7.1	0.22	10.63	35.04
12	B.Pochampalle	Juloor	Sandy clay loam	1.56	8.2	0.43	12.71	32.84
13	Chilkur	Chilkur	Clay loam	1.73	8.2	0.27	13.43	34.87
14	Valigonda	Arrur	Clay loam	1.53	7.6	0.52	13.54	35.18
15	B.Pochampalle	Deshmukhi	Sandy clay loam	1.64	7.8	0.22	11.10	31.12
16	Choutuppal	Malkapur	Sandy clay loam	1.53	8.6	0.31	14.10	38.39
17	B.Pochampalle	Danthur	Sandy clay loam	1.68	7.8	0.26	11.55	34.32
18	Bibinagar	Gudur	Sandy clay loam	1.49	7.7	0.34	11.09	34.80
19	Bhuvanagiri	Anantharam	Sandy clay loam	1.70	6.9	0.33	6.95	26.61
20	Alair	Ammanbole	Clay loam	1.58	6.4	0.29	13.43	36.64

Table 1 (b). Chemical properties of the soils of Nalgonda district

S.No.	Mandal	Village	OC(%)	Available N(kg ha^{1})	Available P_2O_5($kgha^{1}$)	AvailableK_2O (kg ha^{1})
1	Bhuvanagiri	Veeravally	0.64	210	30.67	102
2	Choutuppal	Khairthpur	0.63	202	31.63	140
3	Gundala	Anantaram	0.56	295	24.27	150
4	Tungathurthy	Reddygudem	0.62	448	29.08	163
5	Yadgirigutta	Kacharam	0.22	207	53.86	175
6	Alair	Kolanupaka	0.52	123	17.87	177
7	Bibinagar	Kondamadugu	0.62	250	16.52	195
8	Bibinagar	Jameelapet	0.61	274	60.23	197
9	Yadgirigutta	Saidapur	0.44	213	77.86	297
10	Alair	Sharmapuram	0.62	247	89.77	317
11	Chilkur	Kondapuram	0.52	313	30.22	327
12	B. Pochampalle	Juloor	0.60	190	36.92	356
13	Chilkur	Chilkur	0.61	215	81.52	413
14	Valigonda	Arrur	0.64	338	77.94	462
15	B.Pochampalle	Deshmukhi	0.51	186	47.44	480
16	Choutuppal	Malkapur	0.63	163	73.34	492
17	B.Pochampalle	Danthur	0.45	331	32.06	542
18	Bibinagar	Gudur	0.65	210	92.30	591
19	Bhuvanagiri	Anantharam	0.48	162	17.17	671
20	Alair	Ammanbole	0.58	302	35.70	790

Table 2. Fractions of potassium in the soils of Nalgonda district (mg K kg^{-1})

S. No.	Village	Water soluble K	N *N* NH_4OAc extractable K	Exchangeable K	1 *N* HNO_3 extractable K	Non exchangeable/ fixed K	Total K
1	Veeravally	12.0	38.0	26.0	252	214.0	14,800
2	Khairthpur	14.0	52.0	38.0	244	192.0	13,600
3	Anantaram	14.0	56.0	42.0	260	204.0	11,500
4	Reddygudem	13.0	60.5	47.5	320	259.5	15,300
5	Kacharam	15.0	65.0	50.0	288	223.0	14,900
6	Kolanupaka	10.5	66.0	55.5	272	206.0	11,500
7	Kondamadugu	13.5	72.5	59.0	280	207.5	15,100
8	Jameelapet	14.5	73.5	59.0	284	210.5	13,800
9	Saidapur	16.0	110.5	94.5	332	221.5	15,500
10	Sharmapuram	15.0	118.0	103.0	296	178.0	18,800
11	Kondapuram	17.0	121.5	104.5	376	254.5	16,800
12	Juloor	20.0	132.5	112.5	356	223.5	13,400
13	Chilkur	17.0	154.0	137.0	412	258.0	15,900
14	Arrur	25.5	172.0	146.5	380	208.0	12,000
15	Deshmukhi	31.0	178.5	147.5	320	141.5	17,100
16	Malkapur	23.5	183.0	159.5	332	149.0	18,200
17	Danthur	32.5	201.5	169.0	388	186.5	18,300
18	Gudur	34.0	220.0	186.0	360	140.0	12,400
19	Anantharam	67.5	249.5	182.0	400	150.5	14,200
20	Ammanbole	55.0	294.0	239.0	556	262.0	16,000
	Mean	23.0	130.9	108.0	305.7	194.0	14,960
	% of total K	0.15	-	0.72	-	1.30	-

Table 3. Correlation among different fractions of potassium

	K	K	K	K	K
Water soluble K	-	0.82*	-0.11	0.18	0.88*
Exchangeable K	-	-	0.005	0.38	0.99*
Non Exchangeable K	-	-	-	0.02	-0.02
Total K	-	-	-	-	0.34
Available K	-	-	-	-	-

*Significant at 5% level of significant

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A STUDY ON INNOVATIVE FARMERS NETWORK (IFN) FOR TRANSFER OF COTTON (*Gossypium* spp) PRODUCTION TECHNOLOGIES IN TELANGANA STATE

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In an agrarian economy like India, farmers play a major role in agricultural production. In India, more than 65 per cent of the people depend on agriculture to earn their livelihood. In order to augment agriculture and to help the farmers, many policies were evolved over years and they get reflected in the successive Five Year Plans. However, the small and marginal farmers and the landless agricultural labour have been facing problems due to significant changes in production system. A farmer is always under stress and has to struggle for inputs, resources, credit and market support price. In sense, farmers and agriculture always continue to be in the grip of crisis.

With increased emphasis on the demand-driven development, organization of farmers into groups or networks is an important tool that enables them to act as a pressure group to demand their due share in the economic and political power. Everywhere in the globe, small and marginal farmers are collaborating with each other in some or the other way by forming into groups, sharing information and working with each other. Under the existing circumstances, farmer networks can make a positive difference to the lives of the farmers and agricultural labour, as they work towards improving their livelihood options, as well as sustainable management of natural resources.

The networks with common interest can secure access to services, such as training, credit or equipment. Lack of access to any of these could be a vital issue that an individual farmer faces and it gets resolved when he is in a group. This is particularly the case where farmers organize themselves as a response to credit and input needs, marketing concerns, etc., as there are clear economic benefits of working in groups. These include the ability of networks or groups to buy seed and fertilizers in bulk, or access more distant markets, etc. Working together can increase member bargaining power, which helps to share and lower risks of costs. In areas where farmers are scattered geographically and communication is difficult, there is a need for such networks.

Farmers Networks are seen as a useful organizational mechanism for mobilizing farmer's collective self-help action aimed at improving their own economic and social situation and that of their communities. Considering this factor there is a need for not only providing credit to the groups, but also as part of an overall management of financial resources and also agriculture and allied sector development in a sustainable manner, leading to empowerment of the members of farmers networks. Such organizations were perceived to have an ability to generate resources from their members. They could operate at different levels from the local to the national and from adaptive research and extension through the overall technology priority setting and form multiple linkages with the technology and marketing systems.

A Farmer Network – sometimes called a discussion group, gathering or conference-is a way for farmers to exchange information, socialize, learn and connect with peers on a regular, ongoing basis. What is most important about a farmer network and sets it apart from, for example, traditional Extension-based classes is that the farmers decide what they want to learn and create together. Through the network farmers can also organize subgroups based on their interests such as crop based groups, Farmer Interest groups, Commodity based groups, Women groups etc. Network analysis aim to assess the actors, groups, modes of information sharing and the implication of neighbourhood influence on direct and spill over benefits from adopting new varieties and cropping practices. Successful farmer to farmer networks assume that each person has valuable

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knowledge and experience to contribute. Farmer to farmer networks are thriving in India as a way for farmers to pool ideas, exchange perspectives and learn from each other.

Innovative Farmers Network - An ANGRAU's (At present PJTSAU) flagship programme was started with a view to encourage, motivate and also to develop competitive spirit among the farmers. Five identified Innovative farmers from each District were felicitated during 2011 on the occasion of District Agril.Advisory and Transfer of Technology Centre (DAATTC) foundation day celebrations at respective districts. As a follow up action, one innovative farmer from each district having good communication skill and innovative in agriculture were selected for the workshop held during 1st and 2nd of June 2012 at Rajendranagar, Hyderabad. The main objective of the workshop was to develop a Network of Innovative Farmers in the state and to further expand the extension outreach of University Agril.technologies.

The network farmer should educate/ share his innovative / experience / learnings for about 30 farmers (10 in his village, 10 in mandal and 10 in district).This Innovative farmer is a coordinator of 30 farmers in the district and he is the resource person for the farmers training programmes conducted in their locality.

The network coordinators performance is being reviewed at every crop season to document the lessons and also developing future strategies. They are also taken to an exposure visit to Tamil Nadu during 2014 and provided to see practically the precision farming, organic farming and future prospects.

The Telangana state was selected purposively for the study. The Warangal district of Telangana state was selected purposively as cotton is the major crop in Warangal district and networking is also in progress.

There are fifty seven (51) mandals in Warangal district, among these three mandals were selected randomly for the study. From each mandal five (02) villages i.e. a total of ten (06) villages were selected randomly. From each selected village, ten network farmers were selected randomly, thus a total of 60 network farmers of cotton cultivation were constituted as sample for the study.

The variables selected to study the profile of the farmers were age, education, farm size, farming experience, socio political participation, mass media exposure, risk taking ability, innovativeness, extension contact, socio economic status, service orientation and team work. The data from the respondent farmers were collected with the help of schedules and interviews. The data collected were analysed and suitable interpretations were drawn. The statistical techniques like class interval, frequency and percentage were followed to analyse the data. Accordingly the respondents were classified into various groups.

The data were collected from the network farmers on selected profile characteristics. The data thus collected were analysed and interpreted.

It is evident from the Table 1, that majority (68.30%) of the Network respondents belonged to middle age followed by young (21.70%) and old (10.00%) age respectively. The reason for this trend was due to that the young and middle aged farmers were highly innovative, energetic and willing to work in team and were service oriented compare to non-network farmers. They were also motivated by DAATTC scientists and private companies to cultivate cotton crop. The results were in confirmation with the findings reported by Gangadhar (2009) and Prashanth (2011)

It could be observed from the (Table 1.) that majority of the Network respondents had education up to high school level (41.70%) followed by primary education (23.30%), College and above (21.70%) and illiterate (13.30%). Reasons for some of the members to pursue above high school level was due to their keen interest to study. As majority of network farmers belong to high school, they can easily disseminate the information to other farmers and motivate others to join the Innovative Farmers Network.

It could be observed from the (Table 1.) that majority (85.00%) of Network farmers were big farmers followed by small (8.30%) and marginal (6.70%). This is because most of them were from joint families and

land was not fragmented and also they have high socio economic status. As the majority of them are middle and young farmers, they work hard and also doing business also.

The results in the (Table 1.) indicated that, majority of Network members had medium level of farming experience (56.70%), followed by low (35.00%) and high (8.30%) respectively in cotton cultivation. The reason for medium farming experience could be attributed to their middle age and young age. This experience enabled them to better comprehend and adopt the technologies in Bt cotton and communicate easily. Similar results were obtained by Shanti Nirmala (2010).

The results in the (Table 1.) indicated that, majority (60.00%) of Network members had medium level of socio political participation, followed by low (33.30%) and high (6.70%) respectively. The reason could be due to the fact that few social organizations are active in the villages and the small and marginal farmers were not in reach of social organizations at present in the villages and it might also be due to the lack of awareness of the importance of participation in these organizations in terms of roles, responsibilities and functions.

The results in the (Table 1.) indicated that, most (46.70%) of Network members had medium level of mass media exposure, followed by high (40.00%) and low (13.30%) level respectively. The reason for this is the network farmers are educated up to high school and can access TV, mobile, Radio to know latest agricultural information and to communicate the same in networking. Some of them were unable to access internet and kiosks

The results in the (Table 1.) indicated that, majority (65.00%) of Network members had high level of risk taking ability, followed by medium (30.00%) and low (5.00%) respectively. The reason could be regular agro advisory services given by network coordinator, more experience in farming, awareness of technology, confidence on research scientists, better team work and availability of inputs from the local farmers society at lesser prices etc. Hence they are capable to face risk. Similar results were obtained by Anitha (2003).

The results in the (Table 1.) indicated that, majority (86.70%) of Network members had high level of Innovativeness, followed by medium (11.60%) and low (1.70%) respectively. It was due to the fact that majority of the respondents had formal education and having high risk taking ability. Findings also revealed that they are ready to change enterprise if better opportunity comes and want to try always new things. Farmers are more interesting and enthusiastic towards income generating activities.

The results in the (Table 1.) indicated that, majority (66.70%) of Network members had medium level of extension contact, followed by high (21.60%) and low (11.70%) respectively. It was because of their good contacts with PJTSAU University, the extension personnel, department of agriculture staff and frequent contact with DAATTC/KVK scientists for want of timely agricultural advisory. This might be due to fact that the immediate and long term needs of farmers would force them to have more contacts with scientists of KVK, ARS and extension workers. The results are in accordance with the findings of Reddy (2003).

The results in the (Table 1.) indicated that, majority of Network members had high level of socio economic status (83.30%), followed by medium (11.70%) and low (5.00%) respectively. This is because majority of them are from joint families resides in pucca house and engaged in agricultural and also business activities.The results are in accordance with the findings of Roy *et.al*., (1969)

The results in the (Table 1.) indicated that, majority (91.70%) of Network members had high level of service orientation, followed by medium (5.00%) and low (3.30%) respectively. The reason for this is they are highly innovative, risk oriented and are willing to work in teams. All the network farmers, not only giving agro- advisory services, but also supplying quality inputs at reasonable price through Mahalakshi society.

The results in the (Table 1.) indicated that, majority (70.00%) of Network members had high level of Team work, followed by medium (25.00%) and low

(5.00%) respectively. This is because most of the network farmers had high service orientation, innovative and big farmers. They were motivated by DAATTC scientists and other extension personnel to work in teams for regular agricultural information flow and to achieve best results. Similar results were obtained by Krotz (2003).

Table 1. Distribution of beneficiaries according to their profile characteristics

n=60

S.No	Profile characteristics	Class	Frequency	Percentage (%)
1.	Age (years)	Young (up to 37) Middle aged (37-53) Old (>53)	13 41 6	21.7 68.3 10
2.	Education	Illiterate	8	13.3
		Primary school	14	23.3
		High school	25	41.7
		College and above	13	21.7
3.	Farm size	Marginal	4	6.7
		Small	5	8.3
		Large	51	85
4.	Farming experience	Low	21	35
		Medium	34	56.7
		High	5	8.3
5.	Socio political participation	Low	20	33.3
		Medium High	36 4	60 6.7
6.	Mass media exposure	Low	8	13.3
		Medium	28	46.7
		High	24	40
7.	Risk taking ability	Low	3	5
		Medium	18	30
		High	39	65
8.	Innovativeness	Low	1	1.7
		Medium	7	11.6
		High	52	86.7
9.	Extension contact	Low	7	11.7
		Medium	40	66.7
		High	13	21.6
10.	Socio economic status	Low	3	5
		Medium High	7 50	11.7 83.3
11.	Service orientation	Low	2	3.3
		Medium	3	5
		High	55	91.7
12.	Team work	Low	3	5
		Medium	15	25
		High	42	70

The analysis of profile characteristics of network farmers indicates that majority of them were middle aged with high school education, big farm size and fell under medium category in terms of farming experience, socio political participation, mass media exposure, extension contact and high level of risk taking ability, innovativeness, socio economic status, service orientation and team work.

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BUSINESS FEASIBILITY OF MANUFACTURING COIR FIBRE AND COIR YARN

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Coir is the fibre or thread obtained from the husk of the fruit of the coconut *(Cocos nucifera*). It is one of the innumerable products of the coconut palm, and is a by-product of the coconut industry. Coir fibre is 100 per cent natural, biodegradable and environmental friendly.

Coir has been known and is in use in India for more than 1000 years. India is now the largest producer and consumer of coir and coir products of the world with a contribution of 70 per cent to the world production of coir and coir products. The coir industry has its presence in major coconut growing states and union territories i.e. Kerala, Tamil Nadu, Odisha, Andhra Pradesh, Karnataka, Maharashtra, Goa, Assam, Andaman and Nicobar, Lakshwadeep. Climate of these states is suitable for coconut plantation, hence coir units find it easy to procure raw material in these states. The Coir Board, a statutory body was established by the Government of India under the aegis of Ministry of Micro, Small and Medium Enterprises, Government of India. It helps in development and strengthening of domestic market for coir and coir products and also development of export market (MSME, 2013). Kerala registered highest number of coir units i.e. 8790, whereas Tamil Nadu is in second position with 3824 coir units in the year of 2013-14. Tamil Nadu stands first in production of coir fibre and coir yarn among all the coir producing states in india.

The study was conducted in Puri district which stands first in production in Odisha state. Puri district has 15 blocks out of which one block Satyabadi was selected based on criteria of highest production and number of coir units. Six gram panchayats Biswanathpur, Kadua, SriRamachandrapur, Nuasomeswarapur, Biraramachandrapur and Penthapada were selected randomly to collect data from coir manufacturers. The primary data relating to costs and returns in manufacturing coir fibre and coir yarn was selected from a sample of 15 coir products manufacturing units through personal interview method with the help of pre-tested schedule. Secondary data pertaining to coir units was collected from coir board, journals, magazines and Government websites.

Processing of coir husk to fibre and then to yarn is an important process in manufacturing other coir products like coir ropes, coir mats and coir rugs. The firms which process coir husk into fibre also process it into coir yarn.

Table 1. Variable cost components for producing coir fibre and coir yarn

Sl.No	Cost components	Cost of production of coir fibre (Rs q^{-1})	Percentage	Cost of production of coir yarn (Rs q^{-1})	Percentage
1.	Cost of raw material	1000.00	56.29	2500.00	63.29
2.	Cost of procurement	250.00	14.08	250.00	6.33
3.	Cost of labour	253.33	14.25	800.00	20.25
4.	Cost of power	160.00	9.00	266.67	6.75
5.	Cost of machine running	80.00	4.50	133.33	3.38
6.	Interest on working capital	33.33	1.88	-	-
		1776.66	100	3950.00	100

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The returns of the processors depend upon the efficient utilization of the raw materials. Costs are estimated based on per quintal of raw material used. Of the total variable cost of making coir fibre, the cost of raw material (Rs. 1000 per q^{-1}) was the major cost component which constituted about 56.28 per cent of the total processing cost. The next important variable cost incurred was transportation of raw material which was estimated at around Rs. 250 q^{-1} which contributed about 14.07 per cent to the total processing cost. The other important cost incurred was labour wages i.e. Rs. 253.33 q^{-1} (14.25 per cent), besides electricity charges, miscellaneous costs and interest on working capital were about Rs. 160 q^{-1} (9.00 per cent), Rs. 80.00/ quintal (4.50 per cent) and Rs. 33.33 q^{-1} respectively. Total variable cost of processing coir into coir fibre was around Rs. 1776.66 q^{-1}, which is 30.11 per cent of total cost of producing coir fibre.

The variable cost of producing coir yarn was estimated at Rs. 3950 q^{-1}. The cost of raw material was the major component of variable cost and it worked out to Rs. 2500 q^{-1} (63.29 per cent). The other major component of variable cost was labour wages, which accounted for Rs. 800 q^{-1} i.e. 20.25 per cent of total variable cost. Electricity cost, transportation cost and miscellaneous costs amounted to Rs. 266.67 q^{-1} (6.75 per cent), Rs. 250 q^{-1} (6.85 per cent) and Rs. 133.33 q^{-1} (3.38 per cent) respectively. Variable cost of making coir yarn accounted to 66.95 per cent of total cost.

The main component of fixed cost was interest on the long term borrowing which amounted to Rs. 80.03 q^{-1} constituting 47.92 per cent of total fixed cost. The depreciation on machinery and building was valued at 53.87 q^{-1} (31.09 per cent). Other fixed cost component was office and administrative charges which was around Rs. 36.36 q^{-1} (20.98 per cent). Total fixed cost of coir processing unit was Rs. 173.26 q^{-1}.

Raw material required for making coir fibre is coir husk whose cost is Rs. 1000 per quintal of husk and for making coir yarn coir fibre is used as raw material. The cost of coir fibre processing firm is around 2500 q^{-1} of coir fibre. It is essential to mention that white fibre is usually used for making coir yarn because of its superior quality than brown fibre.

100 kg of coir husk generally results in production of 90 kg of coir fibre. Hence cost for 90 kg of coir fibre works out to around Rs. 1776.66. 100 kg of coir fibre, which is raw material for coir yarn, produces 98 kg of coir yarn. The cost of producing one kg of coir fibre is Rs. 19.74, whereas the cost of producing one kg of coir yarn is Rs. 40.30.

Table 2. Fixed cost components for producing coir fibre and coir yarn

SL.No	Cost components	Amount in Rs	Percentage
	Fixed cost:		
1.	Office and administrative expenses	36.36	20.98
2.	Depreciation on building and machinery	53.87	31.10
3.	Interest on long term borrowings	83.03	47.92
		173.26	**100**

Source: Primary data

The coir processing unit processed about 82.5 quintals of raw material per month, working 8 hours a day and 180 days in a year (15 days in a month). On an average eight persons were working per day i,e. 120 man days per month. As indicated in the table 3 total cost of the processing was Rs. 5899.92/quintal and the gross return worked out to Rs. 6668.00/quintal. Therefore a net return of Rs. 768.08/quintal was obtained from the processing of coir husk into coir fibre and coir yarn.

Table 3. Returns from processing of coir husk into fibre and then coir yarn

Sl.No	Particulars	Unit	Coir fibre	Unit	Coir yarn	Total
1.	Quantity processed	Qt/month	75		7.5	
2.	Quantity produced	Qt/month	67.5	Qt/month	7.35	
3.	Price	Rs./kg	24	Rs./kg	46	
4.	Total cost	Rs./qt	1863.29	Rs. /qt	4036.63	5899.92
5.	Gross return	Rs./month	162000	Rs./month	33810.00	2992500
6.	Gross return	Rs./qt	2160	Rs./qt	4508	6668.00
7.	Net return	Rs./qt	296.71	Rs./qt	471.37	768.08

Source : Primary data.

Total cost of making coir fibre (Rs. 1863. 29^{-1}quintal) is less than coir yarn (Rs. 4036.63). Net return of coir fibre is Rs. 296.71^{-1} quintal which is lower than coir yarn (Rs. 471.37). However coir fibre is used as raw material for making yarn, hence cost of making coir fibre is less than coir yarn. But coir units produce high quantity of coir fibre than coir yarn per year, hence returns from coir fiber are more than coir yarn. Coir fibre and yarn are used as raw material for making different coir products like coir ropes, mats, rugs and mattings. From the analysis of costs and returns of manufacturing coir fiber and coir yarn it can be concluded that these units give a return of about 13 per cent over the investment. So it can be taken up as a secondary occupation by farmers who are into coconut plantations

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PRODUCTION AND EXPORT OF ALMONDS – A CASE STUDY OF AFGHANISTAN

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Agriculture sector in Afghanistan contributed 24.32 per cent to the Gross Domestic Product (GDP) in 2014-15. The agriculture sector's share in overall employment in Afghanistan is 59 per cent. The total exports from Afghanistan were US$570.5 million in 2014-15. The major export items were carpets and rugs (17% of the total export of the country), dried fruits (37%), medicinal plants (6%), fresh fruits (5%), skin (2%) and other items (33%). Hence, dry fruits constitute an important export item from Afghanistan.

In 2014-15, World production of almonds was 1,077,000 MT (kernel basis), 96 per cent increase compared with 2004, which confirms the upward growth trend in the last decade. The United States of America with 834,000 MT, Australia with 65,000 MT and Spain with 48,000 MT remain the major producers, accounting for 87 per cent of World's almond production, followed by Iran 35.000 MT, Afghanistan 14850 MT, Tunisia 14.000 MT and others, 50.150 MT. (Angaza, 2007).

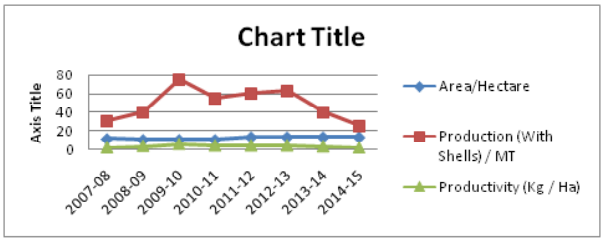
The data for the study was collected from various secondary sources, like Government of Afghanistan publications, USAID reports, FAO reports, journals and websites. The data to estimate the trends in production, area, productivity and export of Almonds from Afghanistan has been collected for the period of 2007-2014. The cultivated area of almonds is during 2013-14 was 13703 hectares, which constituted 0.82 per cent of the total cultivated area.

Four aspects related to Afghan almond production and exports were studied: the trends in area, production and productivity of almonds in Afghanistan, the trends in domestic consumption and exports of almonds from Afghanistan, SWOT analysis of almond sub sector in Afghanistan and export channels and problems inherit in these channels.

Trends in area, production and productivity of almonds from Afghanistan

(Figure 1) depicts the year wise area, production and productivity of almonds in Afghanistan. It shows that there is an increase in area with respect to the period from 2007-08 up to 2014-15, expect for the years 2009-10 and 2010-11 which shows a decrease in area under cultivation of almonds. In case of production, there is a high instability in production of almonds. It shows an increase from 2007-08 upto 2009-10. In the year 2010-11 production has decreased. Again there is an increase in production of almonds from 2010-11upto 2012-13. From 2012-13 the production has decreased continuously upto the year 2014-15. Similarly, productivity of almond has shown downward trends from the period of 2007-08 upto 2014-15. The productivity of almonds has shown a downward trend in the study period. Though area under almond cultivation has shown a slight increase during the study period, production and productivity have shown a negative trend. This was due to adverse weather conditions during the blooming of almond trees and other factors such as the attack of pests and diseases.

Fig 1. Area, Production and Productivity of Almonds in Afghanistan from (2007-08-2014-15)



Source: Afghanistan Central Statistic Organisation Yearbook (CSO), FAOSTAT.

Trends in domestic consumption and exports of almonds to various countries

It is observed from the figure 1 that has production has decreased over the study period, however there is substantial increase in domestic consumption of almonds in Afghanistan. The exports have continuously decreased from the year 2007-08 up to 2010-11. In 2011-12 there is slight increase in

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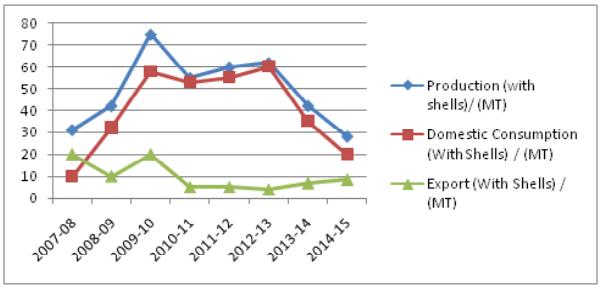
the export of almonds from Afghanistan. In 2012-13 Afghanistan has again exported less in comparison to the previous year. A slight increase in exports was noticed during 2014-15. Exports of almonds have decreased by more than 60 per cent from 2007-08 to 2014-15, though there are years when exports have shown a positive growth trend in comparison to the previous years. This trend in exports can be attributed to the activities taken up by almond organizations such as Afghanistan Almond Industry Development Organisation and many other almond exporting organizations established during the period and agreement called APTTA (Afghanistan – Pakistan Transit Trade Agreement) signed by Afghanistan and Pakistan which allows Afghanistan trucks to transit goods to both nations. However, it can be noticed that the activities of theses organizations have been sporadic hence, increase in exports can be noticed only in few years.

Fig 2. Productions, Domestic Consumption and export of Almond from Afghanistan (2007-08 to 2014-15)



Source: Afghanistan Central Organisation Yearbooks (CSO), FAOSTAT, 2014-15

With regard to the domestic consumption, people prefer soft shell type of almonds and soft shell and hard medium shell types of almonds are usually exported as kernel or in shells.

The export destinations for Afghan almonds and amounts exported are shown in the (Tables 1, 2 and 3.) Afghanistan has exported 6800 MT of soft almond, hard almonds and pip of almonds in the year 2014-15 from the production of 27400 MT. Most of almonds are exported to the regional traditional markets such as India, Pakistan and Iran. In the year 2014-15 India has imported 320954 kg of soft almonds, 356330 kg of hard almonds and 1335274 kg kernels of almonds which was worth 1609111 US$, 498862 US$ respectively. Hard almonds were mostly exported to Pakistan. In the year 2014-15 Pakistan has imported 1427749 kg hard almonds, 147958 kg soft almonds and 514848 kg of almond kernels. Germany and Turkey are other export destinations for Afghan almonds in Europe. In the year 2014-15, 201252 kg and 347000 kg kernels of almonds were exported respectively to these countries.

Table 1. Exports of Afghan soft almonds to various countries in 2014-15

Sl. No	Country	Soft Almonds (Kg)	Value (US$)
1	India	320954	1609111
2	Pakistan	147958	746245
3	Iraq	2040	10404
4	Tajikistan	2104	8104
5	UAE	15610	79611
6	UK	657	3443
Total		**489323**	**2456918**

Source: Afghanistan Central Statistic Organization Yearbook, 2014-15.

Table 2. Export of Afghan almond kernels to various countries in 2014-15.

Sl. No	Country	Kernel of almonds (Kg)	Value (US$)
1	India	1335274	14530366
2	Pakistan	514848	5435478
3	Turkey	347000	3742000
4	Germany	201252	2269268
5	Iran	45680	529888
6	Iraq	22200	180480
7	UAE	10039	116452
8	Tajikistan	3000	34800
9	Australia	1646	19088
10	Canada	1705	19772
11	USA	652	7563
12	Saudi Arabia	568	6589
Total		**2483864**	**26891744**

Source: Afghanistan Central Statistic Organization Yearbook, 2014-15.

Table 3. Export of Afghan hard almonds to various countries in 2014-15

Sl. No	Country	Hard almonds (Kg)	Value (US$)
1	India	356330	498862
2	Pakistan	1427749	1998849
3	China	11000	15400
Total		**1795079**	**2513111**

Source: Afghanistan Central Statistic Organization Yearbook, 2014-15

SWOT analysis of Afghan almond production and export

The various strengths of the Afghan almonds include almond being competitive export product for Afghanistan, existence of a domestic market, the Afghan product being well-known in certain export markets (India), suitable for growing almonds in Afghanistan, product does not require cold storage (easy storage) and availability of almonds. Whereas the weakness of almonds production and exports include, inconsistent supply and quality, relative high cost of raw products, lack of quality control (sorting and grading) and certification, lack of packaging and labeling, lack of value addition by processing, lack of diversified export buyers, lack of direct linkages with export markets, lack of professional (honest) business conduct and general low level of technical knowhow and marketing skills.

The opportunities that exist for the almond industry in Afghanistan are in the area of sorting, grading,

control, certification, packaging and labeling, low-value processing, like chafed, nakul (sugared almonds), etc, high-value processing, especially almond oil and addressing new export markets (may require meeting higher standards). However, the Afghan almond industry also faces certain threats like infection of almonds by aflatoxins, competition in international markets getting more intense (US almonds are dominating many traditional markets like Pakistan), price competition in international markets and international competitors entering domestic markets. (Afghanistan investment support Agency, 2006).

From the SWOT analysis of almond production and marketing in Afghanistan it can be seen that though Afghanistan has the resources to produce almonds and has a rich base of different varieties of almonds, it is unable to tap the export markets as it is unable to maintain quality standards according to the international standards.

Another major issue being faced by Afghan almonds industry is lack of deshelling and processing units. No value addition is being done to almonds. Because of these reasons, Afghan almonds command a very less price in international markets. Only the high grade nuts are accepted by importing countries. Interventions in the area of training the farmers in production techniques would help in increasing the quality and quantity of produce. Encouraging investments in producing technologies which can be managed at the farmers level would help in augmenting the income of farmers. Ensuring a fair and hassle free trading atmosphere will help traders as well as the farmers and would boost the exports of almonds to other countries.

Channels adopted to export almonds from Afghanistan

One of the objectives of the study is to analyze the channels of marketing adopted to export almonds from Afghanistan to various countries. Hence, the various market participants are identified. The channels that are usually adopted to export almonds are:

1. Producers Middlemen/trader Wholesalers Exporters Destination country.
2. Producers Wholesalers Exporters/processor Destination country
3. Producers Middlemen/trader Exporters/processor Destination country

The almond value chain is plagued by many constraints like : (i) limited access to high-quality inputs and supplies; (ii) overall lack of access to extension services; and (iii) lack of market information at the lower levels, specifically among producers, middlemen, and village traders. The other constraints include poor quality control and post-harvest handling, lack of appropriate financing services, lack of formal export support, trade barriers, access to land, unpredictable and inconsistent taxation environment, multiple export control, absence of an agreement with the Pakistani authorities on transit of Afghan goods, lack of support from the Raisin and Dried Fruit Export Promotion Institute, absence of insurance services, absence of quality standards and certification and security challenges.

Afghanistan has the climatic capability that allows it to produce high quality almonds. Afghanistan also has indigenous varieties grown nowhere else and these varieties hold a special position in the markets where they are exported to. Therefore, Afghanistan has the potential for being a significant competitor in at least the Indian market, plus it has potential in other regions of the world that have significant number of ethnic South Asians. However, the Afghan almond industry must initiate changes in how they grow, handle and market their product. Government support and subsidies to farmers will help them lower the cost of raw material and inputs. Thus it will increase production and farmer's income as well as trader's income in the almond value chain. Farmer and middle level traders can be trained in low level of processing like chafed and Naku l (sugared almonds). Entrepreneurs can be encouraged to take up high value processing like almond oil, flour etc. Enhancement of the general level of technical knowledge and marketing skills of farmers is required to have positive impact on production and export of almonds from Afghanistan. Afghanistan almond industry should create a brand name for Afghan almonds to differentiate it from other almonds in the market and invest in promotion of the product to other countries.

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EFFECT OF HEAT TREATMENT AND GAMMA IRRADIATION ON THE TOTAL BACTERIAL COUNT OF SELECTED MILLET GRAINS

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Irradiation is one of the processing technologies currently available for the inactivation of microorganisms, and it has proved successful in ensuring the safety and extending the shelf life of foods (Mahapatra *et al.*, 2005). Irradiation protects foods by reducing parasites, food borne pathogens and spoilage microorganisms, and eliminating pests and insects. Proper irradiation in terms of intensity and treatment time or irradiation rate can maintain, extend shelf life or improve the technological properties of food (Loaharanu, 1989),while providing an alternative to chemical conventional treatments (Toledo *et al.*, 2007). The Food and Agriculture Organization of the United Nations (FAO)/ International Atomic Energy Agency (IAEA)/World Health Organization (WHO) announced that dosages or irradiation not more than 10 kGy would not result in toxic danger in the case of meat and meat products. It is a non-thermal treatment used for food preservation because it eliminates insects, insect eggs and microorganisms, improving the hygienic quality and maintaining nutritional value of food. Ionizing radiation can improve quality of food by inactivating the anti-nutritional factors and inhibiting the allergenic compounds. Moreover, it is a quick treatment that requires minimal sample preparation and not depends on reagents.

Millet processing and heating was carried out at millet processing centre; grains were irradiated at irradiation unit of Professor Jayashankar Telangana State Agricultural University. The microbiological analysis was conducted at the department of Agricultural Microbiology and Bio energy, College of Agriculture. Sorghum and foxtail millet grains were collected from RARS , Nandyal, ANGRAU and pearl millet from RARS, Palem, Professor Jayashankar Telangana State Agricultural University. All the grains were stored in polythene bags until used under dry and cool conditions away from insects and pests. The grains were dehulled in an abrasive dehuller (Gurunanak Engineering Co, Hyderabad) up to 17 % removal of bran. In the present experiment electric rotary dryer (S K Engineering, New Delhi) was used which can be operated continuously for large quantity of grain. Whole and dehulled grains of 5kg of all three millets were exposed to heat treatment at a temperature of 150-170°C for 1.5 min at 300 rpm. The millet grains were irradiated using cobalt – 60 gamma sources. Two dosages 1.0kGy and 2.5 kGy were administered. Grains of 500 g were packed in polythene pouches and exposed to the irradiation .Grains from various millets were ground into flour (NISA Mill, Amin enterprises, Hyderabad) to pass through BSS no 60 mesh sieve (British sieve standard to obtain uniform particle size of the flour)

The TBC of the samples was determined by using plate count agar**.** This was estimated according to the procedure of Aneja *et al.* (2003). The sample was agitated for 15 minutes on a vortex and serial dilutions of sample suspensions were prepared. Serial dilutions were prepared for different bacteria and molds.0.1ml of respective dilutions were spread on sterilized petri plates containing specific media *i.e.* Nutrient agar (general cultivation of bacteria.) and the petri plates were incubated at room temperatures ($28^0C \pm 2\ ^0C$) for 24-72 h and 25^0C respectively.

All the treated grains along with a control sample (500g each) were stored for 30, 60, 90 days in HDPE pouches at 34°C to 36°C of temperature and 23% of humidity. The estimations were done at the end of 30^{th} day, 60^{th} day and 90^{th} day. The study was conducted using 3x8x4 factorial design, with three types of grains, eight types of treatments and four levels of storage (Table 1)

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Table 1. The details of treatments used for the study

SNo	Treatments (8)	Grains (3)	Storage period(4)
1	Control –Whole grain	Sorghum	0 Day
2	Control- Dehulled grain	Pearl millet	30th day
3	Heat treated –Whole grain	Foxtail millet	60th day
4	Heat treated –Dehulled grain		90th day
5	Heat and 1.0kGy Irradiated -Whole grain		
6	Heat and 2.5kGy Irradiated - Whole grain		
7	Heat and 1.0kGy Irradiated -Dehulled grain		
8	Heat and 2.5kGy Irradiated - Dehulled grain		

All the results were statistically analyzed using STAT GRAPHICS centurion version 17.1.11. Multifactor ANOVA technique was used to test the significance of treatments total bacterial count of the millet grains (Snedecor and Cochran, 1983). Comparison and significant difference between samples were found by conducting multiple range tests using Fisher's Least Significant difference (LSD).

In the present study whole and dehulled grains of Sorghum, Pearl millet and foxtail millet were used as controls to investigate the effects of heating and irradiation (1.0kGy and 2.5kGy) on TBC. In general WC grains had higher bacterial count than that of dehulled grains. In whole grains TBC was found to be 160.125×10^{-6} $CFUg^{-1}$. Heat treatment reduced the TBC by 130.5×10^{-6} $CFUg^{-1}$ (81.50 %, $p<0.01$). A higher reduction (89.75 %, $p<0.01$) was observed in heat coupled with irradiation at 1.0 kGy. Further increase in the irradiation dosage from 1.0 kGy to 2.5 kGy reduced the TBC significantly by 150.56×10^{-6} $CFUg^{-1}$ (94.02 %t, $p<0.01$). The effect of heat treatment is higher in whole grains than that of dehulled grains.

The TBC of dehulled control sample was 38.6×10^{-6} $CFUg^{-1}$. Heat treatment resulted in the reduction of TBC by 10.15×10^{-6} $CFUg^{-1}$ (26.6 percent, $p<0.05$). There was no significant difference between DHE and WHE. Combination of heat and irradiation at 1.0 kGy and 2.5kGy reduced the TBC by 67.1 % (25.54×10^{-6} $CFUg^{-1}$) and 33.51×10^{-6} $CFUg^{-1}$ (88.04 %, $p<0.01$) respectively in dehulled grains ($p<0.01$). Both in whole and dehulled grains irradiation at 2.5kGy is more effective than all other treatments .Overall there was a gradual reduction in the TBC from control to heat, heat and irradiation at 1.0 and 2.5 kGy suggesting that irradiation is an effective measure for the selected millets to control the bacterial contamination during storage (90 days).

Irrespective of treatments and storage, highest total bacteria count was observed in foxtail millet (50.2×10^{-6} $CFUg^{-1}$) followed by sorghum (44.140×10^{-6} $CFUg^{-1}$) and pearl millet (17.75×10^{-6} $CFUg^{-1}$). The predominant microorganism present in pearl millet has *Bacillus subtilis* (Badau, 2006). The studies on storage effect revealed that the total bacterial count has significantly increased from 0 to 90 days ($p<0.01$). However, there was no significant difference between 0 to 30 days and 60 to 90 days of storage. From initial (34.03×10^{-6} $CFUg^{-1}$) there was a slight increase (3.87 %) and from 30 to 60 days and 90 days there was a significant ($P<0.05$) increase of 15.78 percent and 9.48 percent respectively. However there was no significant increase from 60 to 90 day ($P>0.05$). In whole grains maximum TBC was observed in sorghum followed by pearl millet and foxtail millet, while it was foxtail millet followed by sorghum and pearl millet in dehulled grains. Dehulling of foxtail grain itself reduced the TBC to a large extent, and there was no significant difference in DC and WHE grains, suggesting that dehulling is on par with heat treatment in controlling TBC in foxtail millet. The effect of heat treatment is more in pearl millet than in sorghum and foxtail millet. The combination effect of heat treatment with irradiation at 1.0 kGy is higher in pearl millet than in sorghum and foxtail millet. Amongst all the treatments, heat treatment in combination with irradiation at 2.5kGy was more effective than 1.0 kGy. The effect of irradiation treatment was more on pearl millet followed by foxtail millet and sorghum (Fig 1).

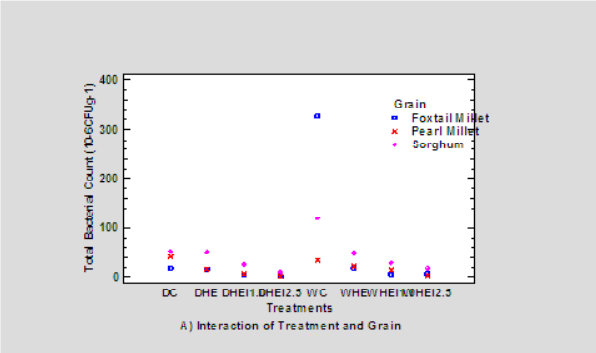

Fig 1. Effect of Interaction of Treatment and Grain

The interaction effect of treatment and storage clearly showed that TBC in WC is much higher at all storage periods (Fig.2). In DC highest TBC was in sorghum, followed by pearl millet foxtail millet, while in WC it was foxtail millet, sorghum and pearl millet.

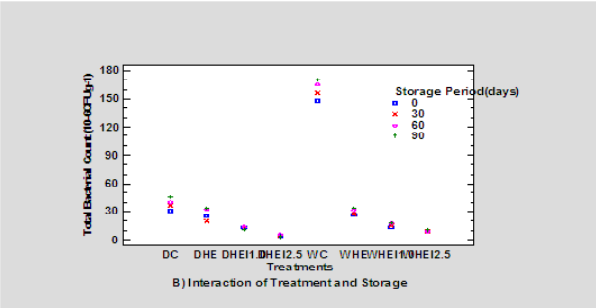

Fig 2. Effect of Interaction of Treatment and Storage

Interaction of grain and storage revealed that least TBC was found in pearl millet at all storage periods and maximum in foxtail millet. In foxtail millet there was gradual increase in TBC during the storage. In pearl millet there was a reduction from 0 to 30 days, however from 30 to 60 days, there a significant increase; and from 60 to 90 days there was no significant change ($p>0.05$). In sorghum there was a marginal reduction in the TBC at 30 days but again slight increase and then again a reduction was observed (Fig. 3).

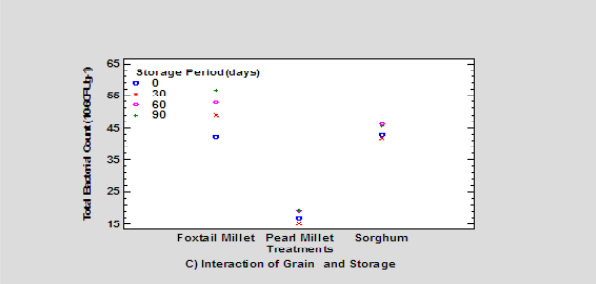

Fig 3. Effect of Interaction of Grain and Storage

The irradiation significantly reduced the TBC in both dehulled and whole grains. However the effect was more pronounced in whole grains than in dehulled grains. Higher reduction (89.75 percent) was observed in heat coupled with irradiation at 1.0 kGy. Further increase in the irradiation dosage from 1.0 kGy to 2.5 kGy reduced the TBC significantly ($p<0.05$) by 150.56×10^{-6} $CFUg^{-1}$ (94.0 %). No significant difference between was observed in DHE and WHE. Both in whole and dehulled grains, irradiation at 2.5kGy is more effective than all other treatments. Storage studies revealed that the least TBC was found in pearl millet at all storage periods and maximum in foxtail millet.

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EFFECT OF SEWAGE SLUDGE ON GOLDEN ROD (*Solidago* spp.)

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India has a long tradition of floriculture. In India, flowers are cultivated in area of 2.72 lakh ha with annual production of about 16.8 lakh million tonnes during the year 2013, earning 17.7 lakh million rupees by their export (Indian Statistical Data Base 2013). Golden rod is considered as one of very desirable wildflower. Most of its species are used in making medicines, carotene extraction and decorations. Sewage sludge is a by product of municipal sewage treatment processes and its land application is one of the important disposal alternatives. Being rich in organic and inorganic plant nutrients, sewage sludge may substitute for fertilizers, and as a amendment to the soil, modifies its physico-chemical and biological properties. But, presence of heavy metals may limit its usage in crops which can be circumvented if used for flower crops as they don't enter into food chain.

Pot culture experiment was conducted on alfisols (red soil) at green house farm of the Department of Horticulture, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2013 to study influence of sewage sludge on growth and yield of golden rod (Var. Early Bird). The sewage sludge for present study was taken from Noor Mohammad Kunta-Sewage Treatment Plant (NMK-STP) which is situated 2.5 km away from College of Agriculture, Rajendranagar, Hyderabad. The experiment was laid out in Completely Randomized Design (CRD) with three replications. There were seven treatments consisting of T_1 (20% sewage sludge), T_2 (40% sewage sludge), T_3 (60% sewage sludge), T_4 (80% sewage sludge), T_5 (100% sewage sludge), T_6 (RDF-Inorganic N, P and K @ 100, 100 and 100 kg ha^{-1}, respectively) and T_7 (Control).

The results revealed that the sewage sludge was moderately acidic in reaction with a pH of 5.81, EC of 5.48 dS m^{-1}, total organic carbon content of 25.76 per cent and with a sludge volume index (SVI) of 482.71 mL g^{-1}. Total N, P and K contents of sewage sludge were 3.29, 1.23 and 2.98 per cent, respectively. The triacid extractable zinc in sewage sludge was 27.72 mg kg^{-1} while, the diacid extractable heavy metals viz., Cd, Co, Ni and Pb were 0.97, 0.37, 1.69 and 6.86 mg kg^{-1}, respectively and are within the permissible limits as per the standards of USEPA.

Application of sewage sludge increased the plant height of golden rod at all (30, 45 and 60 DAT, (Table. 1.) growth stages of crop. The plant height was linearly increased with increase in sewage sludge application rates and it was significantly highest in 100% sewage sludge treatment (44.4, 57.5 and 72.5 and 72.5 cm, respectively) at all growth stages of crop of study.

Significantly maximum number of leaves (67.9 plant-1, (Table 1.) were recorded at 30 DAT in 100% sewage sludge (T5) followed by 80% sewage sludge (48.1 plant-1) and in contrast, the lowest number of leaves (14.9 plant-1) were recorded in Control (T7). Sewage sludge application at higher dose (20 t ha^{-1}) enhanced number of leaves, leaves area, shoot length and root length in maize Qasim *et al*. (2001).

Application of sewage sludge increased in carotene content (optical density) in inflorescence as compared with Control and Recommended dose of fertilizer. Carotene content was significantly highest (1.277 OD, Table 1.) in 80% sewage sludge treatment (T4). Antolin *et al*. (2005) evaluated the effect of the sewage sludge on the barley and opined that, the leaf protein concentration was higher in plants from the beginning of development stage to era emergence in sewage sludge amended soil over other treatments.

Weight of 100 spikes recorded on the basis of randomly selected 100 spikes (g 100-1) ranged from 640.0 g 100-1 in Control (T_7) to 850.0 g 100-1 in 80% sewage sludge (T4). The maximum weight (850.0 g 100-1, Table 2.) recorded in 80% sewage sludge

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(T4) was on par with 100% sewage sludge treatment (825.0 g 100-1).

Significantly maximum dry matter production (31.7 and 67.5 g plant^{-1}, respectively, Table 2.) was recorded in 100% sewage sludge treatment (T_5) in contrast to the lowest value recorded in control (15.6 and 31.7 g plant^{-1}, respectively) at mid (45 DAT) and harvesting stages (90 DAT) of crop. Higher availability of nutrients in soil under sewage sludge amendment was the main factor contributing to higher biomass of plants (Singh and Agarwal, 2009). As the doses of sewage sludge increased from 20 to 30 t ha^{-1}, the production of dry matter also increased in maize (Krishnasamy *et al.*, 2002).

The striking and interesting feature observed in terms of days to first bud appearance (DAT) was that unlike to the values recorded with respect to earlier mentioned parameters viz., plant height, number of leaves and dry matter production, the minimum days for first bud appearance (30.6 DAT, Table 2.) were noticed in 80% sewage sludge (T_4) followed by 100% sewage sludge (32.7 DAT). In contrast, the maximum days for first bud appearance (40.8 DAT) were observed in Control (T_7). Begum (2011) reported that, application of municipal sewage sludge vermicompost (MSSVC) @ 20 t ha^{-1} significantly increased number of fruits per plant and fruit weight of tomato than more dose (30 t ha^{-1}) of MSSVC.

The maximum number of spikes per plant (5.43 platn^{-1}, Table 2.) were recorded in 100% sewage sludge (T_5) followed by 80% sewage sludge (5.06 plant^{-1}). The lowest number of spikes (2.53 platn^{-1}) were recorded by the treatment of Control (T_7) throughout the crop growth stages. Sewage sludge application @ 6, 9 and 12 kg m^{-2} resulted in, respectively about 39%, 60% and 76% more yield in *Vigna radiata* (Singh and Agarwal, 2010).

The total weight of spikes per plant was linearly increased with increase in sewage sludge application rates. The highest (44.8 g platn^{-1}) and lowest (16.2 g platn^{-1}) total weight of spikes per plant was observed in treatments of 100% sewage sludge (T_5) and Control (T_7), respectively.

Table 1. Effect of sewage sludge on plant height, number of leaves per plant and carotene content of Golden Rod

Treatments		Plant height (cm)			Number of leaves per plant			Carotene content (Optical density)	Weight of 100 spikes (g 100^{-1})
		30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT		
T_1	20 % of sewage sludge	22.4	35.7	51.4	15.8	3.8	64.0	0.927	703.0
T_2	40 % of sewage sludge	26.5	39.8	55.1	22.8	38.0	71.1	1.127	722.0
T_3	60 % of sewage sludge	31.3	44.9	59.8	32.1	47.8	80.8	1.170	741.0
T_4	80 % of sewage sludge	37.3	50.3	66.0	48.1	64.6	93.8	1.277	850.0
T_5	100 % of sewage sludge	44.4	57.5	72.5	67.9	83.9	1.6.5	1.197	825.0
T_6	RDF (Recommended Dose of Fertilizer)	25.4	38.9	54.2	17.3	32.8	65.9	1.007	660.0
T_7	Control (Untreated)	20.2	33.6	48.4	14.9	29.6	63.0	0.780	640.0
	SEM±	1.1	1.5	1.6	1.3	1.5	2.0	0.023	19.2
CD at 5%		4.6	4.6	4.9	4.1	4.8	6.3	0.071	58.9

DAT-Days After Transplanting

Table 2. Effect of sewage sludge on dry matter production, days to first bud appearance, number of spikes per plant and total weight of spikes per plant of Golden Rod

Treatments		Dry matter production (g plant^{-1})		Days to first bud appearance (DAT)	Number of spikes per plant	Total weight of spikes per plant
		Mid stage	Harvesting stage		Up to harvesting stage	Up to harvesting stage
T_1	20 % of sewage sludge	15.9	32.3	39.5	3.76	26.4
T_2	40 % of sewage sludge	19.2	39.8	36.6	4.16	30.0
T_3	60 % of sewage sludge	23.0	48.2	34.7	4.76	35.3
T_4	80 % of sewage sludge	27.9	59.0	30.6	5.06	43.0
T_5	100 % of sewage sludge	31.7	67.5	32.7	5.43	44.8
T_6	RDF (Recommended Dose of Fertilizer)	17.5	36.0	37.7	4.10	27.0
T_7	Control (Untreated)	15.6	31.7	40.8	2.53	16.2
	SE m±	0.9	1.3	0.8	0.12	0.8
CD at 5%		2.8	4.0	2.6	0.38	2.4

DAT-Days After Transplanting, Mid stage – 45 DAT, Harvesting stage – 90 DAT

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INTEGRATED WEED MANAGEMENT IN *RABI* GROUNDNUT (*Arachis hypogea* L.)

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Groundnut or peanut (*Arachis hypogea* L.) is known as the *'king'* of oilseeds. India is one of the largest producers of Oilseeds in the world, accounting for 8% of the global oilseeds production using 14% of the world land area, and notified as the second largest producer of groundnut. The demand for edible oils in the country is rising by 6 per cent per year. Therefore, concerted efforts are now being made for increasing and stabilizing oilseed production. One of the major constraints in groundnut production is the weed menace and losses caused by weeds are more than any other causes like insects, diseases and nematodes. On an average the loss of groundnut production in the country due to weeds has been estimated to the tune of 13-80% (Ghosh *et al.* 2000).

In groundnut, less crop canopy during the first 6 weeks of crop growth favours strong competition with weeds, causing significant reduction in yield. Therefore, timely and effective weed control during this critical period of crop weed competition becomes necessary for attaining maximum yield (Etejere *et al.* 2013). (Wesley *et al.* 2008) reported that the critical period of grass weed control was found to be from four to nine weeks after planting whereas, the critical period of broad leaved weeds control was from two to eight weeks.

It has also been recommended that there should be no intercultural operations applied at pegging stage of the crop (45 days after sowing). Thus, in case of groundnut, early removal of weeds before flowering and during pegging is important (Page *et al.*, 2002).

Pre-plant or pre-emergence chemical weed management using selective herbicides like fluchloralin and pendimethalin control weeds during early stages but late emerging weeds seriously affect the pegging and pod development , disrupt digging, harvesting operations and difficult to strip the pods. Apart from competition for nutrients and other inputs, these late emerging weeds infest the land with weed seeds and make the land less productive in the subsequent seasons (Kanagam, 2003). Early post-emergence herbicides offer great scope to tide over these situations (Vaghasia *et al.*2013)

Weeding and hoeing are common cultural and manual weed management methods for groundnut, but considering the scarcity of labour, these methods are very costly and tedious Mechanically operated power weeder annot be used after peg initiation of groundnut. On the other hand, use of herbicides is also limited due to their selectivity (Walia *et al.*2007).

Henc3 integrated weed management in groundnut has great importance to reap maximum benefit therefore an agronomic investigation was conducted to find out practically convenient and economically feasible combination of chemical and cultural methods of weed management in groundnut.

Field experiment was conducted during *rabi* 2015-16 at College farm,college of agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University. Which is geographically situated at 17º19^{1} N latitude, 78º 28^{1} E longitude and at an altitude of 542.3 m above mean sea level. The results of physico-chemical analysis revealed that the soil was sandy loam in texture, slightly alkaline in reaction, low in organic carbon, high in available nitrogen and potassium, low in available phosphorus.

The experiment was laid out in a Randomised Block Design with 10 treatments replicated thrice in sandy loam soils and kadiri 6 is used as a variety.

The treatments were T_1 oxyfluorfen @ 0.15kg a.i ha^{-1}(PE) fb imazamox + imazethapyr. 70%WG @ 70g a.i ha^{-1} (POE) at 30DAS, T_2 oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE), *fb*imazamox.+

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imazethapyr 70% WG @ 70 g a.i ha^{-1} (POE) at 25 DAS *fb* hand weeding at 40 DAS,T_3 imazamox +imazethapyr 70 % WG @ 70g a.i ha^{-1} (early POE) at 15 DAS and hand weeding at 40 DAS, T_4 imazamox. + imazethapyr 70 % WG @ 70 g a.i ha^{-1}(early POE) at 20 DAS *fb* hand weeding at 40 DAS,T_5 oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) *fb* imazethapyr 10% SL (POE) @ 100 g a.i ha^{-1} at 30 DAS, T_6 oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) *fb* imazethapyr 10% SL (POE) @ 100 g a.i ha^{-1} at 25 DAS and hand weeding at 40 DAS, T_7 imazethapyr 10 % SL (early POE) @ 100 g a.i ha^{-1}at 15 DAS *fb* hand weeding at 40 DAS, T_8 imazethapyr 10% SL (early POE) @ 100 g a.i ha^{-1} at 15 DAS *fb* imazamox.+ imazethapyr @ 100 g a.i ha^{-1} at 40 DAS, T_9 two hand weedings at 15 and 40 DAS,T_{10} unweeded check.

The predominant weed flora of the experimental field consisted of 5 species of grasses, one species of sedge and 8 species of broad leaved weeds. Among the grasses, *Cynodon dactylon, Digitaria sanguinalis, Rotttobolia exaltata, Echinochloa colonum* and *Dactyloctenium aegyptium* were predominant.The only sedge observed was *Cyperus rotundus*. Among the broad leaved weeds, *Parthenium hysterophorus, Commelina benghalensis, Trianthema portulocastrum, Digera arvensis* and *Celosia argentia* were the major weeds.

Herbicidal treatments significantly influenced the Weed control efficiency, Weed index, Pod yield and Haulm yield. At harvest, Lowest weed dry matter (32.67) as well as higher WCE (81.9%), pod yield (1632 kg ha^{-1}) and haulm yield (2456 kg ha^{-1}) was recorded with hand weeding twice at 15 and 40 DAS (T_9) which was at par with T_2 *i.e* oxyfluorfen @ 0.15 kg a.i ha^{1}(PE) *fb* imazamox+imazethapyr @ 70 g a.i ha^{-1} (POE) at 25 DAS *fb* HW 40 DAS ,T_6 *i.e* oxyfluorfen @ 0.15 kg a.i ha^{-1}(PE) *fb* imazethapyr (POE) @ 100 g a.i ha^{-1} at 25 DAS and HW at 40 DAS.(Table 1.)

Imazamox+imazethapyr applied as early post-emergence herbicide also showed highest weed control efficiency applied at 15 DAS but the application of imazamox+imazethapyr at other stages has lower weed control efficiency.Integration of imazamox+imazethapyr with pre-emergence followed by HW at 40 DAS shows good weed control efficiency.

Integration of herbicides and cultural methods like hand weeding has shown significant reduction in weed density. Application of pre-emergence herbicide like oxyfluorfen controls weeds at early stages followed post-emergence application of imazamox+imazethapyr, imazethapyr has controlled weeds at 15,20,25,30 DAS,this was followed by handweeding at 40 DAS has reduced weed density, higher pod yield and b:c ratio this was in agreement with sasikala *et al.* 2004

Table 1. Weed Control Efficiency ,Weed Index,Weed Dry Matter ,Pod yield, Haulm yield and B:C ratio of of groundnut as influenced by integrated weed management practices.

Treatments	WCE (%)	WI (%)	WDM (g m^{-2})	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	B:C ratio
T_1: Oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) fb imazamox+imazethapyr 70% WG @ 70 g a.i ha^{-1} (POE) at 30 DAS	63	24	8.16 (65.67)	1231	1869	3.54
T_2: Oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) fb imazamox+imazethapyr 70% WG @ 70 g a.i ha^{-1} (POE) at 25 DAS fb HW 40DAS	78	1	6.32 (39.00)	1615	2393	3.59
T_3: Imazamox+imazethapyr 70% WG @ 70 g a.i ha^{-1} (early POE) at 15 DAS fb HW at 40 DAS	77	11	6.43 (40.33)	1444	2257	3.40

T_4: Imazamox+imazethapyr 70% WG @ 70 g a.i ha^{-1}(early POE) at 20 DAS fb HW at 40 DAS.	78	17	6.30 (38.67)	1339	2243	3.16
T_5: Oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) fb imazethapyr 10% SL (POE) @ 100 g a.i ha^{-1} at 30 DAS	58	25	8.75 (75.67)	1208	1875	3.58
T_6: Oxyfluorfen 23.5% EC @ 0.15 kg a.i ha^{-1}(PE) fb imazethapyr 10% SL (POE) @ 100 g a.i ha^{-1}at 25 DAS and HW at 40 DAS	77	2	6.48 (41.00)	1593	2327	3.62
T_7: Imazethapyr 10% SL (early POE) @ 100 g a.i ha^{-1} at 15 DAS fb HW at 40 DAS	75	23	6.78 (43.67)	1252	2174	3.01
T_8: Imazethapyr 10% SL (early POE) @ 100 g a.i ha^{-1} at 15 DAS fb imazamox.+ imazethapyr @ 70 g a.i ha^{-1} at 40 DAS.	50	36	9.56 (90.33)	1033	1884	2.94
T_9: Two hand weedings at 15 and 40 DAS	81	0	5.80 (32.67)	1632	2456	3.36
T_{10} :Unweeded check	0	63	13.50 (181.33)	623	1068	2.14
SE(m) ±			0.12	51.33	58.19	
CD at 5%			0.35	152.51	172.90	

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EFFECT OF TEMPERATURE ON RICE BROWN PLANT HOPPER *(Nilaparvata lugens* Stall)

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Rice (*Oryza sativa* L.) is one of the world's most important food crop and is the most widely consumed staple food for a large part of the world's human population, especially in Asia. The average per hectare yield in the country tends to be relatively low compared to China, Sri Lanka, mainly due to heavy losses caused by pests. Rice crop is attacked by 800 species of insect pests in both field and storage. Among these one of the most economically important insect pests is the Brown planthopper (BPH), *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae). The BPH has become more problematic, posing a threat to rice production throughout South and South East Asia. Due to infestation plants turn yellow and dry up rapidly. At early infestation, round and yellow patches appear, which soon turn brownish due to the drying up of the plants and is called as 'Hopper burn' which is reported to cause yield loss ranging from 10-75% (Tirumala rao, 1950).

The rice BPH occurs during both dry and wet seasons and survival, growth, development and multiplication are effected by several biotic and abiotic factors. Among the abiotic factors, temperature play a major role. As a result of climate change it is predicted that global mean temperature will increase by 1.5-6.0ºC by the end of the century (IPCC, 2001). Such changes will alter plant-herbivore interactions through effects on plant, insect growth, development and survival. The temperature effect on BPH studies will pave way for devising suitable management strategies against BPH under climate change scenario and to understand the impact of BPH on different rice varieties.

The effect of temperature on BPH studied at 25ºC, 30ºC, 35ºC and 40ºC, because in telangana region temperature present in between these temperature ranges among several seasons.

The Rice plants were maintained in the glass house at Rice Research Centre, ARI, Rajendranagar.

The brown planthopper populations were reared in insect rearing cages on the susceptible rice variety Taichung Native 1 (TN1) in poly house facility available at Rice Research Centre, ARI, Rajendranagar. The effect of four constant temperature levels *i.e.* 25ºC, 30ºC, 35ºC and 40ºC on BPH fecundity, nymphal survival, duration, adult longevity were studied in B.O.D at 75% RH. For fecundity studies one brachypterous female and one macropterus male were released per hill and each mylar tube was covered with muslin cloth to prevent escape of adults and to provide aeration. The pots were kept at the required temperature in B.O.D. and the BPH were confined for 4 days. The emerged nymphs were observed daily and the total number of emerged nymphs per hill were counted. After nymphal emergence is completed, the unhatched eggs were counted by dissecting leaf sheath and observed under binocular microscope.

Fecundity was calculated by using the following formula given by Manikandan and Kennedy (2013), Fecundity= no of nymphs hatched+unhatched eggs.

% Hachability = no of nymphs×100/no of nymphs + unhatched eggs.

%Unhatched eggs = Unhatched eggs×100/ no of nymphs + unhatched eggs

From 45 to 50 days old rice plants nine tillers were taken from the glasshouse. Each tiller was kept in a glass tube of 2cm diameter and 20cm height. A slice of sponge was placed at the bottom of glass tube to secure rice plant from quick moisture evaporation. The newly hatched nymphs were transferred to glass tubes @ 5 nymphs per glass tube. The glass tubes were covered with muslin cloth

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to prevent escape of nymphs and to provide aeration. After transfering the nymphs, the glass tubes were kept in B.O.D. at required constant temperature. The rice tillers in the test tubes were replaced by fresh rice tillers on alternate days. The nymphal survival data was recorded by observing the nymphs and the dead nymphs were removed with a fine brush. For observing total nymphal survival, five nymphs per glass tube were placed separately at respective temperatures and observed till they become adults. Percent nymphal survival was calculated by using the following formula given by Sucheta Rout and Mayabini Jena (2012),

$$\text{Percent nymphal survival} = \frac{\text{Number of adults emerged}}{\text{Number of nymph released}} \times 100$$

Data on nymphal duration was recorded by observing the exuviae of the nymphs and the mean time taken at respective instars and time from nymphal release to adult emergence was computed. Data on adult longevity was recorded by observing the adults from emergence till death and mean adult longevity was computed in days. For adult longevity studies at 40ºC temperature, the newly emerged adults were released in to glass tubes @ 5 adults per glass tube, the data was recorded by observing the adults from release till death and mean adult longevity was computed in days.

Present results revealed that the temperature of 30ºC resulted in significantly higher nymphal emergence (132.89/female). The next effective temperature was 25ºC (116.78/female) which was significantly different from 35ºC (90.00/female). Compared to 25 and 30ºC, very less number of eggs were laid at 35ºC (90.00/female).There was no egg laying at 40ºC, because the adults did not survive at 40ºC. The per cent hatchability of eggs recorded was significantly higher at 30ºC (100%). The per cent hatchability at 25ºC was found to be 90.02 which was significantly higher than at 35ºC (80.09%). Since the adults did not survive at 40ºC, no hatching was noticed at this temperature.

Table 1. Effect of Temperature on BPH fecundity (Egg/Female)

Treatment	Temperature regimes	Emerged nymphs*	Unhatched eggs*	Total eggs*	%Hatchability*	%Unhatchability
T_1	25°C	105.11[b] (10.27)	11.67[b] (3.48)	116.78[b] (10.83)	90.02[b] (71.62)	9.98[b] (18.38)
T_2	30°C	132.89[a] (11.55)	0.00[c] (0.71)	132.89[a] (11.55)	100.00[a] (85.95)	0.00[c] (4.06)
T_3	35°C	72.00[c] (8.51)	18.00[a] (4.29)	90.00[c] (9.51)	80.09[c] (63.52)	19.91[a] (26.48)
T_4	40°C	0.00[d] (0.71)	0.00[c] (0.71)	0.00[d] (0.71)	0.00[d] (4.06)	0.00[c] (4.06)
C.D.at 5%		0.19	0.20	0.22	0.87	0.87
SE(m)±		0.06	0.07	0.08	0.30	0.30
C.V. (%)		2.51	8.88	2.88	1.61	6.86

* Figures in parantheses are Squre root transformed values

** Figures in parantheses are ARC SIN transformed values

These results are in agreement with the findings of Sucheta Rout and Mayabini Jena (2012) who reported that at a temperature range of 27-33ºC, maximum eggs were laid and the egg laying was completely stopped above 40°C. Manikandan *et al.* (2015) revealed that total number of eggs recorded was more (233) at 30.0°C and less (116) at 36.0°C.

Temperature of 30ºC resulted in highest per cent nymphal survival (Table 4.2) compared to the 25ºC and 35ºC while nymphs could not survive at

constant temperature of 40ºC. Incase of 1st instar nymphs, all the nymphs survived at 25ºC and 30ºC while at 35ºC, the nymphal survival was significantly reduced to 95.56 per cent. In case of 2nd instar nymphs, 95.56 per cent of nymphs survived at 25ºC and 30ºC which was on par with 88.33 per cent nymphal survival at 35ºC. However, compared to 25ºC and 30ºC, slight reduction in nymphal survival was observed at 35ºC. No significant differences were observed across different temperature regimes (25, 30 and 35ºC) with regard to 3rd, 4th and 5th instar. However, relatively higher survival (95.56, 93.33 and 97.22 per cent respectively at 3rd, 4th and 5th instars) was observed at 30ºC. At 40ºC, none of the nymphal instars survived.

The total nymphal survival at 25ºC was 68.89 per cent and at 30ºC it was 71.11 per cent and both were on par with each other. At constant temperature of 35ºC, total nymphal survival was found to be significantly reduced (40.00%) while none of the nymphs developed into adults at 40ºC.

Table 2. Effect of temperature on BPH nymphal survival

Treatment	Temperature regimes	1st instar**	2nd instar**	3rd instar**	4th instar**	5th instar**	TNS**
T1	25°C	100.00^{a} (85.95)	95.56^{a} (80.94)	91.11^{a} (75.94)	92.22^{a} (77.68)	92.22^{a} (77.68)	68.89^{a} (56.40)
T2	30°C	100.00^{a} (85.95)	95.56^{a} (80.94)	95.56^{a} (80.94)	93.33^{a} (78.44)	97.22^{a} (83.06)	71.11^{a} (57.81)
T3	35°C	95.56^{b} (80.94)	88.33^{a} (73.06)	90.56^{a} (75.56)	88.89^{a} (74.41)	91.67^{a} (77.30)	40.00^{b} (39.11)
T4	40°C	0.00^{c} (4.06)	0.00^{b} (4.06)	0.00^{b} (4.06)	0.00^{b} (4.06)	0.000^{b} (4.06)	0.00^{c} (4.05)
C.D.at 5%		4.77	8.95	9.51	10.39	9.58	5.39
SE(m)±		1.65	3.11	3.31	3.61	3.32	1.87
C.V. (%)		7.73	15.60	16.75	15.08	16.48	14.26

TNS=Total Nymphal Survival

** Figures in parantheses are ARC SIN transformed values

Krishnaiah *et al.* (2005) reported that temperatures ranging from 25 to 30ºC are most favourable for multiplication of BPH and the insect cannot tolerate > 35ºC of constant temperature. Sucheta Rout and Mayabini Jena (2012) found that BPH thrived and multiplied well at a temperature of 30 ± 3ºC and temperatures above 30ºC, *i.e.* 33ºC to 35ºC are unfavourable for insect survival.

The developmental time taken by five nymphal stages varied significantly with respect to the temperature. Among different temperature regimes, the nymphal duration at 30°C was lowest during most of the instars except at 3rd to 4th instar, wherein the nymphal duration was lowest at 35°C (2.18 days) as against 2.74 days at 30°C. At 40°C, none of the nymphs survived and reached to respective instars.

During 1st to 2nd instar, lowest developmental time (2.02 days) was recorded at 30°C which was significantly different than at 25 and 35°C. At both the temperatures, the duration was 3.00 and 2.87

days respectively and both were on par with each other. Similar observations were made during 2nd to 3rd and 4th to 5th instars also. However, during 5th instar to adult emergence, all the temperature regimes differed significantly with each other with lowest duration at 30°C, 25°C and 35°C (2.04, 2.27 and 2.96 days respectively). The total nymphal duration was significantly highest at 25°C (12.09 days) while it was significantly lowest at 30°C (9.93 days). The total nymphal duration at 35°C was on par with 30°C (10.73 days).

Sucheta Rout and Mayabini Jena (2012) reported that at mean temperature of 30°C, the nymphal duration was shortest (9-15 days). N.V. Krishnaiah *et al.* (2005) found that the total nymphal duration was 13.68 and 11.88 days at 25 and 30°C respectively. Ramya *et al.* (2012) reported that total life span of BPH at 38°C decreased significantly than at 30°C.

The adult longevity was highest at 25°C (14.97 days) while at 30°C and 35°C the adult longevity was 12.59 and 7.72 days, respectively and at all the three temperature regimes, adult longevity differed significantly with each other. However, at 40°C, adults lived for 2.38 days. Manikandan and Kennedy (2013) reported that the longevity of adult male was 13.25 and 8.5 days at 28.3°C and 36°C, respectively.

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EFFECT OF N, P AND K FERTIGATION LEVELS ON YIELD AND WATER PRODUCTIVITY OF DIFFERENT RICE (*Oryza sativa* L.) VARIETIES UNDER AEROBIC CULTIVATION

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Aerobic rice production is a revolutionary way of growing rice in well-drained, non -puddled, and non-saturated soils without ponded water. This system uses input-responsive specialized rice cultivars and complementary management practices using only 50-70% of the water required for irrigated rice production.This is recommended in areas where water is too scarce or expensive to allow traditional irrigated rice cultivation. As water is becoming a scarce commodity nowadays and it is necessary to find ways and means of using the available water resources in a judicious manner to attain maximum productivity per unit quantity of water. In drip irrigation, water is provided most efficiently at right time and practically near the root zone of the crop. Generally, between 15 to 60 per cent of the fraction of the soil alone is wetted. It enables precise application of water and nutrients at precise zone avoiding soil erosion and drain of water by deep percolation. Irrigation is scheduled through drip to maintain the soil water content near field capacity in the root zone. Another advantage of the drip irrigation is the application of nutrients through fertigation, which could reduce the total amount of nutrients needed by the rice crop thereby increase in nutrient use efficiency. Fertigation is a frontier technology, which permits application of various nutrients and fertilizer formulations directly at the site of active roots in desired concentration, time and thus improves the nutrient use efficiency and the yield of crops. Information on the performance of aerobic conditions with drip fertigation levels is meager.

Keeping in view of above facts a field experiment was conducted at Water Technology Centre, College farm, Rajendranagar, Hyderabad during *kharif,* 2015 to study the response of different varieties of aerobic rice (*oryza sativa l.*) under drip fertigation levels**.** The experiment was conducted with three main treatments and four sub treatments. The main treatments were three rice varieties (RNR 15048, MTU 1010 and Anagha) and the sub treatments were four different fertigation levels (S_0:Control, S_{75}: 90-45-30 kg N-P_2O_5-K_2O ha^{-1}, S_{100}: 120-60-40 kg N-P_2O_5-$K_2O$$ha^{-1}$, S_{125}: 150-75-50- N-P_2O_5-K_2O ha^{-1}). The experimental soil was sandy clay loam in texture, slightly alkaline in reaction (pH-7.9), non-saline (EC-0.65 dS m^{-1}), low in organic carbon (0.12%) and available nitrogen (180 kg N ha^{-1}), medium in available phosphorous (44 kg P_2O_5 ha^{-1}) and high in available potassium (574 kg K_2O ha^{-1}).The mean weekly maximum (RH-II) and minimum relative humidity (RH-I during the crop growing period varied from) 73 to 95.28 % and 39.5 to 75.42 % respectively, during *kharif,*2015 and 369.9 mm of rainfall was received in 26 rainy days. The mean bright sunshine hours per

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day varied from 1.77 to 8.25. The average wind speed varied from 0.1 to 11.34 km h^{-1} in 2015. With respect to pan evaporation, mean pan evaporation ranged 2.7 to 7.98 mm day^{-1} in 2015. The seasonal cumulative pan evaporation during the crop period of *kharif,* 2015 was 687.6 mm.

The amount of water used for irrigating the crop was measured by using water meters and the water productivity was computed and expressed as grain yield in kg per cubic meter of water used. Drip irrigation was scheduled once in 3 days based on daily data of USWB class 'A' pan evaporimeter at 1.5 Epan. The amount of total irrigation water used including effective rain fall (277 mm) was 9720 m^3 for Anagha, 9910 m^3 for MTU 1010 and 10110 m^3 for RNR 15048 through drip irrigation. The differences in amount of water used for different varieties was due to the differences in their crop growth period. The crop growth period noticed was 131, 139 and 151 days for Anagha, MTU 1010 and RNR 15048 respectively. The fertigation was given in ten splits at weekly interval to aerobic rice starting from emergence and ending in flowering stage. The fertigation schedule included application of 5-15-5 % of N-P_2O_5-K_2O during germination and emergence stage in one split (0-10 DAS), 20-39-23% of N-P_2O_5-K_2O during active vegetative stage (11-40 DAS) in three equal splits, 20-26-17 % of N-P_2O_5-K_2O during maximum tillering to panicle initiation stage (41-50 DAS) in two equal splits, 30-15-45% of N-P_2O_5-K_2O during panicle initiation to heading stage (51-80 DAS) in three equal splits and 15-5-10 % of N-P_2O_5-K_2O during heading to flowering (81-90 DAS) in one single split. The fertilizers used were urea, mono ammonium phosphate (MAP) and potassium nitrate.

The additional benefit : cost ratio was worked out by partial budgeting technique by taking into consideration of additional cost incurred for implementation of the treatments and additional benefit obtained. The cost of urea was Rs. 300 per 50 kg bag, mono ammonium phosphate was Rs. 3000 per 25 kg bag, potassium nitrate was Rs. 2500 per 25 kg bag, labour cost was Rs. 200 per eight hours, time required for each fertigation was one hour, cost of paddy was Rs. 17.50 kg^{-1} and paddy straw was Rs. 1.00 kg^{-1}. The total fertigation cost was worked out to be 11,545, 22,050 and 27,450 Rs. at S_{75}, S_{100} and S_{125} fertigation levels respectively. The fertigation cost was high due to use of water soluble phosphatic fertilizer (MAP) and use of potassium through potassium nitrate.

Data on yield attributes like no. of panicles m^{-2}, no. of grains $panicle^{-1}$, panicle length and test weight (g) are presented in Table 1. It is significantly influenced by the varieties, fertigation levels but not by their interactions. At harvest, no. of panicles m^{-2} ranged from 138 to 201. Among all varieties, Anagha (188) recorded significantly the highest no. of panicles m^{-2} followed by MTU 1010 (171) and RNR 15048 (166). The varieties MTU 1010 and RNR 15048 were found to be on par to each other. Among the NPK fertigation levels, S_{125} (192) recorded significantly the highest no. of panicles m^{-2} followed by S_{100} (181), S_{75} (174) and S_0 (152) respectively. Among interactions, higher no. of panicles m^{-2} was observed in Anagha at S_{125} (201) followed by the same variety at S_{100} (195) and

the lowest in RNR 15048 at S_0 (138) followed by MTU 1010 at S_0 (149) respectively. Application of NPK fertilizers by fertigation at regular intervals resulted in better availability of these nutrients during the active vegetative stage and panicle initiation stage and resulted in more number of panicles m^{-2}. Among the varieties, even at lower level of fertigation also the variety Anagha was observed to produce more no. of panicles m^{-2} when compared to the other two varieties. Increase in no. of panicles m^{-2} with increase in N fertilizer level was also reported by Adikant Pradhan *et al*. (2014) among different varieties.

The mean panicle length ranged from 19.3 to 22.5 cm (Table 1). Among all varieties, Anagha (21.9 cm) recorded significantly the highest panicle length followed by MTU 1010 (19.9 cm) and RNR 15048 (19.5 cm). Among the NPK fertigation levels, S_{125} (20.9 cm) recorded higher panicle length followed by S_{100} (20.5 cm), S_0 (20.5 cm) and S_{75} (19.7 cm) respectively. The S_{125} was on par with S_{100} and S_0 and was significantly higher over S_{75}.The S_{125}recorded 1.95 higher panicle length than both S_{100} and $S_0$and 6.09 % higher panicle length than $S_{75.}$ Among interactions, higher panicle length was observed in Anagha at S_{125} (22.5 cm) and the lowest in RNR 15048 at S_{75}. Nonsignificant influence of irrigation methods, schedules and water management practices was reported by Balamani *et al*. (2012).

The no. of grains $panicle^{-1}$ ranged from 71 to 110 (Table 1). Among all varieties, Anagha (99) recorded significantly the highest no. of grains $panicle^{-1}$ followed by MTU 1010 (93) and RNR 15048 (90). Among the NPK fertigation levels, S_{125} (106) recorded significantly the highest no. of grains $panicle^{-1}$ followed by S_{100} (99), S_{75} (92) and S_0 (80) respectively. Among interactions, higher no. of grains $panicle^{-1}$ was observed in Anagha at S_{125} (110) followed by the same variety at S_{100} (105), and the lowest was noticed in RNR 15048 at S_0 (71) followed by MTU 1010 at S_0 (83). Increase in no. of grains $panicle^{-1}$ with increase in NPK doses by fertigation indicates favourable effect of NPK nutrition in increasing the number of grains $panicle^{-1}$.

The test weight ranged from 16.1 to 24.6 g (Table 1). Among all varieties, Anagha (24.1 g) recorded significantly the highest test weight followed by MTU 1010 (21.4 g) and RNR 15048 (17.1 g). Among the NPK fertigation levels, S_{125} (21.7 g) recorded higher test weight. Among interactions, higher test weight was observed in Anagha at S_0 (24.6 g) followed by Anagha at S_{75} (24.2 g), and the lowest in RNR 15048 at S_{75} (16.1 g).The present study revealed that test weight varied mostly with varieties but not by fertigation levels indicating that it is mostly a genetically influenced parameter. Non-significant influence of irrigation schedules on test weight under aerobic cultivation was reported by Balamani *et al*. (2012).

Data on grain yield, straw yield and water productivity are presented in Table 2. The grain yield (kg ha^{-1}) was significantly influenced by both varieties, fertigation levels and by their interactions. It ranged from 1103 to 2578 kg ha^{-1}. Among all varieties, Anagha (1987 kg ha^{-1}) recorded significantly the highest grain yield followed by MTU 1010 (1432 kg ha^{-1}) and RNR 15048 (1360 kg ha^{-1}). The varieties MTU 1010 and RNR 15048 were observed to be on par to each other.

Anagha, recorded 38.75 % and 46.10 % higher grain yield than MTU 1010 and RNR 15048 respectively. There was linear increase in grain yield with increase in fertigation levels. Each higher NPK level was significantly higher over lower NPK level. Among the NPK fertigation levels, S_{125} (1959 kg ha^{-1}) recorded significantly the highest grain yield followed by S_{100} (1707 kg ha^{-1}), S_{75} (1485 kg ha^{-1}) and S_0 (1221 kg ha^{-1}) respectively. The S_{75}, S_{100} and S_{125} have recorded 21.6 %, 39.8 % and 60.4 % higher grain yield over control (S_0). The S_{125}, has recorded 14.76 % and 31.91 % higher grain yield than $S_{100,}$ S_{75} respectively. Among interactions, highergrain yield was recorded by Anagha at S_{125} (2578 kg ha^{-1}) followed by the same variety at S_{100} (2136 kg ha^{-1}) and at S_{75} (1852 kg ha^{-1}). The lowest was recorded by RNR 15048 at S_0 which was on par with MTU at S_0. It was noticed that Anagha at S_0 has recorded on par grain yield (1382 kg ha^{-1}) with RNR 15048 and MTU 1010 at S_{75}. Similarly Anagha at S_{75} has recorded significantly higher grain yield (1852 kg ha^{-1}) than the other two varieties at S_{100} (1504 and 1481 kg ha^{-1}).

It was noticed that under aerobic cultivation, among the varieties tested, Anagha was observed to perform better over other two varieties. As it is the variety specially released for aerobic cultivation, it could adopt to aerobic conditions better than the other two varieties. Katsura and Nakaide (2011) found that the varieties with greater sink activity and source capacity per plant during the ripening period could produce larger grain weight under aerobic culture. Patel *et al.* (2010) identified the rice variety 'Sahsarang 1' as the better choice under aerobic condition in Meghalaya, mid hill eco system and it exhibited the moderate values of photosynthetic rate, transpiration rate and WUE. Mallareddy *et al.* (2012) suggested WGL 32100 variety as better variety in Central Telangana Zone. All the varieties showed linear increase in grain yield with increase in NPK fertigation levels. Application of these fertilizers in multiple splits at regular intervals through fertigation has favoured its all the time availability to the crop which is reflected in increase in yield attributes and finally as grain yield. Among the yield attributes, the no. of panicles m^{-2} and no. of grains $panicle^{-1}$ have mainly contributed to the better performance of Anagha at different NPK fertigation levels. Increase in grain yield of aerobic rice with increase in fertilizer levels was also reported by Malla Reddy *et al.* (2012). Reduction in grain yield to the extent of 19 % to 59 % under aerobic conditions at different moisture regimes than transplanted conditions was reported by Patel *et al.* (2010). Yield reduction of 25 % was observed by Modinat *et al.* (2014) under aerobic conditions in China and 27.5 % by Patel *et al.* (2010) in Meghalaya when compared to flooded condition.

The straw yield (kg ha^{-1}) was significantly influenced by both varieties, fertigation levels and by their interactions (Table 2). It ranged from 2501 to 6378 kg ha^{-1}. Among all varieties, Anagha (4880 kg ha^{-1}) recorded significantly higher grain yield followed by MTU 1010 (3213 kg ha^{-1}) and RNR 15048 (3046 kg ha^{-1}). The varieties, MTU 1010 and RNR 15048 were on par to each other. Anagha, recorded 51.88 % and 60.22 % higher straw yield than MTU 1010 and RNR 15048 respectively. Among the NPK

fertigation levels, S_{125} (4707 kg ha^{-1}) has recorded significantly the highest straw yield followed by S_{100} (3976 kg ha^{-1}), S_{75} (3364 kg ha^{-1}) and S_0 (2805kg ha^{-1}) respectively. Thus with increase in NPK fertilizer levels, a linear increase in straw yields were noticed.The S_{75}, S_{100} and S_{125} have recorded 19.9 %, 41.7 % and 67.8 % higher straw yield over control (S_0). The S_{125} has recorded 18.38 %, 39.92 % and 67.80 % decreased straw yield in $S_{100,}$ S_{75} and S_0 respectively. Among the interactions, significantly the highest straw yield was observed by Anagha at S_{125} (6378 kg ha^{-1}) followed by the same variety at S_{100} (5332 kg ha^{-1}) and at S_{75} (4404 kg ha^{-1}). The lowest was recorded by MTU at S_0 which was on par with RNR 15048 at S_0. Increase in straw yield with increase in NPK / N fertilizer doses was also reported by Rakesh *et al.* (2012) and Malla Reddy *et al.* (2012).

Among all the varieties, Anagha recorded the highest water productivity (0.21 kg m^{-3}) followed by MTU 1010 (0.15 kg m^{-3}) and RNR 15048 (0.14 kg m^{-3}) respectively (Table 2). Anagha recorded 42.5 % and 53.8 % higher water productivity over MTU 1010 and RNR 15048 respectively. With increase in NPK fertigation levels, an increase in water productivity was noticed. Among NPK fertigation levels, S_{125} recorded the highest water productivity (0.20 kg m^{-3}) followed by S_{100} (0.15 kg m^{-3}), S_{75} (0.15 kg m^{-3}) and S_0 (0.12 kg m^{-3}). The S_{75}, S_{100} and S_{125} have recorded 25 %, 25 % and 66.7 % higher water productivity over control (S_0) respectively. Anagha at S_{125} has recorded the highest water productivity (0.27 kg m-3) followed by the same variety at S_{100} (0.22 kg m^{-3}), S_{75} (0.20 kg m^{-3}) and the lowest water productivity was observed in RNR 15048 at S_0 (0.11 kg m^{-3}). Bouman *et al.* (2005) observed that, total water used was 27-51% lower and water productivity was 32 – 88 % higher in aerobic cultivation than that of flooded rice. A water productivity of 2.8 kg ha^{-1} mm was reported by Patel *et al.* (2010) in a sandy clay loam soil in Meghalaya under mid hill ecosystem.

For aerobic cultivation in the present experiment, the additional benefit cost ratio was found to be negative. Data is represented in Table 3. Because of expensive water soluble P and K fertilizers, it dominated the income from the grain and straw yield. However among all varieties, Anagha (-0.29) has recorded lesser negative benefit: cost ratio followed by MTU 1010 (0.70) and it was on par with RNR 15048 (-0.72). Among fertigation levels, S_{125} (-0.46) has recorded lesser negative benefit: cost ratio followed by S_{100} (-0.56) and S_0 (-0.68). Taking in to consideration of economics, to make the fertigation programme for aerobic rice more economically viable, it is suggested to avoid use of costly fertilizers and better to use N through urea, potassium through white potassium chloride. Regarding phosphorus, better to eliminate it in fertigation programme as the water soluble MAP is costly and go for soil application of phosphorus in single basal dose.

Table 1. Effect of different levels of NPK fertigation levels on no. of panicles m^{-2} , panicle length (cm), no. of grains $panicle^{-1}$, test weight (g) of different varieties of rice at final harvest under aerobic cultivation during *kharif*, 2015.

Varieties	Fertigation levels*				Mean
	S_0	S_{75}	S_{100}	S_{125}	
No. of panicles m^{-2}					
RNR 15048	137	163	172	188	**165**
MTU 1010	149	174	175	187	**171**
Anangha	168	186	195	201	**188**
Mean	**152**	**174**	**181**	**192**	
	Main (V)**	Sub (S)	V at same S	S at same V	
SEM ±	2	2	3	4	
CD at 5%	6	7	NS	NS	
Panicle length (cm)					
RNR 15048	19.5	19.3	20.1	20.7	**19.9**
MTU 1010	19.9	18.6	19.6	19.6	**19.5**
Anangha	22.1	21.1	21.8	22.5	**21.9**
Mean	**20.5**	**19.7**	**20.5**	20.9	
	Main (V)	Sub (S)	V at same S	S at same V	
SEM ±	0.3	0.4	0.6	0.6	
CD at 5%	1.2	1.1	NS	NS	
No. of grains $panicle^{-1}$					
RNR 15048	71	89	94	105	**90**
MTU 1010	83	89	96	102	**93**
Anangha	84	97	105	110	**99**
Mean	**80**	**92**	**99**	**106**	
	Main (V)	Sub (S)	V at same S	S at same V	
SEM ±	1	2	3	3	
CD at 5%	4	6	NS	NS	
Test weight (g)					
RNR 15048	17.3	16.1	16.2	19.2	**17.2**
MTU 1010	21.1	20.9	21.6	21.9	**21.4**
Anangha	24.6	24.2	23.5	24.1	**24.1**
Mean	**21.1**	**20.4**	**20.5**	**21.7**	
	Main (V)	Sub (S)	V at same S	S at same V	
SEM ±	0.7	0.4	0.6	0.8	
CD at 5%	2.6	NS	NS	NS	

* S_0= Control (No N, P_2O_5,K_2O), S_{75} = 90-45-30 kg N, P_2O_5, K_2O ha^{-1},
S_{100} = 120-60-40 kg N, P_2O_5,K_2O ha^{-1}, S_{125} = 150-75-50 kg N, P_2O_5,K_2O ha^{-1}
** Main (V) = Main treatments (Rice varieties); Sub (S) = Sub treatments (Fertigation levels)
Interactions = Main treatments x Sub treatments (Rice varieties x fertigation levels)

Table 2. Effect of different levels of NPK fertigation levels on grain yield (kg ha^{-1}), straw yield and water productivity of different varieties of rice at final harvest under aerobic cultivation during *kharif,* 2015.

Grain yield (kg ha^{-1})

Varieties	Fertigation levels*				Mean
	S_0	S_{75}	S_{100}	S_{125}	
RNR 15048	1103	1226	1504	1606	**1360**
MTU 1010	1177	1376	1481	1692	**1432**
Anangha	1382	1852	2136	2578	**1987**
Mean	**1221**	**1485**	**1707**	**1959**	
	Main (V)**	Sub (S)	V at same S	S at same V	
SEM ±	59	45	78	90	
CD at 5%	233	134	163	215	

Straw yield (kg ha^{-1})

RNR 15048	2508	2708	3285	3682	**3046**
MTU 1010	2501	2979	3311	4062	**3213**
Anangha	3406	4404	5332	6378	**4880**
Mean	**2805**	**3364**	**3976**	**4707**	
	Main (V)	Sub (S)	V at same S	S at same V	
SEM ±	136	120	181	206	
CD at 5%	527	309	378	491	

Water productivity (kg m^{-3})

RNR 15048	0.11	0.12	0.15	0.16	**0.14**
MTU 1010	0.12	0.14	0.15	0.17	**0.15**
Anagha	0.14	0.20	0.22	0.27	**0.21**
Mean	**0.12**	**0.15**	**0.15**	**0.20**	

Table 3. Effect of different levels of NPK fertigation levels on additional B:C ratio of different varieties of rice under aerobic cultivation during *kharif,* 2015.

Varieties	Fertigation levels*				**Mean**
	So	S_{75}	S_{100}	S_{125}	
RNR 15048	-	(-) 0.86	(-0.65)	(-0.64)	**(-) 0.72**
MTU 1010	-	(-) 0.74	(-0.61)	(-0.61)	**(-) 0.70**
Anagha	-	(-) 0.44	(-0.13)	(-0.13)	**(-) 0.29**
Mean		**(-) 0.68**	**(-) 3.28**	**(-0.46)**	

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EFFECT OF VARIOUS SOURCES OF ZINC WITH PARTICULAR REFERENCE TO NANO ZINC CARRIER ON GROWTH AND YIELD OF RICE (*Oryza sativa* L.)

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Rice (*Oryza sativa* L.) is the dominant staple food for more than 50% of world population and India ranks first in the world in terms of area of rice cultivation with 44.6 m ha and second in productivity of 2.96 t ha^{-1}. In Telangana state, rice is grown in an area of 1.7 m $ha^{-1}$with a production of 6.4 m tons with a of productivity 3.6 t ha^{-1}(India Stat.com., 2015-16).

Micronutrients are essential for crop production and their deficiency affects growth, metabolism and reproductive phase of crop plants. Among the micronutrients, zinc deficiency in plants and soils has been reported across the world. In India, zinc is considered as the fourth important yield limiting nutrient after nitrogen, phosphorus and potassium respectively.

Application of zinc fertilizers is essential in keeping sufficient amount of available zinc in soil solution, maintaining adequate zinc transport to seeds and increases the crop yield. Hence it is essential to minimize the nutrient losses in fertilizer application, increase the crop yield through the exploitation of new applications with the help of nano technology and nano materials. The nano fertilizers or nano encapsulated nutrients might have the properties that are effective to crops, release the nutrients on demand, controlled release of chemical fertilizers that regulate the plant growth and enhanced target activity. Owing to the high surface to volume ratio, the efficacy of nano fertilizers may surpass the most innovative polymer coated conventional fertilizers which have seen little improvement in the past decade. Thus nanotechnology could provide devices and mechanisms for release of zinc when it is stable, there by releasing the nutrients on demand, by preventing them from getting converted to unavailable form. (DeRosa *et al.,* 2010).

An experiment was conducted during *kharif*, 2015 at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University in Randomized Block Design with 12 treatmentsand 3 replications. The treatments were viz., T1-Control (no fertilizers were applied), T2-RDF@ N,P_2O_5 and K_2O@120:60:40 kg ha^{-1}, T3-RDF+soil application of $ZnSO_4$@25kgha^{-1} at transplanting, T4 and T5- RDF +soil application of nano Zn @10 kg $ha^{-1}$and 15 kg ha^{-1},T6 and T7- RDF +soil application of bio Zn @15 kg $ha^{-1}$and 30 kg ha^{-1} at transplanting , T8-RDF +foliar application of 0.2 % as $ZnSO_4$ at tillering and panicle emergence stage, T9 and T10-RDF +foliar application of 1 ml l^{-1} and 2 ml l^{-1} as nano zinc at tillering and panicle emergence stage, T11 and T12 - RDF +foliar application of 1.5ml l^{-1} and 3ml l^{-1} as bio zinc at tillering and panicle emergence stage.

It can be reported that with the application of zinc the plant height increased with the increasing age of the crop. There was a significant difference and the highest plant height at 60DAT, 90DAT and harvest (Table1) was recorded in the treatment receiving RDF + Soil application of bio Zn @ 30 kg ha^{-1} (100.6cm) was followed by T8 (100.3cm) andT9 treatment (98.6cm). Similar results were also observed by Khan *et al.* (2007).

The highest number of tillers m^{-2} was observed in the treatment receiving RDF+ Soil application of bio zinc @30 kg ha^{-1} (440.0 tillers m^{-2}), RDF +foliar spray of 0.2% $ZnSO_4$ (433.4 tillers m^{-2}), RDF+ foliar spray of 1ml l^{-1} as nano zinc (426.8 tillers m^{-2}) which were on par with each other. The lowest was recorded in control (338.8 tillers m^{-2}) followed by RDF@120:60:40 kg ha^{-1}(341.0 tillers m^{-2}).The results indicated that all the applied doses of zinc fertilizers increased significantly the number of panicles m^{-2} (Table2) as compared to absolute control or RDF. The maximum number of panicles was recorded in the treatment receiving RDF+ Soil application of bio zinc @30kg ha^{-1} (446.6 panicles m^{-2}), which was on par

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with RDF +foliar spray of 0.2% $ZnSO_4$ (444.0 panicles m^{-2}), RDF+ foliar spray of 1ml l^{-1} as nano zinc(442.1 panicles m^{-2}), RDF+ Soil application of $ZnSO_4$@25kg ha^{-1} (434.5 panicles m^{-2}).

Highest number of filled gains $panicle^{-1}$ was recorded in the treatment receiving RDF+ Soil application of bio zinc @30 kg ha^{-1} (133.3 $panicle^{1}$). Nawaz *et al.*(2004) reported that the increase in number of filled grains $panicle^{-1}$ could be attributed to adequate supply of zinc and its effect on enhancing the physiological function of the crop influencing the uptake of plant nutrients through enzymatic activity in the metabolic process and better assimilation of carbondioxide in the panicle.

The influence of zinc application was not significant on the 1000 grain weight in rice. However an increasing grain weight was recorded with the application of zinc. A slight increase in 1000 grain weight could be due to efficient participation of zinc in the number of metabolic processes involved in the production of healthy seed. Similar results were also reported by Abid *et al.* (2011).

There was a significant difference between the treatments related to grain yield. The treatment receiving RDF+ Soil application of bio zinc @30 kg ha^{-1} (5355 kg ha^{-1}) recorded the highest grain yield and was on par with RDF +foliar spray of 0.2% $ZnSO_4$ (5268 kg ha^{-1}), RDF+ Foliar spray of 1ml l^{-1} as nano zinc(5247 kg ha^{-1}).The lowest grain yield was recorded in the treatment receiving RDF@120:60:40 kg ha^{-1}(3768 kg ha^{-1}) followed by control (2604 kg ha^{-1}).

There was a significant difference seen among different zinc treatments for their effect on straw yield. The treatment receiving RDF+ Soil application of bio zinc @30 kg ha^{-1} (6347 kg ha^{-1}) recorded the highest straw yield and was on par with RDF +foliar spray of 0.2% $ZnSO_4$ (6258 kg ha^{-1}), RDF+ foliar spray of 1ml l^{-1} as nano zinc(6189 kg ha^{-1}).Compared to all the treatments the lowest straw yield was recorded in the treatment receiving RDF@120:60:40 kg ha^{-1}(4621 kg ha^{-1}) followed by control (3324 kg ha^{-1}).These findings are in agreement with the results obtained by Keram *et al.*(2012). The results have clearly brought out the fact that application of bio zinc and nano zinc fertilizers both as soil and foliar application have resulted in obtaining the yields and on par with the conventional zinc application.

Table 1. Effect of various sources of zinc on plant height(cm).

S.No	Treatment	Tillering stage	Panicle emergence stage	Grain filling stage	Harvest
T1	Control (no fertilizers were applied)	30.0	76.0	85.9	91.1
T2	Recommended dose of N:P_20_5:K_2O @120:60:40 Kg ha^{-1}	35.5	87.3	90.0	95.6
T3	RDF +Soil application of $ZnSO_4$ @25Kg ha^{-1} at transplanting	39.0	92.0	96.0	97.6
T4	RDF +Soil application of nano zincas impregnated granules @10kg ha^{-1} at transplanting	35.8	88.6	93.2	95.9
T5	RDF +Soil application of nano zinc as impregnated granules @15kg ha^{-1} at transplanting	36.1	89.4	93.7	96.0
T6	RDF +Soil application of bio zinc@15 kg ha^{-1} at transplanting	37.0	90.2	94.7	96.3
T7	RDF +Soil application of bio zinc@30 kg ha^{-1} at transplanting.	40.6	93.8	98.9	100.6

T8	RDF +Foliar spray of 0.2% as $ZnSO_4$	40.1	93.2	97.9	100.3
T9	RDF +Foliar spray of 1ml l^{-1} as nano zinc	39.8	92.9	96.8	98.6
T10	RDF +Foliar spray of 2ml l^{-1} as nano zinc	36.8	89.6	94.0	96.0
T11	RDF +Foliar spray of 1.5ml l^{-1} as bio zinc	38.3	91.4	95.8	97.5
T12	RDF +Foliar spray of 3ml l^{-1} as bio zinc	37.8	90.4	95.0	97.3
	SE(m) ±	0.7	0.91	1.21	1.34
	CD at 5%	2.1	2.6	3.7	3.9

Table 2. Effect of various sources of zinc on growth and yield components

S.No	Treatment	No of tillers m^{-2}	No of panicles m^{-2}	Filled grain panicle^{-1}	Test weight	Grain yield	Straw yield
T1	Control (no fertilizers were applied)	315.8	348.8	84.0	17.0	2604	3324
T2	Recommended dose of $N:P_20_5:K_2O$ @120:60:40 Kg ha^{-1}	341.0	365.5	94.0	20.0	3768	4621
T3	RDF +Soil application of $ZnSO_4$ @25Kg ha^{-1} at transplanting	398.3	434.5	116.9	21.3	4807	5855
T4	RDF +Soil application of nano zinc as impregnated granules @10kg ha^{-1} at transplanting	363.0	370.6	97.6	20.2	3942	4806
T5	RDF +Soil application of nano zinc as impregnated granules @15kg ha^{-1} at transplanting	356.4	376.9	94.3	20.3	4043	4963
T6	RDF +Soil application of bio zinc@15 kg ha^{-1} at transplanting	374.0	400.4	109.0	20.6	4623	5531
T7	RDF +Soil application of bio zinc @30 kg ha^{-1} at transplanting.	440.0	446.6	133.3	21.8	5355	6347
T8	RDF +foliar spray of 0.2% as $ZnSO_4$	433.4	444.0	123.6	21.7	5268	6258
T9	RDF +foliar spray of 1ml l^{-1} as nano zinc	426.8	442.1	121.3	21.5	5247	6189

T10	RDF +foliar spray of 2ml l^{-1} as nano zinc	365.0	389.9	106.0	20.3	4370	5306
T11	RDF +foliar spray of 1.5ml l^{-1} as bio zinc	392.6	411.7	114.6	21.1	4740	5740
T12	RDF +foliar spray of 3ml l^{-1} as bio zinc	383.8	405.9	109.3	20.9	4625	5603
	SE(m) ±	5.7	11.6	2.3	0.4	71.5	70.8
	CD at 5%	17.0	34.5	7.0	NS	209.7	207.8

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EFFECT OF BIOSOLIDS ON LEAF YIELD OF SPINACH AND FENUGREEK

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Biosolids are rich in several nutrients and trace elements and thus serve as good source of plant nutrients (Hampton and Peach 2002). Land application of biosolids for agricultural production has become a prominent worldwide practice, because it offers the possibility of recycling plant nutrients, provides organic material, improves soil fertility along with physical properties and enhances crop yields (Epstein, 2003; Lu *et al.*, 2012).

The pot culture experiment was conducted on alfisols (red soil) at green house farm of the Department of Horticulture, College of Agriculture, PJTSAU, Rajendranagar, Hydeabad during *kharif* 2014. The new approach of application of biosolids and its effect on growth and quality of leafy vegetables was addressed. The biosolids for present study was taken from Noor Mohammad Kunta-Sewage Treatment Plant (NMK-STP). It is situated 2.5 km away from College of Agriculture Rajendranagar, Hyderabad. The pot culture experiment was laid out in Completely Randomized Design (CRD) with four replications. There were eight treatments consisting of T_1 (3t ha^{-1} tons/ha of Biosolids to Spinach), T_2 (3 t ha^{-1} of Biosolids to Fenugreek), T_3 (4 t ha^{-1} of Biosolids to Spinach), T_4 (4 t ha^{-1} of Biosolids to Fenugreek), T_5 (5 t ha^{-1} of Biosolids to Spinach), T_6 (5 t ha^{-1} of Biosolids to Fenugreek), T_7-Control (Spinach) and T_8-Control (Fenugreek).

Significantly highest plant height of spinach (13.98 and 18.92 cm, respectively, Table 1.) was recorded in 5t ha^{-1} of biosolids (T_5) as compared to other treatments at 30 and 60 DAS of crop (9.41 and 15.62 cm, respectively). In fenugreek crop also significantly highest dry matter production (13.40 and 18.80 cm, respectively, Table 1.) was recorded in 5t ha^{-1} of biosolids (T_5) in contrast to the lowest value recorded in Control (8.56 and 15.00 cm, respectively) at 30 and 60 DAS of crop. Similar findings of increase in plant height were earlier reported by Madhvi *et al*. (2014) in spinach but with use of waste water.

Significantly maximum number of leaves in spinach (20.9 plant^{-1}, Table 1) were recorded at 60 DAS in 5 t ha^{-1} of biosolids (T_5) followed by 4 t ha^{-1} of biosolids (19.2 plant^{-1},T_3). In fenugreek crop also significantly maximum number of leaves (46.3 plant^{-1}, Table 1.) were recorded at 60 DAS in 5 t ha^{-1} of biosolids (T_6) followed by 4 t ha^{-1} of biosolids (40.7 plant^{-1}, T_4), 3 t ha^{-1} of biosolids (36.3 plant^{-1}, T_2). Sewage sludge amendment at higher dose (20 t ha^{-1}) had enhanced number of leaves, leaves area, shoot length and root length in maize (Qasim *et al*. 2001). Sinha *et al*. (2008) also reported significant increments in growth parameters of two varieties of *Vignaradiata* at higher rate (30 t ha^{-1}) of sludge amendment.

Significantly maximum chlorophyll content in spinach (46.62 and 49.57 SPAD units, respectively, Table 1.) was recorded in 5t ha^{-1} of biosolids (T_5) in contrast to the lowest value recorded in Control at 30 and 60 DAS of crop (45.67 and 46.37 SPAD units, respectively). In fenugreek crop also similar trend was noticed at 30 and 60 DAS of crop. Similarly, Kanbi and Bhatnagar (2005) reported that chlorophyll content (47.6 SPAD units) in potato was highest with application of 30 t ha^{-1} farm yard manure as compared with rest of lower rates of FYM application.

Dry matter production also followed similar trend. Kanbi and Bhatnagar (2005) also reported that nitrogen is an important constitutes of chlorophyll, which enhances the photosynthesis resulting in

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assimilation of more carbohydrates and thus increased plant biomass in potato.

Significantly maximum leaf yield (51.42g plant^{-1}, (Table 2.) at 60 DAS was observed in 5 ha^{-1} of biosolids to Spinach treatment (T_5) followed by 4t La^{-1} (48.47g plant^{-1}, T_3) and 3 t ha^{-1} of biosolids application (37.97 g plant^{-1}, T_1) and in contrast to the lowest leaf yield (35.10 g plant^{-1}) observed in Control (T_7). In fenugreek crop also significantly maximum leaf yield (21.02 g plant^{-1}) was observed in 5 t ha^{-1} of biosolids followed by 4 t ha^{-1} (18.35 g plant^{-1}, T_4) and 3 t ha^{-1} of biosolids application (16.70 g plant^{-1}, T_3).

Thus, application of 5 t ha^{-1} of biosolids to spinach and fenugreek resulted in better performance in terms of growth and leaf yield. However, further study is required to consolidate the results.

Table 1. Effect of Biosolids on plant height (cm), number of leaves and chlorophyll content (SPAD units)

Treatments		Plant height (cm)		Number of leaves		Chlorophyll content (SPAD units)	
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1	3 tons/ha of biosolids to spinach	11.36	16.44	8.21	17.80	45.85	48.00
T_2	3 tons/ha of biosolids to fenugreek	9.32	15.38	16.51	36.32	24.71	35.37
T_3	4 tons/ha of biosolids to spinach	12.01	17.57	9.55	19.20	45.92	48.50
T_4	4 tons/ha of biosolids to fenugreek	10.56	17.42	19.43	40.72	25.90	37.60
T_5	5 tons/ha of biosolids to spinach	13.98	18.92	15.61	20.92	46.62	49.57
T_6	5 tons/ha of biosolids to fenugreek	13.40	18.80	23.17	46.32	27.12	38.30
T_7	Control (Spinach)	9.41	15.62	7.35	16.20	45.67	46.37
T_8	Control (Fenugreek)	8.56	15.00	14.45	31.91	23.90	32.57
	SEM±	0.23	0.27	0.17	0.44	0.40	0.73
CD at 5%		0.68	0.79	0.43	1.30	1.19	2.22
CV (%)		4.18	3.29	2.71	3.08	2.29	3.03

Table 2. Effect of Biosolids on dry matter content (g plant^{-1}) and leaf yield (g plant^{-1})

Treatments		Dry matter content (g plant^{-1})		Leafy yield (g plant^{-1})	
		30 DAS	60 DAS	30 DAS	60 DAS
T_1	3 tons/ha of biosolids to spinach	0.97	2.30	8.31	37.97
T_2	3 tons/ha of biosolids to fenugreek	0.58	1.41	3.83	16.70
T_3	4 tons/ha of biosolids to spinach	1.26	2.58	9.14	48.47
T_4	4 tons/ha of biosolids to fenugreek	0.61	1.75	4.10	18.35
T_5	5 tons/ha of biosolids to spinach	1.60	3.27	10.25	51.42
T_6	5 tons/ha of biosolids to fenugreek	0.90	1.99	4.42	21.02
T_7	Control (Spinach)	0.44	2.10	5.10	35.10
T_8	Control (Fenugreek)	0.32	1.01	3.25	14.26
	SEM±	0.03	0.03	0.07	0.38
CD at 5%		0.09	0.11	0.22	1.16
CV (%)		7.29	3.63	2.17	2.19

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STUDIES ON PHYSIOLOGICAL BASIS OF HETEROSIS IN RICE HYBRIDS

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Rice is the staple food for more than 60% of Indian population and accounts for 43% of total food grain production and 46% of total cereal production. The present rate of increase in rice production (2000-09) has slowed down (1.21%) when compared to previous decades (1970-1998 -2.49%, 1999-2000-1.70%). Hence it becomes imperative to produce more food with the available technologies. Among the innovative options available for enhancing rice production, contribution of hybrid rice offers promise. The gap in food grain production therefore could be met from hybrid rice by exploiting heterosis. Virmani and Edwards (1982) reviewed the status and prospects for breeding hybrid rice and concluded that exploitation of heterosis through hybrid breeding offered an important option to increase yield in this self-pollinated crop.

Pot culture experiment was conducted at ICAR - Indian Institute of Rice Research, Hyderabad, during *Kharif* 2014 to study agro-morphological and physiological characters with a view to elucidate physiological basis of heterosis in rice hybrids. The experiment was laid out in completely randomized block design with 7 rice hybrids along with their parents. The data pertaining to various parameters like germination percentage, tiller number plant^{-1}, photosynthetic rate and yield plant^{-1} had been recorded.

The magnitude of heterosis was worked out on the basis of (i) mid-parent value, (ii) mean value of better parent Liang *et al.,* (1971) and Mather and Jinks (1971).

The data obtained from pot experiments was analyzed using a statistical computer package INDOSTAT. The critical difference (CD) values were calculated at 5 percent probability level, wherever 'F' test was significant.

Germination percentage was recorded on 4th day in all the hybrids, hybrid checks and their respective parents. Tiller number hill^{-1} were counted at 60 90 120 DAS. Photosynthetic rate measurements were taken at 50 percent flowering on flag leaves with Li-Cor 6400 portable photosynthesis measurement system (LCF Model 6400-1, LICOR, USA). P_N was expressed as ì mol of CO_2 m^{-2} s^{-1}. At maturity whole plant was harvested and the grains were weighed and expressed in grams.

Significant differences with respect to germination percentage were observed in all the hybrids and parents. The average values varied from 87.7- 99.7%. The maximum germination percentage in the parental lines was recorded in APMS6B (98.3%) and among the hybrids in DRRH3 (99.7%) which was found to be on par with KRH2. The minimum germination percentage was found in the parental line IR68897B (87.7%). Among the hybrids, minimum values were recorded in APMS6A X AjayaR (89.3%) and PUSA5A X BR 827-35 (92.3%) (Table 1.). The germination percentage values of 83.72% - 93.67% were recorded by Islam *et al.*, (2012) in rice varieties. The hybrid KRH2 with 6.76 % and 5.8 % recorded maximum positive heterosis and heterobeltiosis for germination percentage. Significant negative heterosis and heterobeltiosis were recorded in hybrids APMS6A X C20R (-0.52 and -3.05%), APMS6A X AjayaR (-7.43 % and -9.15%) and PUSA5A X BR 827-35 (-1.6 and -1.77%) (Table 2.)

Number of tillers per plant has an indirect effect on yield, but it has a positive effect via the number of panicles plant^{-1} (Jahan and Golam Adam, 2011). Tiller population gradually increased in all the lines up to 120 DAS. The values which were recorded at 60 DAS varied from 3.0-6.3 plant^{-1}. There exists a significant difference between the lines. Among the

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hybrids, the maximum tiller number was found in APMS6A X C20R (6.3 plant^{-1}) which was on par with all other hybrids except APMS6A X AjayaR and PUSA5A X BR 827-35. At 90 DAS, among the parents significant maximum tiller number was recorded in BR 827-35 (15 plant^{-1}) followed by KMR3R (13 plant^{-1}) (Table 1.) The maximum tiller number was observed in the hybrid KRH2 (17.3 plant^{-1}) which was on par with the hybrids DRRH3 and DRRH2. At 120 DAS, among the parents significant maximum tiller number were recorded in KMR3R (19 plant-1) and IR58025B (17.7 plant^{-1}). The high tillering ability of both the lines had been reflected in their hybrid KRH2 which recorded the maximum tiller number plant^{-1} (23.3 plant^{-1}) (Table 1.). Similar results of 15- 17 tillers plant^{-1} at 50 and 75 DAT were observed by Islam *et al.* (2009).

The heterobeltiosis values for tiller number plant^{-1} were observed to be maximum in DRRH2 at 60 DAS (92.86%), at 90 DAS in APMS6A X C20R (37.50%) and at 120 DAS in KRH2 (22.81%). Similar results for heterobeltiosis (-22.6 to 80.34) were found by Bagheri *et al.* (2010). Negative heterosis was observed at all the stages in both the hybrids APMS6A X AjayaR and PUSA5A X BR 827-35 (Table 2.). The negative estimates of heterosis and heterobeltiosis are not always desirable because of less number of tillers plant^{-1} and consequent low yield. Negative heterosis for tiller number has also been reported by Farooq and Khaliq, 2004 in wheat.

The average values for photosynthetic rate recorded at flowering stage varied from 5.4-15.7 ì mol CO_2 m^{-2} s^{-1}. Significantly maximum photosynthetic rate was recorded in the parental line KMR3R (15.7 ì mol CO_2 m^{-2} s^{-1}) which was on par with the hybrid KRH2 (15.6 ì mol CO_2 m^{-2} s^{-1}) and minimum value was recorded in the hybrid PUSA5A X BR827-35 (5.4 ì mol CO_2 m^{-2} s^{-1}) (Table 1.). Photosynthetic rate values of 19.5-20 ì mol CO_2 m^{-2} s^{-1} at 65 DAT was observed by Islam *et al.* (2009).

Significant average heterosis for photosynthetic rate was recorded in the hybrids DRRH2 (29.09%) and KRH2 (26.25%) and for heterobeltiosis in DRRH2 (0.85%). Negative average heterosis and heterobeltiosis was observed in rest of the hybrids (Table 2.).

Significant difference was observed between the parents and hybrids for grain yield. The average values for grain yield plant^{-1} varied from 14.1 - 34.9 g. Among the parents, maximum and minimum grain yield was recorded in KMR3R (27.6 g) and in AjayaR (20.3 g) respectively. The maximum and minimum grain yield among the hybrids was recorded in APMS6A X BCW56 (34.9 g) and PUSA5A X BR 827-35 (14.1 g) respectively (Table 1). Significant seed yield values of 26-39 g palnt^{-1} were reported by Arasakesary *et al.* (2015).

Among the seven hybrids, positive average heterosis and heterobeltiosis for grain yield was observed with five crosses namely DRRH3, DRRH2, KRH2, APMS6A X C20R and APMS6A X BCW56. Positive heterosis for grain yield was earlier reported by Dalvi and Patel (2005). Negative average heterosis and heterobeltiosis was observed in the hybrids APMS6A X AjayaR (-35.98%, -40.83%) and PUSA5A X BR827-35 (-40.06%, -40.14%) (Table 2.). Similar results were reported by Joshi (2001) and Allah (2006).

From the physiological studies, it was observed that the hybrid checks performed well over all the crosses. Among the heterotic hybrids, APMS6A X C20R, APMS6A X BCW56 showed positive heterosis and heterobeltiosis for the physiological traits, whereas the hybrids APMS6A X AjayaR, PUSA5A X BR 827-35 showed negative heterosis. From these results, it can be concluded that the hybrids APMS6A X C20R, APMS6A X BCW56 were positively heterotic and the hybrids APMS6A X AjayaR, PUSA5A X BR 827-35 shown negative heterosis.

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Table 1. Germination percentage, tiller number plant^{-1}, Photosynthetic rate and Yield (g plant^{-1}) in different rice hybrids and their parents

S. No	Parents / Hybrids	Germination percentage (%)	Tiller number plant^{-1}			Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})	Yield (g plant^{-1})
			At 60 DAS	At 90 DAS	At 120 DAS		
1	APMS6B	98.3	4.7	10.7	16.0	14.5	24.0
2	IR68897B	87.7	3.7	12.3	16.3	8.3	25.5
3	IR58025B	92.0	4.0	11.7	17.7	9.1	24.8
4	PUSA5B	93.7	5.0	12.3	15.7	8.8	23.5
5	RPHR1005	92.7	3.7	12.0	15.3	10.9	25.4
6	DR714-1-2R	91.3	4.7	12.7	16.3	14.7	20.9
7	KMR3R	90.3	3.3	13.0	19.0	15.7	27.6
8	C20R	93.3	4.0	10.7	16.0	9.8	23.4
9	BCW56	92.7	3.3	12.0	16.0	11.2	23.2
10	AjayaR	94.7	3.3	12.3	15.7	6.7	20.3
11	BR827-35	94.0	4.0	15.0	18.0	8.8	23.5
12	DRRH3	99.7	4.7	16.0	18.7	12.3	31.9
13	DRRH2	94.3	4.3	15.7	19.3	14.8	31.0
14	KRH2	97.3	6.0	17.3	23.3	15.6	33.3
15	APMS6A X C20R	95.3	6.3	14.7	17.3	8.6	31.4
16	APMS6A X BCW56	96.3	5.0	14.3	15.3	10.6	34.9
17	APMS6A X AjayaR	89.3	3.0	11.0	14.0	7.9	14.2
18	PUSA5A X BR827-35	92.3	4.0	10.3	15.0	5.4	14.1
	Mean	93.6	4.3	13.0	16.9	10.8	25.2
	CD at 5%	3.04	1.63	1.96	2.79	0.74	2.85
	SEm±	1.06	0.57	0.68	0.97	0.26	0.98

Table 2. Average Heterosis (Ht) and Heterobeltiosis (Htb) estimates (%) for germination percentage, tiller number plant^{-1}, photosynthetic rate and yield in rice hybrids

S. No.	Hybrid	Germination percentage		Tiller number plant^{-1}						Photosynthetic rate		Yield in g plant^{-1}	
				At 60 DAS		At 90 DAS		At 120 DAS					
		Ht	Htb	Ht	Htb	Ht	Htb	Ht	Htb	Ht	Htb	Ht	Htb
1	DRRH3	4.36	1.36	12.00	0.00	41.18	33.33	19.15	16.67	-3.90	-15.60	29.02	25.29
2	DRRH2	5.40	3.28	4.00	92.86	25.33	23.68	18.37	18.37	29.09	0.85	33.68	21.71
3	KRH2	6.76	5.80	63.64	50.00	40.54	33.33	27.27	22.81	26.25	-0.27	27.06	20.63
4	APMS6A X C20R	-0.52	-3.05	46.15	35.71	37.50	37.50	8.33	8.33	-29.40	-40.84	32.80	31.15
5	APMS6A X BCW56	0.87	-2.03	25.00	7.14	26.47	19.44	-4.17	-4.17	-17.45	-26.96	48.08	45.62
6	APMS6A X AjayaR	-7.43	-9.15	-25.00	-35.71	-4.35	-10.81	-11.58	-12.50	-25.51	-45.66	-35.98	-40.83
7	PUSA5A X BR827-35	-1.60	-1.77	-11.11	-20.00	-24.39	-31.11	-10.89	-16.67	-38.80	-38.82	-40.06	-40.14

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A STUDY ON REPRODUCTIVE PERFORMANCE OF BROILER RABBITS UNDER SEMI-ARID CONDITIONS OF TELANGANA, INDIA

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Rabbit has been encouraged by the FAO (1987) for meat production in the developing countries due to its high prolificacy, outstanding growth rate, shorter generation interval and utilization of low grain and fibre rich feed stuffs. The broiler rabbits are an important source of meat in developed countries where rabbit rearing has been taken upon commercial proportions. It can also serve as alternative source of cheap animal proteins to mitigate the negative impacts of malnutrition in infants and adults which are prevalent in the developing countries. Rabbit production is very essential in improving animal protein intake in developing countries. This is because rabbit is very prolific animal as determined by the number of kits born alive at kindling and birth to weaning viability (Orunmuyi *et al.*, 2006).

Apart from its high prolificacy, the rabbit has several advantages over many other farm species, including its high meat quality due to higher protein and much lower fat/cholesterol contents (Fielding,1991). Rabbit are becoming popular as an additional source of animal protein to meet the increasing demand from the ever growing human population. But in developing countries like India, they have been introduced recently and little work has been done on the production performance of various exotic broiler breeds of rabbits. Diversity of rabbit breeds offers opportunity to increase the efficiency of commercial meat production through crossing. In view of the above characters the proposed study is aimed to aimed to study the performance of purebred and crossbred rabbits were undertaken.

The present study evaluated broiler breeds of rabbit for their performance. Broiler breeds of rabbit viz. Flemish Giant, Californian White and their crosses were taken for the study.

Data on the performance of purebred and crossbred of broiler rabbit breeds viz. Flemish Giant, Californian White and their crossbreds maintained at Rabbit Research Centre, Department of Animal Genetics and Breeding, College of Veterinary Science, Hyderabad were utilized for the present study. All the rabbits were reared in the sheds with asbestos sheet roof. The breeding stock of the two breeds was reared under uniform environmental conditions in pucca shed with proper ventilation.

Rabbits according to their age and sex were placed in different cages. Females were housed in galvanized iron mesh cages with dimensions of 2.5× 1.5× 1 feet, whereas males and weaned rabbits were placed in cages with dimensions of 1.5× 1.5 × 1 feet. Earthen pots of about half a litre volume were used as feeders. Clean drinking water was provided throughout the day using nipple drop system. The does were first mated at 6-7 months of age and thereafter extensive breeding system (re-mating after weaning) was followed. Mating was done as per the breeding plan to avoid inbreeding. Does were taken to the breeding cages of assigned bucks to be bred and returned to their own cages after copulation.

Newborn kits were milk fed manually twice a day in the morning and evening, and 14 day after birth they were offered mashed concentrate diet along with doe's milk till weaning. The young ones were weaned at 28 days of age, sexed and ear tagged.

Conception Rate (CR): Conception rate was calculated as a ratio of the number of does conceived to the total number of does mated multiplied by 100.

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$$CR = \frac{\text{Number of Does that conceived X 100}}{\text{Total number of Does mated} \times 1}$$

Kindling percentage: It is the ratio of number of kindlings (exclude abortions) to the total number of does mated.

$$\text{Kindling percentage} = \frac{\text{Number of Kindlings}}{\text{Total number of does mated}} \times 100$$

Litter size

It is the number of live bunnies at birth and at every week up to four weeks of age.

Litter weights

The sum of weight all live kits born in a litter was regarded as litter weight. It was recorded at birth and at weekly intervals up to four weeks of age.

The results of the reproductive performance of different broiler rabbit breeds are given below. Conception rate indicates the fertility of the rabbit and is an important determinant of profitability of the enterprise. The conception rates of Flemish Giant, Californian White and Crossbreds were 61.45, 57.14 and 66.67% respectively. The kindling rates of Flemish Giant, Californian White and their Crossbreds were 59.04, 51.43 and 60% respectively.

Litter size at birth and weaning are important traits, which actually determine the number of kits for future breeding programme and lifetime productivity. The least squares mean estimates (±SE) of litter size and litter weight at birth, 1, 2, 3 and weaning (4 weeks) are presented in (Table 1) and (Table 2.)

Among the breeds examined, litter size at all ages was higher in Flemish Giant followed by Californian White and their Crossbreds. Similarly Flemish Giant recorded higher litter weights at all ages except at 3 weeks of age.

In this study there was no significant difference in litter size and litter weight between breeds. This concurs with the findings of Iraqi *et al.* (2006) and Sarin (2013) also observed a non-significant effect of breed on litter size at all ages. Similar to our results, Gurmej Singh (1998), Ozimba and Lukefahr (1991) and Sivakumar *et al.* (2013) reported non-significant effect of breed on litter weight.

From the results of the present study, it may be concluded that brred didn't have a significant influence on the litter traits i.e. litter size and litter weight. Higher conception rate and kindling rate were recorded in crossbreds when compared to Flemish Giant and Californian white whereas, litter size and litter weight were higher in Flemish Giant than in Crossbreds and Californian White but the difference was statistically non-significant.

Table 1. Effect of breed on litter size of broiler rabbits

Parameter	Flemish Giant (FG)	Californian White (CW)	Crossbreds	Overall
Birth	5.64 ± 0.34	5.40 ±0.50	4.88 ±0.69	5.44 ±0.26
1 week	4.60 ±0.35	4.33 ±0.45	3.75 ±0.70	4.38 ±0.26
2 week	4.52 ± 0.36	4.00 ±0.37	3.38 ±0.71	4.17 ±0.25
3 week	4.04 ±0.33	3.67 ±0.40	3.38 ±0.71	3.81 ±0.24
4week (weaning)	3.84 ±0.33	3.47 ±0.42	3.13 ±0.67	3.62 ±0.24

Table 2. Effect of breed on litter weight of broiler rabbits

parameter	Flemish Giant (FG)	Californian White (CW)	Crossbreds	Overall
Birth	292.40 ±17.28	286.33 ±23.33	266.25 ±29.90	286.15 ±12.42
1 week	504.80 ±37.40	447.67 ±45.82	470.63 ±79.53	481.25 ±27.18
2 week	757.00 ±50.26	623.33 ±56.21	737.50 ±118.09	711.98 ±37.27
3 week	1037.20 ±72.91	824.00 ±82.36	1053.13 ±167.07	973.23 ±54.35
4 week	1592.80 ± 120.05	1263.00 ±123.87	1209.38 ±233.37	1427.55 ±87.05

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