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Nutritional Physiology of the Brown Rice Planthopper, *Nilaparvata lugens* STÅL (Hemiptera: Delphacidae) III. Essential Vitamins for Nymphal Development

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Essential vitamins for nymphal development of the brown rice planthopper were studied. Newly hatched nymphs were reared on artificial diets deleting a single vitamin. Nymphs could not grow to the adult stage when thiamine, pyridoxine or pantothenic acid was deleted. Therefore, these three vitamins are essential. The minimum concentrations required were 0.005 to 0.01 mg/100 *ml* of thiamine hydrochloride, 0.039 to 0.078 mg/100 *ml* of Ca pantothenate and less than 0.005 mg/100 *ml* of pyridoxine hydrochloride.

INTRODUCTION

Artificial rearing of the brown rice planthopper *Nilaparvata lugens* STÅL, on a synthetic diet was reported by KOYAMA (1979). This facilitated a number of nutritional studies on this planthopper such as nymphal survival on aqueous solutions of several sugars (KOYAMA, 1981), effect of sugars on nymphal development (KOYAMA, 1985 a) and essential amino acids for nymphal development (KOYAMA, 1985 b). The present paper reports the essential vitamins for nymphal development of the brown rice planthopper.

MATERIALS AND METHODS

The brown rice planthoppers used in this study were collected in Saitama Prefecture and maintained for a long time on rice seedlings in short glass tubes in our laboratory. The methods and vessels for artificial rearing have been reported previously (KOYAMA, 1979, 1985 a, b). Test solutions consisted of the synthetic MED-1 diet deleting a single vitamin (Table 1). For those vitamins necessary for completion of nymphal growth, their concentrations in MED-1 were altered to discern the minimum and optimum concentrations for nymphal development. Artificial rearing was conducted at 25°C and under 16 hr illumination. Diets were fed through a stretched Fuji Sealon film and replaced every other day. For each diet, 100 nymphs were individually reared and their growth state (ecdyses, emergence) was recorded until mortality.

RESULTS

Figure 1 shows the duration of the nymphal period of the brown rice planthopper

Table 1. Composition of vitamins in MED-1 diet (mg per 100 m*l*)

Thiamine hydrochloride	2.5
Riboflavin	5.0
Nicotinic acid	10.0
Pyridoxine hydrochloride	2.5
Folic acid	1.0
Calcium pantothenate	5.0
Inositol	50.0
Choline chloride	50.0
Biotin	0.1
Sodium L-ascorbate	100.0

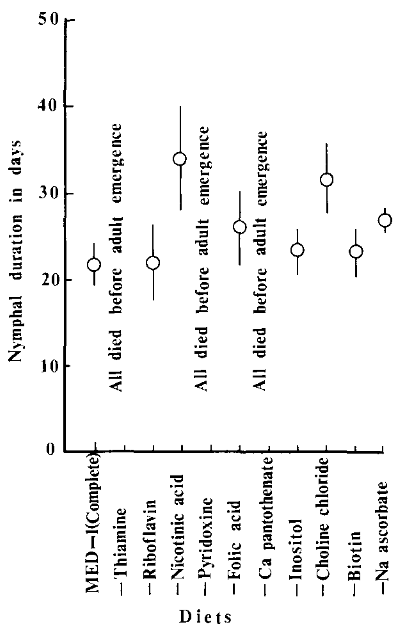

Fig. 1. Nymphal period of *N. lugens* reared on MED-1 diet lacking individual vitamins. ⏀: average ± standard deviation.

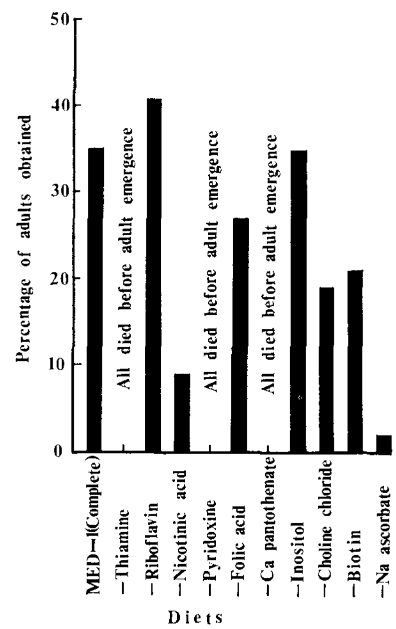

Fig. 2. Adult emergence of *N. lugens* reared on MED-1 diets lacking individual vitamins.

when reared on MED-1 diets lacking one vitamin. When fed on a diet individually lacking thiamine, pyridoxine or Ca pantothenate, nymphs grew to the 4th, 3rd and 4th instar respectively, however they did not reach the adult stage. The nymphal periods were greatly elongated by the deletion of nicotinic acid or choline chloride. Absence of other vitamins did not significantly affect the duration of the nymphal period. The deletion of Na ascorbate or nicotinic acid decreased the rate of adult emergence considerably (Fig. 2). Mortality during the nymphal period was found to be high immediately after the initiation of rearing in every case (Figs. 3 and 4).

It was found that nymphs grew only to the 3rd instar on diets completely lacking thiamin hydrochloride; on a diet containing 0.00488 mg/100 m*l*, nymphs grew to the

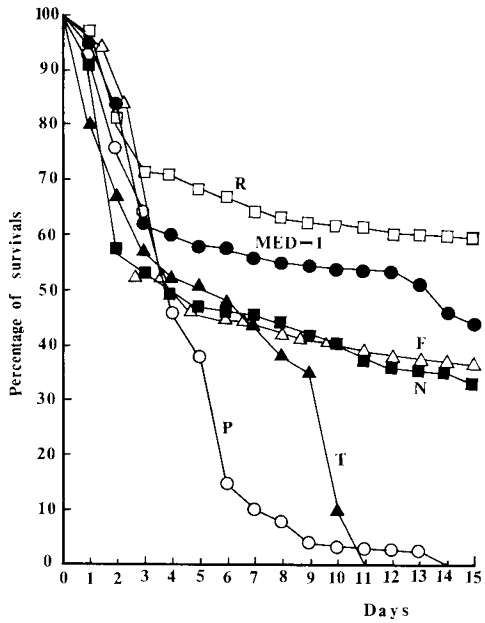

Fig. 3. Survival of *N. lugens* within 15 days after hatching.
MED-1: complete. T: MED-1 diet lacking thiamine hydrochloride. R: MED-1 diet lacking riboflavin. N: MED-1 diet lacking nicotinic acid. P: MED-1 diet lacking pyridoxine hydrochloride. F: MED-1 diet lacking folic acid.

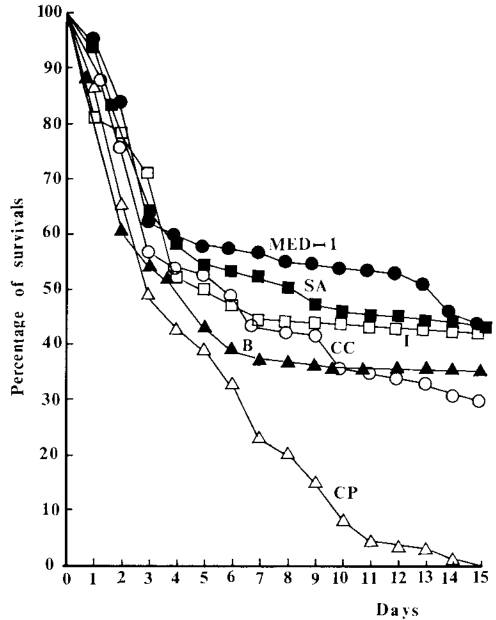

Fig. 4. Survival of *N. lugens* within 15 days after hatching.
MED-1: complete. CP: MED-1 diet lacking calcium pantothenate. I: MED-1 diet lacking inositol. CC: MED-1 diet lacking choline chloride. B: MED-1 diet lacking biotin. SA: MED-1 diet lacking sodium L-ascorbate.

4th instar. The minimum concentration of thiamine hydrochloride in the diet on which nymphs grew to the adult stage was 0.00976 mg/100 m*l*. The nymphal developmental period gradually elongated with the increase of thiamine concentration from 0.019531 mg/100 m*l* to 1.25 mg/100 m*l*, and shortened somewhat with the increase of thiamine concentration above that in the MED-1 diet (Fig. 5). Figure 6 shows the rate of adult emergence. These results suggest that the minimum effective concentration of thiamine was in the vicinity of 0.01 mg/100 m*l*; however, it was impossible to determine the optimum concentration of thiamine.

Nymphs of the brown rice planthopper grew only to the 3rd instar on the diets lacking pyridoxine hydrochloride. They grew to the adult stage on diets containing more than 0.00488 mg/100 m*l* of pyridoxine hydrochloride (Fig. 7). Figure 8 shows the rate of adult emergence. While these results suggest that the minimum effective concentration of pyridoxine was less than 0.005 mg/100 m*l*, it was impossible to determine the minimum effective concentration or the optimum concentration exactly.

Nymphs of brown rice planthopper grew to the 3rd instar on diets lacking Ca pantothenate. They grew to the 4th instar on diets containing 0.03906 mg/100 m*l* of Ca pantothenate, and to the adult stage on the diet containing 0.07812 mg/100 m*l* with elongation of nymphal period (Fig. 9). The rate of adult emergence suggests that the

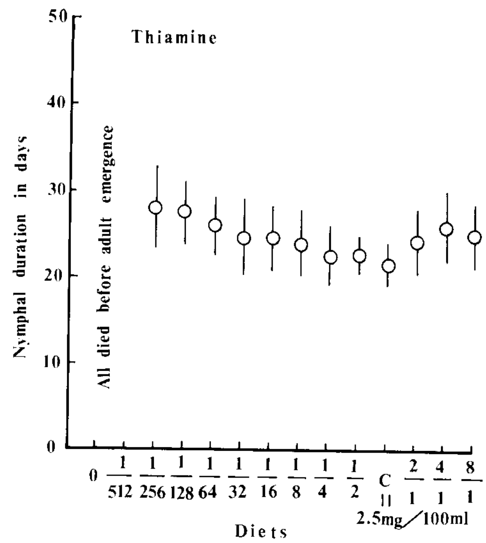

Fig. 5. Effect of thiamine concentration in MED-1 diet on nymphal period. ȹ: average ± standard deviation.

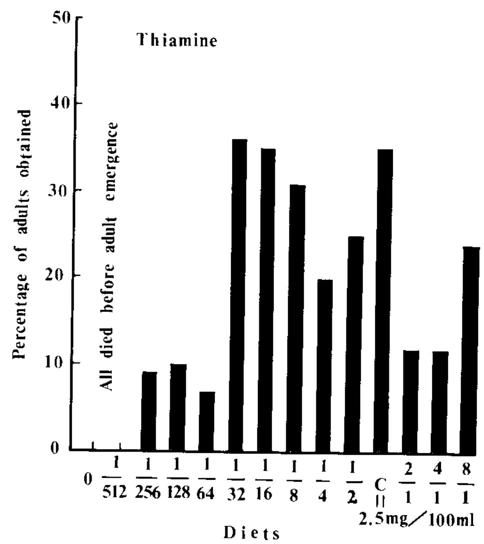

Fig. 6. Effect of thiamine concentration in MED-1 diet on adult emergence.

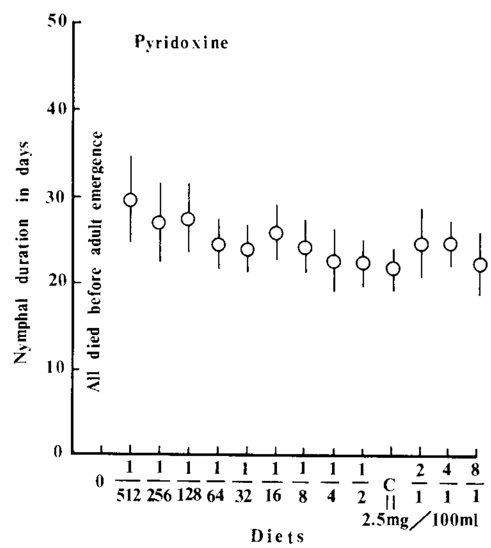

Fig. 7. Effect of pyridoxine concentration in MED-1 diet on nymphal period. ȹ: average ± standard deviation.

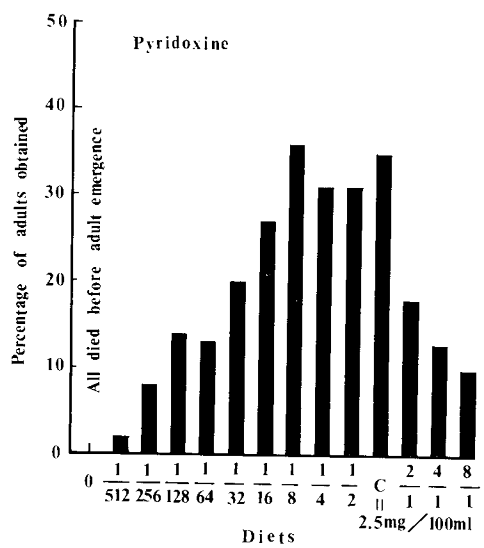

Fig. 8. Effect of pyridoxine concentration in MED-1 diet on adult emergence.

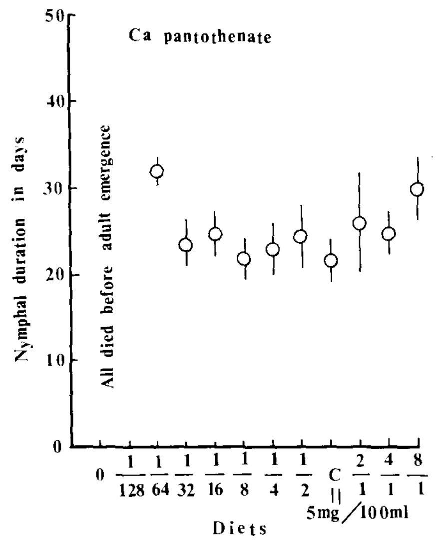

Fig. 9. Effect of Ca- pantothenate concentration in MED-1 diet on nymphal period. ⏀: average±standard deviation.

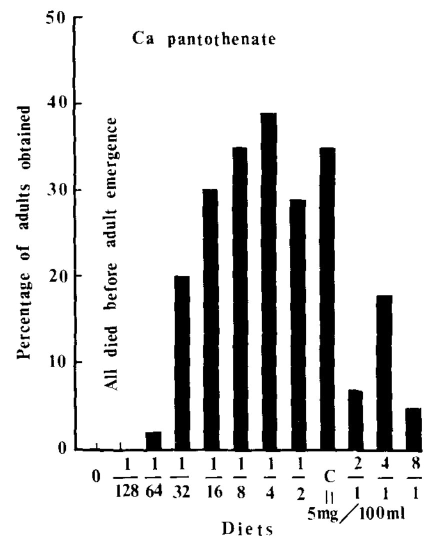

Fig. 10. Effect Ca- pantothenate concentration in MED-1 diet on adult emergence.

minimum effective concentration of Ca panthothenate was in the vicinity of 0.0078 mg/100 m*l*, although the optimum concentration was not determined (Fig. 10).

DISCUSSION

These experiments showed that the essential vitamins for the nymphal development of the brown rice planthopper were thiamine, pyridoxine and pantothenic acid, being similar to the smaller brown planthopper, *Laodelphax striatellus* FALLÉN (KOYAMA and MITSUHASHI, 1977). It was impossible to determine the optimum concentration of these vitamins exactly because the differences in nymphal development and survival over a wide range of concentrations did not greatly vary.

Aphids and true bugs are the only other hemipterous insects whose vitamin requirements have been studied. In *Myzus persicae*, the essential vitamins for nymphal development are thiamine, nicotinic acid and pantothenic acid (DADD et al., 1967). *Riptortus clavatus* was reported to require only riboflavin as an essential vitamin for development (NODA and KAMANO, 1983). Thus, the vitamin requirements of hemipterous insects depend on the species.

The nutritional requirement of a hemipterous insect is less than those of other insects, probably because the intracellular symbionts in hemiptera produce and provide the host with many essential substances. The brown rice planthopper seems to owe a considerable part of its essential nutrition to such microorganisms which make the essential vitamins for their host insect. The vitamins whose deletion had no effect on nymphal growth to the adult stage were regarded as nonessential vitamins. However, the balance among the vitamins as a group also seems to be important, so that there still remains this problem as well as the role of the symbionts.

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