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Effect of Nursery Applications of N and P on Rice (*Oryza sativa*) Yiled

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ABSTRACT

In two glasshouse experiments, one with N and the other with P, plants were treated with combinations of four and two levels of N or P in the nursery and after transplanting respectively. The relative responses of rice were determined from matter, nutrient uptake and grin yield. After 21 days in the nursery, rice seedlings produced 50% and 100 % more shoot dry matter when fertilized with N, and P respectively than when unfertilized. In the nursery, root dry matter was also increased by N, but not by P. After transplanting, the effects of the nursery N and P persisted, leading to increases of up to 10 and 15% in grain yield, respectively. Nitrogen and phosphorus applied in the nursery shoot dry weight at 30 days after transplanting, both with and without added N or P at transplanting. The results suggested that fertilizing the nursery bed would have significant effects on grain yield and that for rice farming in Cambodia, appropriate strategies for the fertilizer management of the nursery as well as the mainfield are required in order to improve rice yield.
Key words : nitrogen, phosphorus fertilizer, nursery bed rice.

INTRODUCTION

The majority of soils in rainfed lowland-rice producing areas of Cambodia are deficient in both phosphorus and nitrogen (Saeki *et al.*, 1959) and accordingly in most situations both N and P fertilizers are needed for adequate yields (Lor *et al.*, 1996).

In the rainfed lowlands of Cambodia, rice seeds are sown in a prepared nursery soon after the break of season rains. Seedlings are transplanted only after there has been sufficient rainfall for land preparation and sufficient water in the mainfield.

Whether to apply fertilizer to the crop or not is an important decision for rice farmers in the rainfed lowlands which depends on the size, the response and the profit. Variability in yield due to environmental stress or other factors is a pervasive element in rainfed rice production. Farmer's concerns with the risks of low returns from fertilizer and the fact that fertilizer availability generally limited, forcees them to make decisions for the best way to use the limited amounts of fertilizer.

Seedling management is of great importance for rainfed lowland rice production in Cambodia. Application of farm yard manure (FYM) to the nursery is a widespread practice in Cambodia and other parts of South East Asis (Dubus and Richards, 1994). In fertilizer application farmers typically apply about two thirds FYM in the nursery on

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which seedlings are raised rather than apply only FYM to the main field (Lando and Mak, 1990).

Field experiments in India showed that rice seedlings from a nursery fertilized with 50 kg N/ha were more healthy, and had denser root systems and greener leaves than unfertilized seedlings. It was concluded that, by making a small investment in raising healthy and vigorous seedlings in the nursery, farmers could harvest an additional yield of 2 t/ha (Panda *et al.*, 1991).

In Cambodia, the comparative effects on yield of applied nutrients both before and after transplanting rice has yet to be closely examined. Such decisions are influenced by the limited availability of inorganic fertilizers, and the magnitude of the responses of the plants to inorganic fertilizers or FYM in the nursery. The hypothesis of the the present study was that application of N and P to the nursery could increase rice grain yield. The present glasshouse experiments were designed to test the effects of N and P fertilizer application to the nursery on grain yield of rice and to compare it with the effect of N and P fertilizer applied at transplanting.

MATERIALS AND METHODS

Two pot experiments were conducted in the glasshouse of the Cambodia -IRRI-Australia Project, Phnom Penh during September 1993 to January 1994.

Experiment 1 was the response of two modern rice cultivars, IR66 (110 days duration), Santepheap III (130 days duration) to the application of four rates of nitrogen (0, 60, 120, 240 mg NH_4NO_3/kg soil) applied prior to sowing seeds in the nursery pots. The four sets of seedlings grown in the nursery pots were transplanted into pots treated with one of two rates of N (0 and 400 mg NH_4NO_3/kg soil) applied at transplanting.

Experiment 2 tested the response of the same rice cultivars as those in experiment 1 to the application of four rates of phosphorus (0, 50, 100, 200 mg KH_2PO_4/kg soil) applied prior to sowing seeds in the nursery pots and two rates of P (0 and 300 mg KH_2PO_4/kg soil) applied at transplanting.

In both experiment, treatments were replicated 3 times. For both experiments, surface (top 20 cm) soil of a *Plithustult* was collected from Kap Srau (Table 1). The soil was dried, crushed and sieved (1 cm) to remove gravel and coarse organic matter. For both nursery pots and those used for transplanted seedlings, 5 kg of sieved soil was placed in plastic pots for each experiment.

Treatments in the form of solution were applied to the soil surface of each pot and allowed the soil to dry. Basal nutrients [0.2 mg $Na_2MoO_4.2H_2O$, 0.7 mg H_3BO_3, 1.2 mg $CuSO_4.5H_2O$, 4.2 mg $MnSO_4.H_2O$, 4.2 mg $ZnSO_4.7H_2O$, 17 mg $MgSO_4.7H_2O$, 75 mg $CaCl_2.2H_2O$, 130 mg K_2SO_4, 150 mg KH_2PO_4 (for N experiment only), 200 mg NH_4NO_3 (for P experiment) per kg of soil] were applied to each pot at the same time. Them the soils in pots were mixed thoroughly. Ten seeds per pot were sown at 3 cm depth. Three weeks after germination, five seedlings per pot were transplanted into new pots and the remaining seedlings were separeted for shoot and root dry weight determining . The soil in each nursery pot was then sieved to recover residual roots.

Thirty days after transplanting (DAT), two seedlings in the pot were pulled out, washed to remove soil, separated int shoots and roots, oven dried and weighed. Three plants per pot were grown to maturity, when were harvested and separated into roots, straw and grain.

Shoots, roots, straw and grain were collected, cut into pieces, sub-sampled and then milled for chemical (N and P) analysis. Plant samples were digested in concentrated HNO_3 at 140°C to determine the P concentration (Zarcinas *et al.* 1987)

Table 1 Chemical and physical properties of soil used in glasshouse experiments. Soil collected from 0-20 cm at Kap Srau Research Station, Cambodia.

Soil properties		
pH (1 : 1, soil : H_2O)		5.4
Organic C (%)1/		0.54
Total N (%)2/		0.07
Avail P, (mg/kg)4/		1.8
Zn (mg/kg)6/		0.83
Cu (mg/kg)6/		0.95
B (mg/kg)7/		0.04
Fe (mg/kg)8/		0.23
Mn (mg/kg)8/		0.01
Exchangeable Cations, (cmol(+) /kg)3/		
	Al	0.25
	K	0.15
	Ca	1.51
	Na	0.35
	Mg	0.55
	CEC	2.35
Particle size analysis (%)5/		
	Clay	16
	Sand	68
	Silt	16

1/ Walkey and Black (1934) 2/ Varley (1966) 3/ ADAS (1981)
4/ Olsen *et al.* (1954) 5/ Pipette method 6/ Katyal and Ponnamperume (1974)
7/ Jackson (1958) 8/ Asami and Kumada (1959)

and in concentrated H_2SO_4 at 400°C to determine the N concentration (Issac and Johnson, 1976).

RESULTS

Results for the two cultivars were pooled for presentation below as there was no interaction between cultivars and their responses to N and P at either sowint or after transplanting.

In the nursery, application of up to 250 mg NH_4NO_3/kg soil increased shoot and root dry matter up to 50 and 30% respectively, at 3 weeks after sowing (Table 2). Application of up to 200 mg KH_2PO_4/kg soil to the nursery pot, increased shoot dry matter twofold (Table 3). Application of N and P nursery pots increased root dry matter by 30% but had no effect on percentage of unrecovered root or shoot root ratio (Table 2 and 3). Nitrogen concentration in shoots at 21 days after sowing ranged from 1.8%, for untreted plants, to 3.8% for the highest rate of N application. In the case of P, the range of shoot P concentration was from 0.11%

Table 2 Response of shoot and root dry matter at 21 days agter sowing to N applied in the nursery. Values are means of three replicates of two cultivars.

Treatment (mg NH_4NO_3/kg soil)	Shoot dry matter (g/pot)	Root dry matter (g/pot)	Unrecovered roots (g/pot)	Shoot root ratio
0	1.33	0.28	0.12	0.21
60	1.84	0.31	0.11	0.17
120	1.97	0.35	0.14	0.18
240	2.06	0.36	0.10	0.18
LSD	0.3**	0.05*	ns	ns

** = significant at the 1% level;
* = significant at the 5% level
ns = not significant at the 5% level

Table 3 Response of shoot and root dry matter at 21 days after sowing to P applied in the nursery. Values are means of three replicates of two cultivars.

Treatment (mg KH_2PO_4/kg soil)	Shoot dry matter (g/pot)	Root dry matter (g/pot)	Unrecovered roots (g/pot)	Shoot root ratio
0	1.22	0.25	0.10	0.21
50	1.79	0.26	0.09	0.21
100	2.24	0.29	0.07	0.13
200	2.62	0.32	0.10	0.12
LSD	0.3**	ns	ns	ns

** = significant at the 1% level;
ns = not significant at the 5% level

for untreated plants, to 0.24% for the highest rate of P application (Figure 1 and 2). Nitrogen and P concentrations in roots at 21 days after sowing also increesed with the increased with the increased application of N and P.

Nitrogen nursery treatments had positive effects ($P<0.05$) on plant growth and yield after transplanting. Nitrogen applied to the nursery pot increased shoot dry matter at 30 DAT by 26% when no N was applied at transplanting but only by 9% when the N fertilizer was applied at transplanting (Table 4). Nitrogen applied in the nursery had no effect no root dry matter and root : shoot ratio at 30 DAT (Table 4). Applying N to the nursery increased straw dry matter and root dry matter at maturity only when N was added at transplanting (Table 4).

At maturity, grain yield was increased by 10% by applying N to the nursery, regardless of N application at transplanting.

Phosphorus application to the nursery increased shoot and root dry matter at 30 DAT regaedless of whether P was applied at transplanting or not (Table 5). When P was not added at transplanting, plants from the highest nursery P rate applied produced at least double the shoot and root dry matter weights compared to those from the untreated nursery. When P was added at transplanting, the highest nursery P rate produced 40% greater shoot dry matter than those of plants grown from untreated nursery (Table 5). Applying P to the nursery decreased the root : shoot ratio at maturity although no difference in the root : shoot ratio was seen at 30 DAS. Nursery applied P increased straw dry matter by 5% and grain yield by 15% regardless of P application (Table 5).

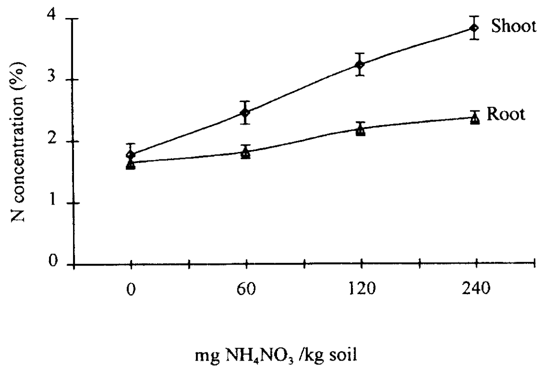

Figure 1 Effect of N application at sowing on shoot and root N concentrations at 21 days after sowing. Values are menas of three replicates. Vertical bars represent the $LSD_{(0.05)}$.

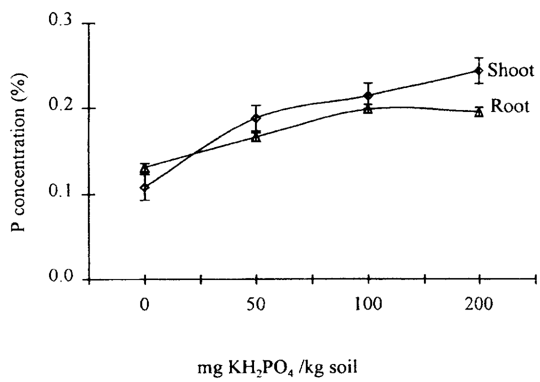

Figure 2 Effect of P application at sowing on shoot and root P concentration at 21 days after sowing. Values are means of three replicates. Vertical bars represent the $LSD_{(0.05)}$.

DISCUSSION

It may be necessary to apply N or P fertilizer to both the nursery and the mainfield in order to obtain maximum yield. Results from the glasshouse experiments showed that on a typical Cambodian rice soil, fertilizing the nursery with N and P not only increased the size of seedlings for transplanting but also increased the grain yield by 10 and 15%, respectively. In addition, without additional fertilizer in the mainfield, especially N, plant growth was retarded and final yield was reduced.

Similar responses to nursery fertilizer addition were found by Panda *et al.* (1991) and Rajagopalan and Krishnarajan (1987). Panda *et al.* (1991) found that rice seedlings from a nursery fertilizer with 50 kg N/ha were taller and had denser root systems and greater shoot vigour than unfertilized seedlings. By raising healthy and vigorous seedlings in the nursery, yield of grain was increased by 2 t/ha. Similarly, application of di-ammonium phosphate and single super phosphate at 50 kg P/ha to the nursery produced maximum grain yield (4.9 t/ha) corresponding to a 21% increase over the control (Rajagopalan and Krishnarajan, 1987).

The present results were consistent with the results from previous studies of N and P fertilizer

Table 4 Respone of shoot and root dry matter at 30 days after transplanting and straw and root dry matter, and grain yield at maturity to nursery and transplanting N treatments. Values are means of three replicates to two cultivars.

Treatment ($mg\ NH_4NO_3/kg$ soil)		Shoot dry matter (g/pot)	Root dry matter (g/pot)	Root shoot ratio	Straw dry matter (g/pot)	Root dry matter (g/pot)	Root:straw ratio (g/pot)	Grain yield
At sowing	At transplanting	At 30 DAT			At maturity			
0	0	3.19	1.01	0.33	6.03	3.78	0.62	6.62
60	0	3.68	1.12	0.31	6.33	3.70	0.60	7.35
120	0	4.18	1.28	0.30	6.03	3.49	0.57	7.34
240	0	4.05	1.50	0.38	6.17	3.67	0.61	7.45
0	400	4.10	1.35	0.34	22.7	16.3	0.73	34.9
60	400	4.33	1.64	0.38	23.5	15.0	0.66	35.8
120	400	4.90	1.67	0.34	24.5	15.3	0.65	36.5
240	400	4.49	1.54	0.34	25.3	13.1	0.52	37.6
LSD :								
- Nursery treatment (S)		1*	ns	ns	1.2*	0.8**	0.04*	1.1**
- Main field treatment (T)		0.9**	0.3*	ns	1.2*	0.5**	ns	0.8**
- S x T		ns	ns	ns	1.3*	1.1**	0.1*	ns

** = significant at the 1% level;
* = significant at the 5% level;
ns = not significant at the 5% level

Table 5 Response of shoot and root dry matter at 30 days after transplanting and straw and root dry matter, and grain yield at maturity to nursery and transplanting P treatments. Values are means of three replicates of two cultivars.

Treatment ($mg\ NH_4NO_3/kg$ soil)		Shoot dry matter (g/pot)	Root dry matter (g/pot)	Root shoot ratio	Straw dry matter (g/pot)	Root dry matter (g/pot)	Root:straw ratio	Grain yield (g/pot)
At sowing	At transplanting	At 30 DAT			At maturity			
0	0	1.57	0.45	0.30	22.4	13.2	0.59	28.3
50	0	2.22	0.58	0.26	22.8	12.9	0.56	29.2
100	0	2.57	0.88	0.32	23.1	12.8	0.55	30.7
120	0	3.24	1.21	0.37	23.3	12.5	0.54	31.9
0	300	2.94	0.97	0.33	22.0	12.1	0.53	31.4
50	300	3.76	1.34	0.36	23.0	11.4	0.49	32.0
100	300	4.43	1.58	0.35	23.7	10.2	0.41	33.7
200	300	4.13	1.56	0.39	23.1	9.00	0.37	36.7
LSD :								
- Nursery treatment (S)		0.6**	0.4**	ns	0.7*	0.6**	0.02**	1.5**
- Main field treatment (T)		0.4**	0.3**	ns	ns	0.4**	0.01**	1**
- S x T		ns	ns	ns	ns	1**	0.05**	ns

** = significant at the 1% level;

* = significant at the 5% level;

ns = not significant at the 5% level

addition to the nursery for two rice cultivars under flooded conditions (Panda *et al.*, 1991; Rajagopalan and Krishnarajan, 1987) even though the present studies were done under glasshouse conditions whereas the previous studies were conducted in the field. The present results were also strongly supported by a recent field study in Cambodia from which it was found that applying fertilizer in the nursery had the benefit of producing tall vigorous rice seedlings which eventually outyielded, by 10%, those grown in an unfertilized nursery (Ros *et al.*, 1996).

The increase in grain yiekld resulting from fertilizer application to the nursery could be attrebuted to any one of several parameters including the increase in plant height, shoot dry matter, nutrient concentration and the increased size of root system. The importance of these parameters will probably vary between the glasshouse and the mainfield. In the glasshouse, external stresses on the seedlings are managed whereas in the typical Cambodian rainfed lowland rice field seedlings are often subjected to both droughts and floods (Huysman, 1983) as well as pests and diseases. Newly transplanted seedlings from a fertilized nursery with vigorous dense root systems and strong stems may cope with these stresses by developing new roots faster than poorly grown seedling from the unfertilized nursery (Grist, 1975). Strong seedlings, Moreover, higher nutrient concentrations in the healthy seedlings grown in a fertilized nursery at sowing, may stimulate plant growth, especially after the transplanting shock period, and consequently produce higher grain yield than the seedlings from unfertilized nurseries.

Since increased seedling vigour and nutrient concentration in the rice plant during early growth appears to be important for improving subsequent plant growth and final grain yield, further consiferation should be griven to improving seedlings vigour by either applying nutrients to the soil or to the seed or by selecting for increased nutrient concentrations in the seed.

Seed coating with nutrients was previously foung to be an effective method for improving seedling vigout of other specied but not yet with rice (Smid and Bates, 1971; Scott and Blair, 1988; Scott, 1989). Coating seeds of phalaris (*Phalaris aquatica*) with P containing the equivalent of 5 kg P/ha procuced plan (at 27 days after sowing) that were as tell as those supplied with 20 kg P/ha by drilling or broadcasting methods but were higher applications of P (Scott and Blair, 1988). Similarly, small aditions of fertilizer in seed coatings were three or four times as effective in providing an early supply of P to corn seedling as was band placement (Smid and Bates, 1971).

Selection of seed with high nutrient concentration is another possible approach for producing healthy seedlings (De Marco, 1990; Thomson and Bolger, 1993; Thomson *et al.*, 1992). Seedling emergence from wheat seed with 0.2% P was more rapid than from seed with 0.14% P (De Marco, 1990). Similarly, in subterranean clover, seed with 0.75% P produced seedlings which emerged faster, produced more leaves and had higher shoot P concentration than seedlings grown from seed with 0.48% P (Thomson and Bolger, 1993).

In the case of rice plants, improving nutrien concentration in seeds by coating them with fertilizer or soaking them or selecting seed with high nutrient concentration may be beneficial for enhancing seedling vigour and subsequent growth, and maximizing the utility of the applied fertilizer. However, the effectiveness of these approaches compared to applying fertilizers to the nursery soil should be furtherly evaluated.

The results suggested a strong correlation between rice seedling growth and nutrition and grain yield. Applying N or P to the nursery increased final grain yield by 10 and 15%, respectively. Thus fertilizer application to the nursery appears to be a necessary supplement to that applied in the mainfield where comparable or substantially larger yield responses have been regularly found (De Datta *et al.*, 1990).

For the high risk rainfed lowland rice crop of Cambodia, adding N and P fertilizers to the nursery in significant proportions relative to the mainfield is necessary to produce strong and healthy seedlings because the soils are generally deficient in N and P (Saeki *et al.*, 1959). Such seedlings, which have higher nutrient accumulation in their tissue, may possibly recover more rapidly from transplanting shock and cope better with water stress, poor soils or other unfavourable environment factors.

Futther investigations on N and P application at sowing should be conducted under field conditions. Other approaches to enhance seedling vigour, such as seed coating, soaking seed with fertilizer and selection of seed with high nutrient concentration should also be tested to evaluate their reliability and effectiveness.

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