Indian J. Plant Physiol., Vol. XXXII, No. 4, pp 364-368, (December, 1989)

SHORT COMMUNICATION

INFLUENCE OF NITROGEN LEVELS ON PHOTOSYNTHESIS AND PRODUCTIVITY IN EARLY RICE VARIETIES

S.K. DEY, V.P. SINGH, AND K.S. MURTY

Central Rice Research Institute, Cuttack-753006,

Received on 23 June, 1989

Influence of N levels (30, 60 and 120 kg/ha) on photosynthesis and productivity was studied in 4 early rice varieties, Ratna, Pallavi, Swarnaprabha and Pusa 33 during wet season. The increase in these traits was mostly apparent up to 60 N. Swarnaprabha consistently showed high plant photosynthesis and grain yield at 60 N. Higher leaf area expansion along with high nitrogen content in leaf (N_{LA}) at flowering as in Swarnaprabha is considered to be an useful index for assessing N response in rice varieties during wet season.

Response to nitrogen on grain yield in rice has been well documented (Evans and De Datta, 1979). However, the response to higher levels of N is poor during wet season due to prevalent low light and its adverse influence on photosynthesis and carbohydrate content in plant and in protein synthesis. Hence high photosynthetic efficiency at canopy level has been considered as a potent factor for efficient nitrogen response and its utilisation (Tanaka *et al.*, (1964). In the present investigation, the influence of increasing N levels on photosynthesis and productivity of early rice varieties was studied during wet season.

Four early modern rice varieties, Ratna, Pallavi, Swarnaprabha and Pusa 33 were grown in field during wet season (July-Oct) at Central Rice Research Institute, Cuttack. Seedling of 25 days were planted at a spacing of 15 x 10 cm. P_2O_5 and K_2O each at 30 kg/ha were applied basal. Nitrogen as urea was added at 30, 60 and 120 kg/ha in three equal splits at planting, 20 days later and primordial initiation stage. The layout was complete RBD with three replications. Plant samples (above ground portions) were collected at 30 and 50 days after planting (D) and flowering (F) for total dry matter (TDM), leaf area index (LAI) and growth parameters. N percent and N uptake at flowering/harvest were assessed. Photosynthetic rate in mg CO_2 $dm^{-2}h^{-1}$ (Pn) of intact flag leaf and stomatal diffusive conductance (Cs) at flowering were measured by LI-COR-6000 between 10 and 11 hrs (radiation 1200 μE $m^{-2}s^{-1}$). Nitrogen (N_{LA}), soluble protein (SP) and chlorophyll (chl) per unit leaf

area (mg dm^{-2}) were also assessed at flowering. TDM, grain yield and yield parameters were recorded at harvest. Nitrogen utilisation efficiency (NUE) for dry matter and yield were calculated (wt per unit N absorbed).

Pn was in the order of Ratna, Pallavi, Swarnaprabha and Pusa 33. The mean Pn for 4 varieties increased by 27 and 33 perent in 60 N and 120 N respectively over 30 N with corresponding increase in Cs, chl, SP and N_{LA} by 14, 7, 10, and 15 percent in 60N and 21, 13, 14 and 18 percent in 120 N over 30 N. The response to N in the above traits was thus mostly apparent up to 60 N. CGR increased while RGR and NAR decreased with N level both at vegetative (30-50D) and reproductive (50D-F) stages. LAI and TDM at different stages, and N uptake at flowering and harvest increased with N level while post flowering N uptake was negligible. N utilisation efficiency for DM and yield decreased with N level (Table I). Swarnaprabha consistently recorded high values in all the above parameters.

Panicles and spikelets/m^2 increased up to 120 N while grains/m^2, HI and grain yield enhanced up to 60 N only. The grains/panicle decreased beyond 60 N with increase in panicles/m^2. Only Pusa 33 showed significant increase in yield beyond 60 N while there was even tendency for reduction in yield at 120 N in Ratna and Swarnaprabha. However, Swarnaprabha recorded highest grain yield at 60 N (488 g/m^2) which was even greater than that obtained at 120 N by Pusa 33 (468 g/m^2) (Table I & II).

Increase in Pn and other leaf characters with N level (Yoshida and Coronel, 1976) and association of Pn with Cs, N_{LA}, SP and chl have been well documented (Dey *et al.*, 1989). Obviously N_{LA} and SP had greater influence on Pn than chl. Contrary to earlier reports by Oritani *et al.*, (1979), LAI showed positive relation (albeit at 5 percent level) with Pn through maintenance of high N_{LA} with enhanced N level. The Pn, N_{LA} and SP were in the order Ratna, Pallavi, Swarnaprabha and Pusa 33. However, the product of LAI x Pn (index of canopy photosynthesis) was invariably the highest in Swarnaprabha due to larger LAI indicating its superiority in whole plant photosynthesis.

N uptake increased with N level (Reddy and Reddy, 1986) with corresponding increase in LAI and at a lower magnitude in TDM. Thus NUE for biomass production decreased with N rate. In the present varieties NUE was similar (1:120) while N uptake varied considerably in order Swarnaprabha, Pusa 33, Pallavi and Ratna suggesting that N uptake rather than NUE influenced TDM and yield. Yield increased upto 60 N mostly through higher panicle and consequent higher grain number/m^2 as also observed by Rahman (1985). HI also increased up to 60 N along with TDM resulting in maximum response in yield at this N level.

Table I. Effect of N levels on photosynthetic characters, growth and yield in wet season

Characters	N level kg/ha		
	30	60	120
LAI 30D	1.33	1.38	1.62
50D	2.86	3.50	4.25
F	3.37	4.09	4.86
TDM 30D (g m^{-2})	116	125	145
50D	305	346	396
F	664	706	817
H	775	858	925
CGR 30-50D (g m^{-2} d^{-1})	9.51	11.0	12.4
50D-F	12.8	12.9	15.0
NAR 30-50D (mg dm^{-2} d^{-1})	47.0	47.0	44.7
50D-F	41.0	34.0	32.0
RGR 30-50D (mg g^{-1} d^{-1})	47.0	51.0	50.0
50D-F	32.0	31.0	29.0
N uptake F (g m^{-2})	5.71	6.98	8.13
H	5.54	7.05	8.11
Pn F (mg CO_2 $dm^{-2}h^{-1}$)	25.4	32.5	33.6
Cs F (cm s^{-1})	1.10	1.26	1.34
Chl (mg dm^{-2})	3.86	4.14	4.40
SLW (mg dm^{-2})	434	442	427
N_{LA} (mg dm^{-2})	11.7	13.5	13.9
SP (mg dm^{-2})	24.2	26.7	27.5
NUE F DM/g N absorbed	116	100	99
H	140	122	114
Yield/N absorbed	59	54	49
Yield parameters			
Yield (g/m^2)	323	380	397
Panicles/m^2	354	397	438
Spikelets/m^2 x 10^3	247	280	315
Grains/m^2 x 10^3	142	181	193
Grains/panicle	40	46	44
1000 g wt (g)	20.7	20.8	20.6
Sterility %	43	35	38
HI %	38	44	42

D = Days. F = Flowering, H = Harvest.

The high yield in Swarnaprabha at moderate level of N (60 N) is attributed to high LAI, CGR, NAR, N uptake, canopy photosynthesis (LAI x Pn), dry matter production during reproductive and ripening stages and greater grain number/m^2

Table II. Effect of N levels on photosynthesis, dry matter and yield in early rice varieties (wet season)

Variety / N level	Stage				
	Flowering			Harvest (gm^{-2})	
	Pn	LAI	N uptake	TDM	Yield
Ratna 30N	27.5	3.49	4.87	713	243
60N	34.8	3.57	5.98	759	300
120N	35.9	3.99	7.06	809	297
Pallavi					
30N	25.6	3.45	5.85	733	320
60N	33.5	4.04	6.56	781	350
120N	34.0	4.31	6.95	791	370
Swarnaprabha					
30N	24.5	3.35	6.83	966	386
60N	31.3	4.60	8.78	1062	488
120N	32.7	5.05	9.41	1080	455
Pusa 33 30N	24.2	3.21	4.60	688	345
60N	30.6	4.15	6.86	834	384
120N	32.1	5.08	9.03	1033	468
CD (5%) V	1.0	0.08	0.13	9	31
N	0.9	0.07	0.11	8	27
V x N	ns	0.14	0.23	15	54

with low spikelet sterility. Adaptability of Swarnaprabha to low light in wet season has been recently reported (Murty and Sahu, 1987) and its yield response to low to moderate N level is demonstrated in the present investigation. Obviously greater leaf area expansion (within the optimum level 5 LAI) combined with leaf nitrogen enrichment (N_{LA}) as observed in Swarnaprabha from 30 to 60 N could be considered as desirable parameters for assessing N response in the early rice varieties during wet season.

REFERENCES

Dey, S.K., Singh, V.P., Swain, P. and Murty, K.S. (1989) Path coefficients of different leaf characters on photosynthetic rate in rice. *Indian J. Plant. Physiol.*, **32** : 237-239.

Evans, L.T. and De Datta, S.K. (1979) The relation between irradiance and grain yield of irrigated rice in the tropics, as influenced by cultivar, nitrogen fertilizer application and month of planting. *Field Crops Res.*, **2** : 1-17.

Murty, K.S. and Sahu, G. (1987) Impact of low light stress on growth and yield of rice. In : *Weather and Rice*. pp. 93-101, IRRI, Philippines.

Oritani, T., Enbutsu, T. and Yoshida, R. (1979) Studies on nitrogen metabolism in crop plants. XVI. Changes in photosynthesis and nitrogen metabolism in relation to leaf area growth of several rice varieties. *Japanese J. Crop. Sci.*, **48** : 10-16.

Rahman, M.S. (1985) The relation between some growth parameters and yield components of rice as influenced by nitrogen level and genotype. *Ann. Appl. Biol.*, **107** : 325-333.

Reddy, G.R. and Reddy, K.A. (1986) Uptake and apparent recovery of nitrogen by rice as influenced by nitrogen levels and forms of urea. *J Res., A.P.A.U.*, **14** : 106-110.

Tanaka, A., Navasero, S.A., Garcia, C.V., Parao, F.T. and Ramirez, E. (1964) Growth habit of rice plant in the tropics and its effect on nitrogen response. IRRI, Philippines, *Tech.* Bull. 3 : p. 80.

Yoshida, S. and Coronel, V. (1976) Nitrogen nutrition, leaf resistance and leaf photosynthetic rate of the rice plant. *Soil Sci. & Plant Nutr.*, **22** : 207-211.