NITROGEN RESPONSE CURVES IN THE RAINFED LOWLANDS AREAS UNDER DIFFERENT ESTABLISHMENT PRACTICES OF RICE IN NATIONAL WHEAT RESEARCH PROGRAM, BHAIRAHWA

***Nabin Rawal[1], Mathura Yadav[1], Janmejai Tripathi[1], Andrew McDonald[2], Bechan Yadav[1] & Narayan Khatri [1]**

[1]Nepal Agricultural Research Council, Nepal
[2]CIMMYT, South Asia Regional Office, Kathmandu, Nepal

(Received on Date: 25th February 2017 Date of Acceptance: 18th March 2017)

ABSTRACT

Field experiments were conducted with an objective to prepare nitrogen response curves in rice for three establishment practices on the alkaline and silt loam soils of NWRP, Bhairahawa during 2012 and 2013. The experiment was laid down in split plot design; three establishment practices were designed (puddled transplanted, non-puddled transplanted and conventional tillage + DSR) as a main plot and four levels of nitrogen (0, 60, 120 and 180 N kgha^{-1}) as a sub-plot and were replicated three times. Significant effect of nitrogen levels and establishment practices on grain yield and other yield parameters was observed in both of the years. The combined analysis results revealed that significantly higher grain yield was obtained under conventional tillage plus DSR (5181 kgha^{-1}) than non puddled transplanted rice (4172 kgha^{-1}) which were at par with puddle transplanted condition (4962 kgha^{-1}). The highest grain yield of 5227 kgha^{-1} was obtained from the application of nitrogen @ 180 kgha^{-1} which was at par with the application of nitrogen @120 kgha^{-1} (5120 kgha^{-1}). Based on two years results, it can be concluded that N was a limiting factor for the productivity of rice in Bhairahawa areas. Yield increased with increasing level of nitrogen but there was not significant response beyond 120 kgha^{-1} nitrogen application. Therefore 120 kgha^{-1} nitrogen could be optimum dose for direct seeded rice (DSR) and puddled transplanting at Bhairahawa condition.

***Keywords*:** Establishment practices, grain yield, nitrogen and Nitrogen response curve

No: of Tables: 4 **No:of Figures: 1** **No:of References: 26**

INTRODUCTION

Rice is the major consumer of fertilizer nitrogen and gives high response to applied N. N is the most limiting nutrient for rice growth and yield in almost all environments (Yoshida 1981, Roy and Mishra 1999). Nitrogen fertilizer is universally accepted as a key component to high crop yield and optimum economic return. One major consequence of inadequate N is reduced leaf area, thereby, limiting light interception, photosynthesis and finally biomass growth, grain yield and water productivity (Sinclair 1990). It is one of the costliest and perhaps the most crucial nutrients limiting crop yields and is a burning problem of most of the rice growing areas of Nepal. Plant growth is adversely affected due to deficiency of nitrogen as it restricts the formation of enzymes, chlorophyll and proteins necessary for growth and development. Generally, rice growers face the problem of skilled labour shortage at the time of transplanting which results into low plant population and eventually low rice yield (Aslam *et al*., 2008). Rice transplantation is usually performed by hired expensive labor, which is not specialized to maintain the required plant population to achieve higher productivity (Mann *et al*., 2007). To overcome this problem, direct seeding of rice seems only viable alternatives in rescuing farmers (Aslam*et al*., 2008). This technique reduces labour needs by more than 25% in term of working hours. The input requirements and the investment in direct seeded rice are much lower than in transplanted rice (Sunil *et al*., 2002). Direct seeded rice, if managed properly, can yield as high as transplanted rice (Hayat *et al*., 2003; Ali *et al*., 2007). Datta*et al* (1988) evaluated DSR and TP rice under similar N management practices and found that N plant recovery was greater for DSR than TP rice. Without applied N, grain yield of transplanted rice was lower than that of DSR. In flood-irrigated rice with the soil being mostly under anaerobic conditions, N is available as ammonium nitrogen (NH4 N) (Vlek and Byrnes, 1986), whereas in DSR N is available mostly in the form of nitrate nitrogen (NO3 N) (George et al., 1992).In recent years, there has been a shift from transplanting to dry seeded rice (DSR) in Southeast Asia (Pandey and Velasco, 2002) to reduce irrigation water input (Sudhir-Yadav et al., 2011a,b), reduce labour and input costs (Jat et al., 2009; Saharawat et al., 2010), improve water- and nutrient-use efficiency and avoid the deleterious effects of puddling and intensive soil tillage on soil structure and fertility (Timsina and Connor, 2001), The preparation of land for transplanting paddy (puddling) consumes about 20-40 % of the total water required for growing of crop and subsequently poses difficulties in seed bed preparation for succeeding wheat crop in rotation. It also promotes the formation of hard pan which effects rooting depth of next crop (Bhuiyan*et al* 1995).Adoption of alternative rice culture, which requires less input and possible increase in yield, is highly desirable (Pingali, 1991).Nitrogen use efficiency for rice grown under different tillage and establishment practices is insufficiently understood, hence so are the fertilizer management practices that can optimize crop performance. Therefore, the present work has been undertaken for determining suitable planting method and optimal quantity of nitrogen fertilizer for increasing yield.This trial develops fertilizer response curves for rice established with different tillage and establishment practices.

The major objectives of the experiment were as follows:

- To assess the effect of rice to different nitrogen levels and different establishment practices to lowland rice

- To prepare the nitrogen response curve in the lowlands areas under different establishment practices of rice

MATERIALS AND METHODS

Site, Treatments and Crop Management

The experimental site is situated at Bhairahawa in the western Terai region of Nepal at the latitude of 27°32' and the longitude of 83°28' with an elevation of 120 masl. Temperature ranges from a minimum of about 7°C in winter to the maximum of about 45 ^{0}C in summer season. In general, the site receives ample rainfall during the rainy season, which starts from June and continues up to September. The mean annual rainfall is about 1800 mm. Initial soil samples were collected before the start of the experiment to determine the fertility status of the experimental site (Table 1). The experimental site was a lowland and the pH of the soil was alkaline (8.0) with low organic matter content of 1.35%. It also had low amount of nitrogen (0.08%), medium phosphorus (53.21 kg/ha) and medium potassium (119.42 kg/ha) supply capacity. Texturally the soil was silt loam with the bulk density of 1.54 gm/cm^3 (0-20 cm soil depth).

Table 1. Chemical and physical soil properties at the experimental site

Soil Depth	pH	OM (%)	N (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Texture		
						clay	sand	silt
0-10	7.91	2.1	0.1	45.59	185.65	3.6	52.7	43.7
10-20	8.1	1.38	0.08	25.14	89.73	4.1	51.9	44
20-30	8.0	0.59	0.06	88.9	82.88	3.5	52.5	44.0
Average	8.0	1.35	0.08	53.21	119.42	3.7	52.4	43.9
Category	Alkaline	Low	Low	Medium	Medium	Silt loam		

The experiment was laid out in split plot design: three establishment practices (Puddled transplanted, Non-puddled transplanted and Conventional tillage + DSR) as a whole plot and four levels of nitrogen (0, 60, 120 and 180 kg/ha) as a sub-plot which were replicated three times. The experiment was conducted during 2012 and 2013 in western terai of Nepal. The plot size was 4 X 3 m^2. Urea, DAP, SSP and MOP were the source of fertilizers used for supplying nitrogen, phosphorus and potash respectively.Half dose of N and full dose of P and K were applied applied at sowing. Remaining 50% was applied in 2 equal splits 25 and 50 DAS or DAT.

Measurement of Crop Parameters

Data were recorded on days to heading, days to maturity, panicle m^{-2}, floret per panicle, floret fertility percentage, 1000 grain weight, biological yield, grain yield and harvest index. Number of panicle in one meter square area at two places were counted in each subplot and converted into number of panicle m^{-2}. A random sample of 1000 grains from each treatment was collected and weighed with digital balance for 1000 grain weight. For biological yield, 7.2 m^2 area from each sub- plot was harvested, sun dried, and weighed into kgha^{-1}. For grain yield, the biomass of 7.2 m^2 area from each subplot was sun dried, threshed, cleaned and grains were weighed into kgha^{-1}.

Statistical Analysis

Recorded data were compiled and tabulated in Ms-Excel. Data for each parameter over two year period was subjected to analysis of variance using a split plot design according to MSTATC (Steel and Torrie, 1980) and GENSTAT. Treatment means were compared using least significant difference (LSD) test at $P \leq 0.05$.

RESULTS AND DISCUSSION

The effect of different establishment methods was significant on heading dates, maturity dates, productive tillers/m^2, thousand grain weight, biological yield, grain yield and harvest index but was non-significant on florets/panicle and floret fertility percentage. The result showed that conventional tillage + DSR headed and matured earlier than other two factors but puddled transplanted gave higher number of tillers (269) with respect to other establishment methods (Table 2). Similarly, the effect of nitrogen levels was significant on heading dates, maturity dates, productive tillers/m^2, biological yield and grain yield but it was non-significant on thousand grain weight, florets/panicle, floret fertility percentage and harvest index.The analysis showed that highest number of tillers (283) was obtained from the higher level of nitrogen rate (180 kg N ha^{-1}) than other treatments.

Table-2. Yield and yield attributes of rice as affected by different establishment methods and nitrogen levels NWRP, Bhairahawa during 2012 and 2013

Treatments	Days to heading(DH)			Days to maturity (DM)			Panicle density (no./m2)		
Years	2012	2013	combined	2012	2013	combined	2012	2013	combined
Establishment methods									
DSR	109	115	112	137	135	136	233	288	261
NPTR	119	121	120	141	146	144	254	244	249
PTR	117	119	118	142	145	144	264	274	269
LSD (p=0.05)	2.9***	Ns	4.8*	Ns	Ns	2.3***	15.51*	Ns	9.3*
Nitrogen level (kg/ha)									
0	117	123	120	138	143	141	226	248	237
60	116	118	117	138	142	140	258	262	260
120	114	116	115	142	141	141	253	262	257
180	113	116	115	142	143	142	265	302	283
LSD (p=0.05)	1.6***	4.9*	3.0**	1.7*	Ns	1.2**	24*	Ns	23.8**
CV (%)	1.4	4.2	2.7	1.2	1.4	1.6	13.4	19.2	16.3

***, ** and * denotes significant at 0.1 , 1 and 5 % level of significance respectively and Ns stands for non significant

Similarly, the results showed conventional tillage + DSR gave higher thousand grain weight in both the years whereas floret per panicle and floret fertility percentage was found non-significant to different establishment methods. At the same time, there was non-significant effect of different levels of nitrogen on floret per panicle, floret fertility percentage and thousand grain weights. Reddy and Reddy (1989) observed that the number of panicles, filled grains/panicle and test weight increased with 40-120 kg N/ha as compared to control. Similarly, increasing levels of N increased growth and yield attributes significantly.

Table-3. Yield attributes of rice as affected by different establishment methods and nitrogen levels NWRP, Bhairahawa

Treatments	Florets/panicle)			% floretfertility			1000 grain wt (g)		
Years	2012	2013	combined	2012	2013	combined	2012	2013	combined
Establishment methods									
DSR	131	135	133	92.7	88.7	90.7	22.1	20.8	22.0
NPTR	123	147	135	86.6	88.7	87.7	21.7	20.2	20.9
PTR	108	134	121	88.1	88.7	88.4	21.8	21.7	21.3
LSD (p=0.05)	12	Ns	Ns	0.03*	Ns	Ns	0.19**	0.27***	0.18***
Nitrogen levels (kg/ha)									
0	124	131	128	88.4	88.3	88.8	21.7	20.9	21.3
60	133	145	139	89.1	90.1	89.6	21..7	20.7	21.2
120	108	137	123	88.0	87.5	87.8	21.8	21.0	21.4
180	118	140	129	90.1	88.9	89.5	22.1	20.9	21.6
LSD (p=0.05)	15	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	10.1	20.3	15.2	3.6	4.1	4.3	3.3	1.4	2.3

***, ** and * denotes significant at 0.1, 1 and 5 % level of significance respectively and Ns stands for non significant

The analysis showed that significantly higher grain yield of 5181 kg ha^{-1} was obtained from conventional tillage plus DSR which was at par with puddle transplanted (4962 kg ha^{-1}). Similar effect was found in biomass yield and harvest index in both years. The data revealed that nitrogen level @ 120 kg ha^{-1} gave significantly higher grain yield (5.1 ton ha^{-1}) and biological yield (12.6 ton ha^{-1}) with respect to other levels of nitrogen which was at par with nitrogen level @ 180 kg ha^{-1} (5.2 ton ha^{-1} and 12.9 ton ha^{-1} respectively). 120 kg/ha nitrogen could be optimum dose for DSR and puddle transplanting at Bhairahawa condition (Fig 1).

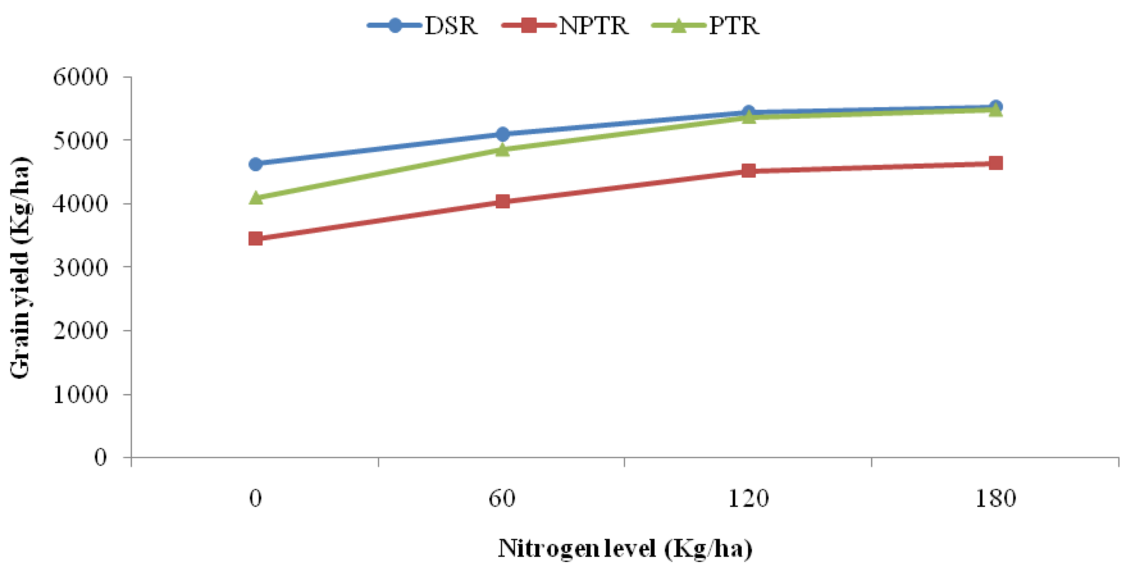

Figure 1: Nitrogen Response Curves in the Rainfed Lowlands areas under Different Establishment Practices of Rice

However, the finding of another study revealed that the N rates significantly increased the grain yield up to 140 kg N/ha as compared with lower doses of N of 80 and 100 kg/ha but was at par with 160 kg N/ha (Hirzel et al., 2011). Similar results were also obtained by Xiang-long et al. (2007) and Huang et al. (2008).Ehsnullah et al. (2001) reported that 125 kg N/ha produced significantly higher number of grains/panicle, 1000-grain weight and grain yield than that of 100 kg N/ha.It has been reported that a significant increase in grain and straw yield of rice when the rate of N application was increased from 0-120 kg N/ha (Singh and Sharma 2000). Further increase in N application from 120 to 180 kg N/ha had no significant effect on the grain and straw yield of rice. Similar reports were observed by Sharma et al. (2007) and Murthy et al. (1992)

Table-4. Yield and yield attributes of rice as affected by different establishment methods and nitrogen levels NWRP, Bhairahawa

Treatments	Grain yield at 14% (kg/ha)			Total above ground biomass (kg/ha)			Harvest Index (%)		
Years	2012	2013	combined	2012	2013	combined	2012	2013	combined
Establishment methods									
DSR	4953	5409	5181	10812	16829	13820	46	32.5	39.1
NPTR	4047	4297	4172	9851	10104	9978	41	42.6	41.8
PTR	4800	5124	4962	10792	12245	11518	45	42.1	43.2
LSD (p=0.05)	480*	824*	515*	814*	3167*	1752*	1.5*	4.58**	2.5*
Nitrogen level (kg/ha)									
0	3769	4362	4066	9098	11265	10181	41.3	40.1	40.7
60	4607	4740	4673	20505	12346	11426	43.7	39.4	41.5
120	4903	5338	5120	20950	14151	12551	44.7	38.8	41.7
180	5120	5335	5227	22387	14475	12931	45.0	38.0	41.5
LSD (p=0.05)	301***	462***	300***	624	1119***	1129***	1.6	Ns	Ns
CV (%)	7.6	9.4	9.2	13.3	8.7	11.5	3.7	10.5	7.7

***, ** and * denotes significant at 0.1, 1 and 5 % level of significance respectively and Ns stands for non significant

Datta et al. (1988) evaluated DSR and TP rice under similar N management practices and found that N plant recovery was greater for DSR than TP rice. Increasing N supply to a crop drives the production of a greater canopy biomass with the potential for higher photosynthesis and productivity. Availability of N has impacts throughout crop development, affecting seedling establishment, tillering, canopy development as well as grain filling, all of which have the potential to influence final yieldand together determine the N requirements of the crop.

CONCLUSION

Data were collected analyzed, and result revealed that crop matured early under direct seeded rice (DSR) than transplanted condition. Panicle density was also higher in DSR and puddle transplanted rice over non puddle transplanted rice. Conventional tillage plus DSR and puddled transplanted rice were at par for grain yield and total biomass but significantly different with non-puddled transplanted rice. Based on two years results, it can be concluded that N was a limiting factor for the productivity of rice in Bhairahawa areas. Yield increased with increasing level of nitrogen but there was not significant response beyond 120 kg/ha nitrogen application. Therefore 120 kg/ha nitrogen could be optimum dose for DSR and puddle transplanting at Bhairahawa condition.

ACKNOWLEDGMENT

The auther express his sincere gratitude to Wheat Coordinator, NWRP, Bhairahawa for providing facilities and proper guidance during the course of this research. The author is grateful to IFAD for providing research fund. Thanks also goes to the present staffs of NWRP without whose assistance, the experiment would not have reached this stage.

REFERENCES

Ali R..I., Awan Z.T.H.,Manzoor Z., Ashraf M.M.., SafdarM.E. and Ahmad M.2007.Screening of rice varieties suitable for direct seeding in Punjab. J. Anim. Pl. Sci. 17 (1–2): 24–26.

Aslam M.., Hussain S., RamzanM. andAkhter M.2008.Effect of different stand establishment techniques on rice yields and its attributes. J. Anim. Pl. Sci. 18 (2–3): 80-82.

Bhuiyan S.I., Sattar M.A. andTabbal D.F.1995. Wet seeded rice: water use efficiency and productivity and constraints to wider adoption. In Moody (ed) Constraints, Opportunities and innovations for wet seeded rice, Los Banos (Phillipines): IRRI Pp: 143-55.

De Datta S.K., Buresh R.J., Samson M.I. andWang K.R.1988. Nitrogen use efficiency and N-15 balances in broadcast seeded flooded and transplanted rice. Soil. Sci. Soc. America J. 52: 849-855.

Ehsanullah Attaullah, Cheema M.S. and Usman M..2001. Rice Basmati-385 response to single and split application of nitrogen at different growth stages. Pakistan J Agric. Sci. **38**: 84-86.

George T., Ladha J.K., Buresh R.J. andGarrity D.P. 1992. Managing native and legume fixed nitrogen in lowland rice-based cropping systems. Plant and Soil 141: 69–91.

Hayat K.., AwanI.U. andHassan G.2003..Impact of seeding dates and varieties on weed infestation, yield and yield components of rice (Oryza sativa L.) under direct wet seeded culture. Pakistan J. Weed Sci. Res. 9: 59–65.

Hirzel J., Pedreros A. and Cordero K.2011.Effect of nitrogen rates and split nitrogen fertilization on grain yield and its components in flooded rice. Chilean J Agric Res **71**: 437-444.

Huang J., He F., Cui K., Buresh R., Xu B., Gong W. and Peng S.2008.Determination of optimal nitrogen rate for rice varieties using a chlorophyll meter. Field Crop Res **105**: 70-80.

Jat M.L., Gathala M.K., Ladha J.K., SaharawatY.S., Jat A.S., Kumar V., Sharma S.K. and Gupta R.. 2009. Evaluation of precision land leveling and double zero-till systems in the rice–wheat rotation: water use, productivity, profitability and soil physical properties. Soil & Tillage Research 105, 112–121.

Mann R.A., Ahmad S., Hassan G. and Baloch M.S.2007. Weed management in direct seeded rice crop. Pakistan J. Weed Sci. Res. 13 (3–4): 219–226.

Murthy P.S.S., Ramesh K.S., Rao G.V.H. and Narayanan A.1992.Influence of nitrogen on grain filling potential and yield of rice (Oryza sativa) varieties. Indian J Agron**37**: 157-158.

Pandey S. and Velasco L. 2002. Economics of direct seeding in Asia: patterns of adoption and research priorities. In: Pandey, S., Mortimer, M., Wade, L., Tuong, T.P., Lope, K., Hardy, B. (Eds.), Direct Seeding: Research Strategies and Opportunities. International Rice Research Institute, Los Banos, Philippines.

Pingali P.L. 1991."Agricultural growth and the environment conditions for their compatibility in Asia's humid tropic," IRRI Social Sciences Div. Paper No.12-19. IRRI, Manila, Philippines, p. 25.

Reddy G.R.S.and Reddy K.A.1989.Effect of levels and sources of nitrogen on rice. Indian J Agron**34**: 364-366.

Roy D.K. and Mishra S.S.1999. Effect of weed management in direct-seeded, upland rice (Oryza sativa) at varying nitrogen levels. Indian J Agron 44: 105-108.

Saharawat Y.S., Singh B., Malik R.K., Ladha, J.K., Gathala M., Jat M.L. and Kumar V. 2010..Evaluation of alternative tillage and crop establishment methods in a rice–wheat rotation in North Western IGP. Field Crops Research 116, 260–267.

Sharma R.P., Pathak S.K. andSingh R.C.2007..Effect of nitrogen and weed management in direct seeded rice (Oryza sativa) under upland conditions.Indian J.Agron.**52**: 114-119.

Sinclair T.N.(1990).Nitrogen influence on the physiology of crop yield. (In) Theoretical Production Ecology: Reflections and Prospects. Pp-181.

Singh M. and Sharma S.N.2000.Effect of wheat residue management practices and nitrogen rates on the productivity and nutrients uptake of rice (Orzya sativa L.)-wheat (Triticumaestivum L.) cropping system. Indian J AgricSci**70**: 835-839.

Steel R.G.D.,Torrie andJ.H. 1980."Principles and Procedures of Statistics" McGraw Hill Book Co. Inc., New York.

Sudhir-Yadav, Gill G., Humphreys E., Kukal S.S. and Walia U.S. 2011a. Effect of water management on dry seeded and puddled transplanted rice, part 1: crop performance. Field Crops Research 120, 112–122.

Sudhir-Yadav, Humphreys E., Kukal S.S., Gill G. and Rangarajan R. 2011b. Effect of water management on dry seeded and puddled transplanted rice: part 2: water balance and water productivity. Field Crops Research 120, 123–132.

Sunil K.., Khajanji S.N.,Shrivastava G.K.,TripathiR.S. and Kumar S. 2002.Comparative study of different methods of sowing on morpho physiological traits and economics of medium duration rice (Oryza sativa) inceptisols. J. Interacademicia 6(2): 244–249.

Timsina J. and Connor D.J. 2001. Productivity and management of rice–

wheat systems: issues and challenges. Field Crops Research 69, 93–132.

Vlek P.L.G. and Byrnes B.H. 1986.The efficacy and loss of fertilizer N in lowland rice. Fertilizer Research 9, 131–147.

Xiang-long P., Yuang-ying.L, Sheng-guo L., Li-chun F., Tiansing and Yan-wen G.2007..Effects of site-specific nitrogen management on yield and dry matter accumulation of rice from cold areas of northeastern China.AgricSci China **6**: 715-723.

Yoshida S.1981.Fundamentals of Rice Crop Science.International Rice Research Institute, Los Banos, Philippines.Pp-269.