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Responses of split application of nitrogen on the performance of *Kharif* rice (*Oryza sativa* L.) in Terai zone of West Bengal

PARTHA SARATHI PATRA, SHYAMAL KHEROAR, ASHOK CHOUDHURY AND RAJESH SAHA

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MEMBERS OF RESEARCH FORUM:

Corresponding author :
SHYAMAL KHEROAR, All India Network Project on Jute and Allied Fibres, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch BEHAR (W.B.) INDIA
Email: kheroarshyamal@gmail.com

Co-authors :
PARTHA SARATHI PATRA, Regional Research Station (U.B.K.V.), Terai Zone, Cooch BEHAR (W.B.) INDIA
Email: parthaagro@gmail.com

ASHOK CHOUDHURY, Department of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch, BEHAR (W.B.) INDIA
Email: ashokc540@gmail.com

RAJESH SAHA, Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch, BEHAR (W.B.) INDIA
Email: rajeshsaha61@gmail.com

Summary

A field trial had been conducted to see the responses of split application of nitrogen on the performance of *Kharif* rice comprising of 5 treatments (T_1=50% N as basal+50% N at active tillering, T_2=50% N as basal+25% N at active tillering + 25% N at panicle initiation, T_3=25% N as basal+25 % N at active tillering+25% N at panicle initiation+25% N at flowering, T_4=40% N as basal+30% N at active tillering basal+30% N at panicle initiation and T_5=100% N as basal) using Randomized Complete Block Design (RCBD) with 4 replications in Terai zone, Cooch Behar, West Bengal during 2015 and 2016. The experimental results showed that all the growth and yield attributes were found to be highest where nitrogen was applied in four equal split (T_3) followed by T_2 and T_4. Higher growth and yield attributes ultimately helped in producing 6.98 and 9.22 per cent more grain yield in T_3 over T_2 and T_4, respectively. 430 to 820 kg ha^{-1} yield reduction has been found when 100 per cent nitrogen applied as basal in comparison with splitting of nitrogen in two (T_1) and four equal parts (T_3).

Key words : Rice, Nitrogen, Split application, Yield, Economics

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Introduction

Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds of millions of people in Africa and Latin America (IRRI, 2006). India is the leading rice producing country in terms of area and is the second largest producer next to China. Nitrogen management is essential for rice under aerobic culture as the nitrogen use efficiency is be in the range of 40 to 60 per cent, application of nitrogen at right time is perhaps the simplest agronomic solution for improving the use efficiency of nitrogen (Devi *et al.*, 2012). Nitrogen (N) is a component of amino acids, proteins and several phytohormones, hence, it is an essential macro element for plants (Wang and Schjoerring, 2012). Nitrogen is the main nutrient associated with yield, its availability promotes crop growth and tillering, finally determining the number of panicles and spikelet's during the early panicle formation stage. This nutrient also provides sink during the late panicle formation stage (Hirzel *et al.*, 2011). Some of the promising N management techniques including split application, rate and timing of N rate critical for optimum rice grain yield (Doberman and Fairhurst, 2000). Nitrogen use efficiency may be increased through it is appropriate level and split application (Ehsanullah *et al.*, 2001). Nitrogen contributes to spikelet production during the early panicle formation stage, and contributes to sink size by decreasing the number of degenerated spikelets and increasing hull size during the late panicle formation stage. Panicle architecture covers several aspects such as spikelet density, panicle length, panicle curvature (Sharief *et al.*, 2006). Rate and timing of nitrogen are critical in terms of their effects on yield. Nitrogen increase plant height, panicle number, leaf size, spikelet number of filled spikelets (Shakouri *et al.*, 2012). For optimal yield, the N supply must be available according to the needs of the plant (Azarpour *et al.*, 2011). Rice being the major feeder of N, requires adequate supply from planting unit flowering for better establishment growth and higher yield level (Pushpanathan *et al.*, 2005). Accumulation of N elements in rice productive organs and it is distribution is

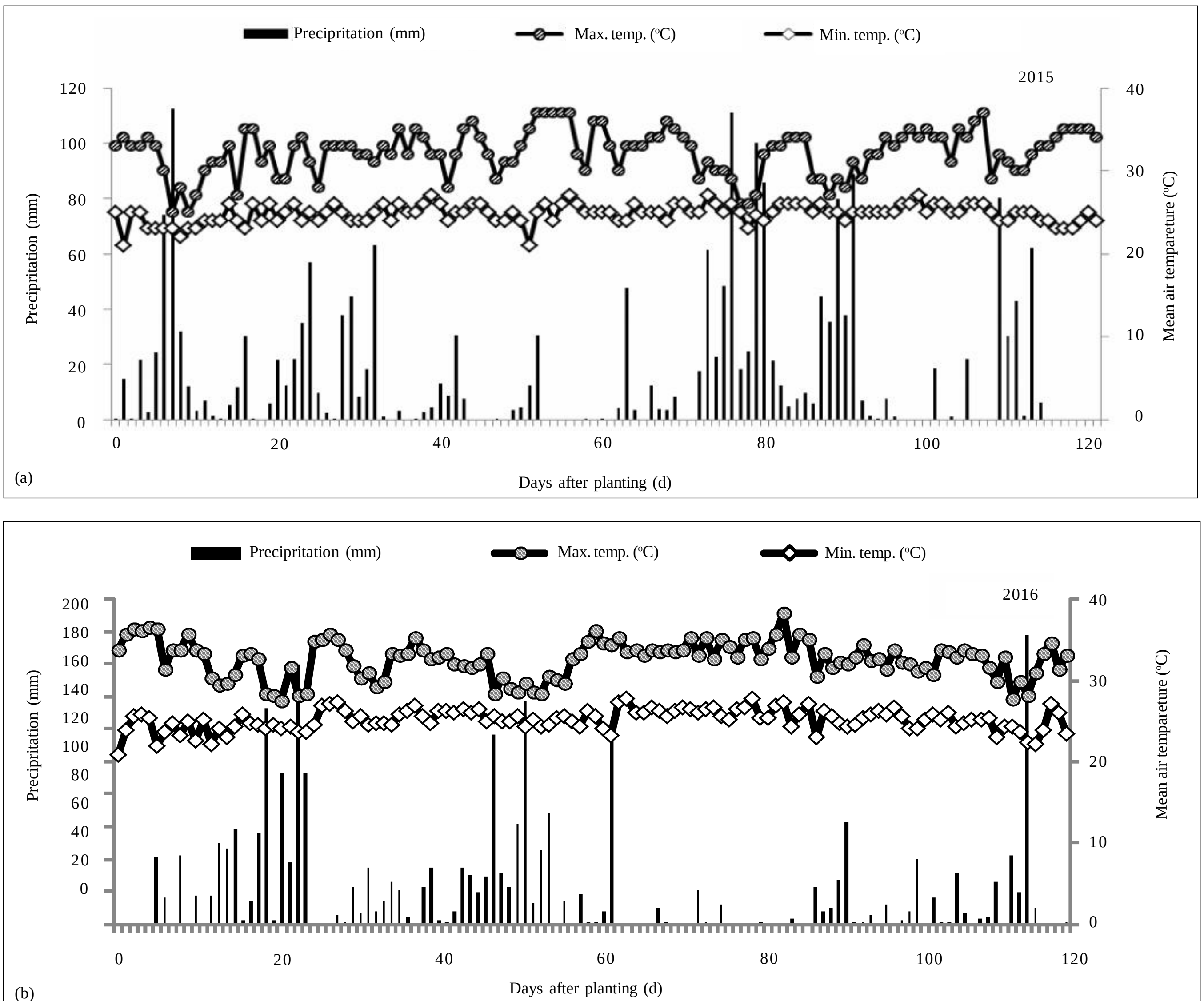

Fig. A : Daily precipitation and mean air temperature during the rice growing seasons in 2015 and 2016

an important process for determination of grain yield (Bahmanyar and Ranjbar, 2007). Grain and straw yields and yield attributes and test weight were effectively increased with fertilizer N application (Vennila *et al.*, 2007). Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the preheading stage and in grain during the grain-filling stage by being a fertilization to prevent the occurrence of N deficiencies, as well as to prevent over fertilization, which contributes to increased lodging, poor grain filling due to mutual shading, and increased severity and incidence of diseases (Ghanbari, 2011) Top dressing of N at heading helped the plants to maintain a high photosynthesis rate, with a subsequent significant increase of grain-filling rate, grain-filling duration, and higher percentage of filled grains, compared with basal application or top dressing of N at tillering (Wei *et al.*, 2011). Nitrogen application in three equal splits at transplanting, tillering and panicle emergence is essential,as nitrogen applied in splits is utilized in a better way towards increasing grain yield (Ehsanullah *et al.*, 2001)

Considering all the facts in mind, present experiment was conducted to see the responses of split application of nitrogen on the performance of *Kharif* rice.

Resource and Research Methods

The experiment was conducted during *Kharif* season 2015 and 2016 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The farm is situated at $26^0$19’86"N latitude and $89^0$23’53" E longitude, at an elevation of 43 meter above mean sea label. The annual average rainfall of the experimental site is 3000 mm and about 75 per cent rainfall receives during *Kharif* (June to September) season (Fig. A). The soil of the experimental site was sandy loam having pH 5.50, organic carbon 0.91 per cent, available nitrogen 117.5 kg ha^{-1}, available phosphorus 20.25 kg ha^{-1} and available potassium 80.00 kg ha^{-1}. The variety used in this experiment was Ranjit. A set of 5 treatments was laid out in Randomized Block Design with four replications. Twenty-six days old seedlings were transplanted at a spacing of 20 × 15 cm. Each plot size was of 10 m x 5 m. Treatment comprised of T_1= 50% N as basal+ 50% N at active tillering, T_2=50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation, T_3=25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering, T_4=40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation and T_5=100% N as basal. Fertilizers were applied at @ 80, 40 and 40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively in the form of urea, single super phosphate and muriate of potash. Full dose of P_2O_5 and K_2O were applied at the time of transplantation. Data were recorded on growth attributes like plant height, dry matter accumulation, leaf area and yield attribute namely number of tiller m^{-2}, number of panicle m^{-2}, panicle length, number of filled grains $panicle^{-1}$, 1000 grain weight and grain yield. Standard statistical methods were used for comparing the treatment means.

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth attributes:

Plant height was recorded at the time of harvest and presented in the Table 1. Tallest plant of 115.88 cm

Table 1: Effect of split application of nitrogen on growth attributes of rice **(Pooled data over years)**

Treatments	Plant height (cm)	DMA ($g\ m^{-2}$) at 75DAS	Leaf area index at75 DAS	No. of tiller $hill^{-1}$ at75 DAS
T_1=50% N as basal+ 50% N at active tillering	109.90	208.69	2.44	11.04
T_2=50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation (PI)	115.73	234.85	2.81	11.74
T_3=25% N as basal+ 25 % N at active tillering+25% N at PI+25% N at flowering	115.88	245.56	2.96	12.24
T_4 =40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation	114.03	212.09	2.73	11.13
T_5=100% N as basal	105.23	182.75	2.17	10.80
S.E. ±	3.31	10.63	0.08	0.201
C.D. (P = 0.05)	NS	33.11	0.26	0.627
CV (%)	5.11	9.80	6.39	3.53

NS= Non-significant

was observed when nitrogen applied in four equal split (T_3) followed by T_2, T_4, T_1 and T_5 though all are statistically at par. Non-significant differences among treatment means of plant height at maturity may partly be due to the genetic characteristics of the variety and partly to the fact that there was no nutrient competition among plants. Shortest plant height (105.23cm) was observed in the plots where full dose of nitrogen was applied as basal. These results are supported by Ha and Suh (1993), who reported more plant height by applying nitrogen in splits and lower plant height by applying whole nitrogen in one dose.

Dry matter, leaf area and number of tiller hill^{-1} were recorded 75 days after transplantation of rice. It was found from the data presented in the Table 1 that T_3 (25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering) recorded significantly highest values of dry matter accumulation (245.56g m^{-2}), leaf area index (2.96) and number of tiller hill^{-1} (12.24) followed by T_2 (50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation) and T_4 (40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation). Adequate and balance supply of nitrogen promotes vigorous vegetative growth and deep green colour of the crop and also influences the utilization of P, K and other plant nutrients which results better growth of the crop. Shortage of assimilate supply due to inhibition of photosynthetic processes is one of the major factors determining grain filling, Inhibition of photosynthesis during the grain filling period due to environmental stresses such as shading or water deficit can result in a major reduction in grain dry matter in rice (Abou-Khalifa, 2012). Different levels of nitrogen significantly affected the 1000-grain weight and this response was liner (Jamil and Hussain, 2000).

Yield attributes and yield :

The numbers of panicles are associated with the tiller production which is most important yield attributing character (Kaushal *et al.*, 2010). Results of the experiment showed that application of nitrogen in four split *i.e.* 25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering (T_3) recorded highest values of panicle m^{-2} (380.50), panicle length (25.50cm), number of filled grains panicle $^{-1}$(225.75), 1000 grain weight (22.46 g) and grain yield (3.58 t ha^{-1})

Table 2: Effect of split application of nitrogen on yield attributes and grain yield of rice **(Pooled data over years)**

Treatments	No. of panicle m^{-2}	Panicle length (cm)	No. of filled grains panicle^{-1}	Test weight (g)	Grain yield (t ha^{-1})
T_1=50% N as basal+ 50% N at active tillering)	340.75	23.75	199.75	21.68	3.19
T_2=50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation (PI)	365.75	24.50	217.75	22.40	3.33
T_3=25% N as basal + 25 % N at active tillering +25 % N at PI+25% N at flowering	380.50	25.50	225.75	22.46	3.58
T_4 =40% N as basal+ 30% N at active tillering basal + 30 % N at panicle initiation	343.00	24.25	215.25	22.15	3.25
T_5=100% N as basal	328.50	23.50	186.00	21.17	2.76
S.E.±	7.20	1.32	16.18	0.71	0.120
C.D. (P = 0.05)	22.44	NS	NS	NS	0.374
CV (%)	4.10	10.81	15.49	6.44	7.46

NS=Non-significant

Table 3: Effect of split application of nitrogen on economics of rice

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1=50% N as basal+ 50% N at active tillering	28124	56240	28116	1.0
T_2=50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation (PI)	28124	58860	30736	1.09
T_3=25% N as basal+ 25 % N at active tillering+ 25 % N at PI+25% N at flowering	28124	63580	35456	1.26
T_4 =40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation	28124	57640	29516	1.05
T_5=100% N as basal	28124	49320	21196	0.75

of rice which was followed by 50% N as basal+ 25 N % at active tillering basal+ 25 % N at panicle initiation stage (T_2) and 40% N as basal+ 30 % N at active tillering basal+ 30% N at panicle initiation stage (T_4) (Table 2). The N application can be increasingly effected some traits such as dry matter, panicle length, panicle number per square meter which are correlated with grain yield (Bahmanyar and Ranjbar, 2007). Nitrogen can increase rice grain yield by increasing the total dry matter production, the number of panicles and the panicle length of rice (Wei *et al.*, 2011). Higher yield of rice to increase split of nitrogen is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and there by resulted in more dry matter accumulation (Chaturvedi, 2005). Basal N application increased total sink size, because of increase in both panicle number and spikelet number panicle. Increase in sink size often resulted in a decrease in grain-filling percentage (Peng *et al.*, 1998).

Availability of nitrogen throughout the growth stages might be responsible for the better performance. Whenever full dose of nitrogen was applied as basal, yield is reduced to the extent of 15.58 to 29.71 per cent (Asif *et al.*, 2000; Vennila *et al.*, 2007 and Bahmanyar and Soodaei Mashaee, 2010).

Economics:

Economic analysis (Table 3) revealed that splitting of nitrogen in four equal part *i.e.* 25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering (T_3) helped in fetching higher net return (Rs.35,456.00) and B: C ratio (1.26) followed by T_2 (Rs.30,736.00 and 1.09), where nitrogen was applied in three splits 50% as basal+ 25 % at active tillering + 25% at panicle initiation was applied, T_4 (Rs. 29,516.00 and 1.05) and T_1 (Rs. 28,116.00 and 1.0). Whenever full nitrogen was applied as basal (T_5) net return and B:C ratio was reduced to the tune of Rs. 14,260.00 and 0.51 as compared to T_3 (25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering). Higher net return and B:C ratio is simply due higher grain yield corresponding to T_3.

Conclusion:

It was concluded from the experiment that splitting of nitrogen will help in improving all the yield attributes and grain yield of rice as compared to 100 per cent basal application. So it is recommended that for getting higher yield with comparatively lesser cost, nitrogen should be applied in four equal parts *i.e.* 25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering during *Kharif* season.

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