International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1629-1633

Received: 13-05-2020
Accepted: 15-06-2020

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Effect of splits of nitrogen application on yield and uptake of irrigated rice

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4p.9843

Abstract
A field experiments was conducted during *kharif* 2016 to study the effect of splits of nitrogen application on yield and uptake on irrigated rice crop at Agricultural Research Station, Bapatla. The experiment was conducted in randomized block design on sandy clay loam soil with six treatments replicated four times. The treatments consisted of control *i.e* no nitrogen application, 1/2N at maximum tillering stage+1/2 N at panicle panicle initiation stage, 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage, 1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage, 1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage, 1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage. The results shown that significantly the highest grain yield (5525 kg/ha), straw yield (7750 kg/ha) and nitrogen uptake (113kg/ha in grain and 75.9 kg/ha in straw) was recorded with 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage when compared to control.

Keywords: Rice, panicle initiation stage

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. Globally it is grown on acreage of 158 million hectares with total production of 700 million tonnes and productivity 4.43 ton per hectare (FAO, 2014) [7]. India has the largest area (44.2 m ha) among rice growing countries and stands second in production (108.9 m t) with a productivity of 2391 kg ha^{-1}. In Andhra Pradesh, rice is grown in an area of 2.4 million hectare with a production of 7.24 million tonnes and productivity of 3022 kg ha^{-1} (Ministry of Agriculture, Government of India, 2016-17).

Rice production depends on several factors: climate, physical conditions of the soil, soil fertility, water management, sowing date, cultivar, seed rate, weed control, and fertilization (Angus *et al*., 1994) [2]. For fertilization, N is the main nutrient associated with yield (Jing *et al*., 2008) [11]. Its availability promotes crop growth and tillering, finally determining the number of panicles and spikelets during the early panicle formation stage. This nutrient also provides sink during the late panicle formation stage (Artacho *et al*., 2009) [3]. Some of the promising N management techniques in clued split application, rate and timing of N rate critical for optimum rice grain yield (Doberman and Fair hurst, 2000) [5]. So it is essential to find out the optimum rate of nitrogen application in different splits for efficient utilization of this element by the plants for better yield. The rice often benefit in rough and whole grain when N is top-dressed at the panicle emergence (early heading) growth stage (Walker, 2006) [26]. 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. Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading 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 increase lodging, poor grain filling due to mutual shading, and increased severity and incidence of diseases (Ghanbari Malidareh, 2011) [8]. Rice tillering is an important agronomic trait for grain production and the number of tillers is dynamic and adjustable, although moderate tillering contributes greatly to rice yields, excessive tillering leads to high tiller abortion, poor grain setting, and small panicle size and ultimately reduces grain yield.

It is important that selecting genotypes with high efficiency in remobilizing N from vegetative parts to the grain with high grain protein concentration. Increase grain yield can be attributed to an increase in the number of grains per panicle (Ghanbari Malidareh, 2011) [8]. Irshad *et al*, 2000 [10]; suggested that for getting maximum yield at least some nitrogen must be applied at tillering stage along with that applied at transplanting.

Materials and Methods

This experiment was conducted at Agricultural Research Station, Bapatla during *kharif* 2016. The experiment was laid out in randomized block design replicated four times with six treatments. The treatments consisted of (T1)-control *i.e* no nitrogen application, (T2)-1/2 N at maximum tillering stage+1/2 N at panicle initiation stage, (T3)-1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage, (T4)-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage, (T5)-1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage, (T6)-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage. Recommended dose of nitrogen, phosphorus and potash for krishna zone was 120:60:40 kg/ha. Nitrogen, phosphorus and potassium were applied throug urea, single super phosphate and murate of potash, respectively. Nitrogen was applied in different splits as per the treatments. Total recommended phosphorus was applied as basal and potash was applied in two splits in that 1/2 potash was applied as basal and 1/2 potash was appled in panicle initiarion stage. Recommended agronomic management practices and plant protection measures were followed during crop growth. The data recorded were analyzed following standard statistical analysis of variance procedure.

Plant height (cm)

Significantly higher plant height (83.9 cm) was recorded with 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment (T3) over control (79.2 cm) which might be due to quick release of nutrients and more availability of nitrogen. Nitrogen is associated with increase in protoplasm, cell division and cell enlargement resulting in taller plants (Tisdale *et al*., 1985) [25] and also in increased chlorophyll content at all growth stages, might have increased the photosynthesis and resulted in increased plant height (Gill and Harsharan Singh, 1985) [9]. Such a favorable effect of nitrogen on increase in plant height of rice has been reported by many researchers (Meena *et al*., 2011 and Prasad Rao *et al*., 2011) [13, 18].

Total Number of Tillers/plant

Data on total number of tillers/plant are significantly affected by different splits of nitrogen application (Table-1). At maturity stage, the treatment that received 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment (T3) recorded higher number of tillers (12) followed T3, T4, T5 & T6 treatments. The lowest number of tillers was recorded with control (9) treatment. Increased availability of nitrogen in different crop growth stages might have supported for increase in number of tillers m^{-2}. Similar results were also reported by Mamata Meena *et al*. (2013) [12].

Drymatter accumulation (kg/ha)

A Perusal of the data on drymatter accumulation (kg ha^{-1}) revealed that there were significant differences in drymatter accumulation among the treatments of rice. Drymatter accumulation followed the similar trend as in case of plant height and total number of tiilers m^{-2}. Significantly the highest drymatter accumulation (14582 kg/ha) was recorded with the treatment that received 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment and the lowest was recorded with control treatment (7985 kg/ha). Drymatter accumulation is an important pre requisite for obtaining higher grain yields, which indicated other bio-synthetic process, associated during the developmental sequences. Nitrogen might have involved in various physiological activities like increased photosynthetic activity and better light interception which in turn resulted in higher drymatter accumulation. Similar results were also noticed by Ameta and Singh (1990) [1].

Panicle length (cm)

A significant difference in length of the panicle (Table-2) was observed among the treatments tested which was followed the same trend as in the case of plant height and drymatter accumulation during the study. Significantly higher panicle length (19.3 cm) was observed in the treatment (T5) i.e 1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation +1/4 N at heading stage which was statistically on a par with T6, T4, T3 and T2 treatments, but proved significantly superior to control (15.2 cm) during the experimentation. Splits of nitrogen application might have supported steady increase in soil nitrogen availability during crop growth which in turn might have increased the length of the panicle and spikelet number $panicle^{-1}$ by enhanced cell division and enlargement (Srilaxmi *et al*., 2005 and Ramana *et al.*, 2012) [22, 19].

Number of grains/panicle

The data on total number of grains $panicle^{-1}$ was presented in Table-2 which revealed significant influence on total number of grains $panicle^{-1}$ by different splits of nitrogen application during the study. Significantly higher number of grains $panicle^{-1}$ was recorded with the treatment that received 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment (150) which was statistically on a par with all other treatment but proved significantly superior to control treatment (119) only. Significantly, higher number of grains $panicle^{-1}$ was recorded with the application of nitrogen in different splits might have supported steady increase in soil nitrogen availability during crop growth which in turn might have increased number of productive tillers, number of panicles and number of filled grains $panicle^{-1}$ (Srivastava *et al*., 2006 and Shekara *et al*., 2011) [23, 20].

Test weight (g)

The data pertaining to the test weight significantly influenced by different splits of nitrogen application. Significantly the highest test weight **(19.9g)**was recorded with the treatment that received 1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation+1/4 N at heading stage treatment and 1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation+1/3 extra N at heading stage treatment (19.9 g) and the lowest test weight (16.9g) was recorded with control treatment. This might be due to increased translocation of photosynthates from source to sink. Such an increase in 1000 grain weight with the application of nitrogen was also noticed elsewhere (Zaidi *et al*., 2007 and Narendra Pandey *et al*., 2008) [28, 15].

Grain yield (kg/ha)
The differences found in growth parameters and yield attributes presented earlier were reflected in grain yield of rice. It was significantly influenced by various treatments of study. The data pertaining to the grain yield of rice are presented in the Table-3. During the study significantly higher yields (6538 kg/ha) was recorded with the 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment, which was statistically on a par with rest of treatments except T1 *i.e* control treatment (3235 kg/ha). The economic yield is a fraction of the total biological yield of the crop and drymatter accumulation, which is an important determinant of the grain yield (Donald, 1962). These results are in confirmation with the findings of Ombir Singh *et al*. (2012) [16] and Sunita Gaind and Lata Nain (2012) [24].

Straw yield (kg/ha)
Perusal of the data on straw yield (Table-3) revealed that the straw yield also followed almost similar trend as that of grain yield during the study. Significantly highest straw yield (7740 kg/ha) was recorded with the 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment, which was statistically on a par with rest of treatments and the lowest straw yield was recorded with control treatment (4460 kg/ha). Overall, the increase in straw yield with these treatments might be due to better growth reflected in these treatments in terms of plant height, drymatter accumulation and tillering. These results are in conformity with Yogeshwar Singh *et al*. (2006) [27] and Zayed *et al*. (2011) [29].

Harvest index (%)
Harvest index (Table-3) was the maximum (46.5%) with treatment that received 1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation +1/4 N at heading stage treatment, which was on par with all other treatment except T1 treatment (42.0%). The increase in harvest index with increasing levels of nitrogen might be due to better translocation of assimilates from source to sink as was observed with number of filled grains per panicle and 1000 grain weight. A few other researchers (Ombir Singh *et al*., 2012 and Sunita Gaind and Lata Nain, 2012) [16, 24] have also noticed such effect of nitrogen on harvest index.

Nitrogen uptake (kg/ha)
A perusal of the data (Table-4) showed significant differences in nitrogen uptake in plant at maturity (grain and straw) due to different treatments while there is no significant variation in nitrogen content among the treatments. The same trend was followed during the study as in case of grain and straw yields of rice. But, it was observed that significantly higher nitrogen uptake (113.6 kg/ha in grain and 75.8 kg/ha in straw) was observed with treatment that received 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage treatment followed by T4 and T2 treatments both in grain and straw of rice crop. The uptake being the product of nutrient content and dry matter accumulation, the increase in N uptake by the crop might be due to increased availability of nitrogen and higher grain and straw yields. Similar results were also reported by Balaji Nayak *et al.* (2011) [4] and Pradeep *et al.* (2012) [17].

Table 1: Effect of splits of nitrogen application on rice plant growth

Treatment	Plant height (cm)	No of tillers/ plant	Drymatter production (kg/ha)
T1- No nitrogen	79.2	9	7985
T2-1/2 N at maximum tillering stage+1/2 at panicle panicle initiation stage	83.3	11	13830
T3- 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage	83.9	12	14582
T4-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage	83.3	12	13835
T5-1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage	82.2	12	13740
T6-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage	82.0	12	13490
SEm±	0.90	0.3	214.4
CD (0.05)	2.68	0.98	633.2
CV (%)	5.19	5.9	7.5

Table 2: Effect of splits of nitrogen application on yield attributes of rice crop

Treatment	Panicle length (cm)	No of grains/ panicle	Test weight (g)
T1- No nitrogen	15.2	119	16.9
T2-1/2 N at maximum tillering stage+1/2 at panicle panicle initiation stage	18.4	144	19.4
T3- 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage	18.9	150	19.5
T4-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage	18.6	145	19.5
T5-1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage	19.3	144	19.9
T6-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage	19.1	146	19.9
SEm±	0.5	4.4	0.6
CD (0.05)	1.5	12.9	1.9
CV (%)	5.6	6.2	7.9

Table 3: Effect of splits of nitrogen application on grain Yield, straw yield and harvest index of rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T1- No nitrogen	3235	4460	42.0
T2-1/2 N at maximum tillering stage+1/2 at panicle panicle initiation stage	6225	7385	45.7
T3- 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage	6538	7740	45.8
T4-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage	6250	7365	45.9
T5-1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage	6200	7125	46.5
T6-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage	6075	7100	46.1
SEm±	142.8	225.4	
CD (0.05)	430.4	669.4	
CV (%)	5.0	6.6	

Table 4: Effect of splits of nitrogen application on nitrogen content (%) and uptake (kg/ha) of rice

Treatment	Grain		Straw	
	Nitrogen content (%)	Nitrogen uptake (kg/ha)	Nitrogen content (%)	Nitrogen uptake (kg/ha)
T1- No nitrogen	1.44	46.5	0.56	24.97
T2-1/2 N at maximum tillering stage+1/2 at panicle panicle initiation stage	1.67	103.8	0.95	70.15
T3- 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage	1.74	113.6	0.98	75.85
T4-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage	1.69	105.6	0.93	68.49
T5-1/4 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage + 1/4 N at heading stage	1.35	83.7	0.61	43.46
T6-1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage + extra 1/3 N at heading stage	1.43	86.8	0.67	47.57
SEm±	0.03	2.16	0.02	0.99
CD (0.05)	0.17	12.9	0.12	5.91
CV (%)	4.44	9.62	4.62	7.21

Conclusion

According to the results of this study 1/2 N at basal+1/4 N at maximum tillering stage+1/4 N at panicle initiation stage produced highest plant height, tiller number, drymatter accumulation, grain yield straw yield and nitrogen uptake both in grain and straw of rice followed by 1/3 N at basal+1/3 N at maximum tillering stage+1/3 N at panicle initiation stage.

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