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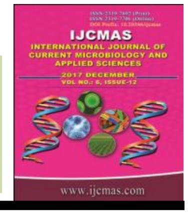

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Response of Machine Transplanted Rice (*Oryza sativa* L.) to Different Nitrogen and Phosphorus Levels during Rabi

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A field experiment was conducted during *rabi*, 2015-16 at farmer's field located at K.C. peta village of Tirupati rural mandal of Chittoor district of Andhra Pradesh for optimizing the nutrient requirement of machine transplanted rice under mechanized system of rice intensification (MSRI) in Randomized Block Design with factorial concept with four nitrogen levels (80, 120, 160 and 200 kg N ha^{-1}) and three phosphorus levels (40, 60 and 80 kg P_2O_5 ha^{-1}) replicated thrice. Application of 160 kg N ha^{-1} and 200 kg N ha^{-1} recorded statistically at par grain, straw yield and returns. Hence, application of nitrogen @ 160 kg ha^{-1} was found to be optimum dose for machine transplanted rice. Levels of phosphorus and their interaction with nitrogen have no significant influence on grain, straw yields and returns due to initial soil phosphorus buildup of experimental site. Hence, application of 160 kg N ha^{-1} coupled with 40 kg P_2O_5 ha^{-1} can be recommended for machine transplanted rice for realizing higher yields and returns under mechanized system of rice intensification (MSRI).

Introduction

Rice is a major crop that is grown in more than 110 countries. India ranks first in the total area planted under rice with 44.1 million hectares, ranks second in the production after china with 158 million tonnes but, ranks 35th with respect to its productivity. India's rice productivity (2.42 t ha^{-1}) is far below the world's average productivity of 4.36 t ha^{-1} (India Stat, 2014). In Andhra Pradesh state, rice is the principal food crop cultivated in an area of 2.39 m ha with a production of 8.45 m t and productivity of 3.53 t ha^{-1} (Statistical Year Book, 2015). Demand for rice is growing every year but, area under rice crop is decreasing year by year due to water shortage and rapid urbanization and it is estimated that the rice requirement by 2025 AD would be 125 million tonnes (Kumar *et al.*, 2009).

Hence, present food self-sufficiency has to be sustained and future food requirement has to be met at the current population growth rate of 1.5 %. To meet burgeoning population rice productivity has to be increased with good management practices under shrinking availability of land and water resources. Land preparation, transplanting and harvesting are the expensive and time consuming operations for successful rice cultivation. Manual transplanting of rice is the most common and popular practice being followed under lowland ecosystem. Manual transplanting is a tedious, laborious, time consuming operation which involves enormous drudgery and human stress in sweltering weather. It requires about 300-350 man-h ha^{-1}, which is roughly 25% of the total labour requirement of paddy cultivation. Labour scarcity during peak period of transplanting and escalating labour cost make the manual transplanting technique more expensive which invariably leads to delay in transplanting and resulting in reduction of yield and leads to less profit (Sreenivasulu, 2014).

Mechanization increases land and labour productivity by timely completion of farm operations and reduces the drudgery of humans and animals. Mechanically transplanted rice gave higher benefit-cost ratio of 34.46% compared to manually transplanted rice (Mohanty *et al.*, 2010). Mechanization in transplanting through rice transplanter using mat nursery reduces the cost of cultivation since large area can be transplanted within a very short period (Mohanty *et al.*, 2014).

Under mechanized system of rice intensification (MSRI), rice crop tends to produce profuse tillering due to planting of relatively younger seedlings at wider spacing. But all the tillers produced are not becoming productive due to less conversion ratio and even the grain filling is poor in tertiary tillers which ultimately causing the reduction in grain yield. This may be attributed to inadequate nutrition and long assigned vegetative period than conventional transplanting at recommended dose of nutrients. To avoid this starvation, due importance should be given to nutrient management under mechanized system of rice intensification. Keeping these points in view the present experiment was planned to optimize nitrogen and phosphorus levels for machine transplanted rice under mechanized system of rice intensification (MSRI) for southern zone of Andhra Pradesh.

Materials and Methods

A field experiment was carried out during *rabi*, 2015-16 at farmer's field of Sri P. Damodar Reddy located at K.C. peta village of Tirupati mandal of Chittoor district situated at an altitude of 182.9 m above mean sea level at $13^{0}32'0''$ N latitude and $79^{o}24'25''$ E longitude in southern agro climatic zone of Andhra Pradesh. The experimental soil was clay loam in texture, slightly alkaline in reaction (8.0), medium in organic carbon, (0.54) and low in available nitrogen (228 kg ha^{-1}), high in available phosphorus (96 kg ha^{-1}) and available potassium (516 kg ha^{-1}). The experiment was laid out in Randomized Block Design with factorial concept with four nitrogen levels (80, 120, 160 and 200 kg N ha^{-1}) and three phosphorus levels (40, 60 and 80 kg P_2O_5 ha^{-1}) and replicated thrice. A uniform dose of 40 kg K_2O ha^{-1} was applied as basal dose to all the treatments. Entire P was applied basally as per treatment and N was applied in three equal splits at basal, 20 DAT and 40 DAT.

Nursery was raised in plastic trays filled with the soil and press mud cake in 70:30 ratio and placed in raised beds. Foliar spray of urea @ 0.5% was imposed at 10 DAS and machine transplanting was done at spacing 30 cm x 13-15 cm using 16 days old seedlings of Nellore Mashuri, medium duration variety with Yanmar - VP8D transplanter. Individual plots were kept at 5.0 m length x 5.0 m width. Growth parameters, yield attributes and yield, economics were worked out. All the necessary plant protection measures were taken up during the crop growth period.

Results and Discussion

Growth parameters

Application of 200 kg N ha^{-1} recorded significant increase in plant height over 80 and 120 kg N ha^{-1} and was comparable with 160 kg N ha^{-1}. Significantly minimum plant height was recorded with the lower level of nitrogen application (80 kg N ha^{-1}) which was at par with 120 kg N ha^{-1}.

These results are in consonance with the findings of Chamely *et al.*, (2015). Leaf area index of rice is closely related to grain production as it affects the rate of photosynthate production. It appears that plant height, tiller numbers and the above-ground biomass were significantly affected by the leaf area index which varied with the rates of nitrogen application. The rice crop responded well to the application of 200 kg N ha^{-1} by producing significantly larger leaf area and LAI at all crop growth stages.

Application of 200 kg N ha^{-1} produced significantly larger LAI which however did not vary significantly from the application of 160 kg N ha^{-1}. As compared to higher levels of nitrogen (160 and 200 kg N ha^{-1}), 120 kg N ha^{-1} resulted in significantly lesser LAI. Application of 80 kg N ha^{-1} recorded significantly lowest leaf area and LAI. Several researchers like Salem *et al.,* (2011) and Verma *et al.,* (2008) reported increased leaf area index with increasing nitrogen levels.

Application of 200 kg N ha^{-1} recorded maximum dry matter production m^{-2} which was comparable with 160 kg N ha^{-1} and significantly higher dry matter production over the application of 120 kg N ha^{-1} and 80 kg N ha^{-1}. Application of 80 kg N ha^{-1} produced significantly lowest dry matter production m^{-2}. Application of 160 kg N ha^{-1} has produced significantly higher dry matter m^{-2} over the application of 120 and 80 kg N ha^{-1}. The increase in dry matter accumulation is justifiable due to increasing rates of applied mineral N fertilizer. Higher level of N produced higher dry matter production, which is quite acceptable due to supply of enough nutrients to satisfy the demand of the crop.

Nitrogen being an important constituent of amino acids and protoplast, directly influences the plant growth and development through better utilization of photosynthates by producing more number of tillers and taller plants and thus, adequate supply of nitrogen results in higher biomass production in plants. Similar results were reported by Babu *et al.*, (2013).

Levels of phosphorus and their interaction with nitrogen could not influence the rice crop significantly with respect to plant height, LAI and dry matter production. These results are in close agreement with the findings of Murthy *et al.*, (2015) who observed comparable growth parameters at higher phosphorus levels but superior over control (without application of phosphorus) (Table 1).

Yield attributes

Yield attributes viz., number of panicles m^{-2}, panicle length, number of filled grains $panicle^{-1}$ were significantly influenced by nitrogen levels and levels of phosphorus and their interaction with nitrogen did not significantly influenced during both the years.

The number of panicle m^{-2} increased linearly with increasing N levels and application of 200 kg N ha^{-1} recorded maximum number of panicles m^{-2} which however, did not vary significantly with 160 kg N ha^{-1} and superior over lower levels of nitrogen (80 and 120 kg N ha^{-1}). Application of 80 kg N ha^{-1} recorded significantly lowest number of panicles m^{-2}.

Table.1 Growth, yield attributes, yield and economics of rice as influenced by N and P levels under MSRI

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	No. of panicles m^{-2}	Panicle length (cm)	Filled grains panicle^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Nitrogen Levels (kg ha^{-1})											
N_1 – 80	80.6	0.62	8570	349	18.7	123.1	5651	6590	87,329	41993	1.93
N_2 – 120	82.9	0.91	9960	383	19.0	126.8	6540	7304	1,00,318	54464	2.18
N_3 – 160	85.4	1.04	11190	409	19.5	139.7	7235	8195	1,11,174	64802	2.40
N_4 – 200	88.2	1.12	12000	424	19.8	146.0	7678	8662	1,18,369	71479	2.52
SEd	2.1	0.05	580	9.9	0.4	5.6	232	269	3718	3718	0.08
CD (p=0.05)	4.3	0.11	1160	20	0.8	11.6	480	556	7693	7693	0.17
Phosphorus Levels (kg ha^{-1})											
P_1 – 40	83.2	0.88	9970	387	19.1	131.7	6631	7439	1,01,789	56674	2.25
P_2 – 60	84.3	0.92	10390	389	19.3	133.9	6657	7662	1,02,320	56207	2.22
P_3 – 80	85.3	0.97	10940	397	19.4	136.0	7039	7963	1,08,783	61670	2.31
SEd	1.8	0.04	490	8.5	0.3	4.8	201	233	3220	3220	0.07
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x P											
SEd	3.6	0.09	970	17.1	0.7	9.7	402	465	6440	6440	0.14
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Panicle length varied significantly due to levels of nitrogen application and application of 200 kg N ha^{-1} recorded significantly longest panicle which was comparable with the application of 160 kg N ha^{-1} and significantly longer than 120 kg N ha^{-1} and 80 kg N ha^{-1}. Shortest panicle was recorded with the application of 80 kg N ha^{-1} which was at par with 120 and 160 kg N ha^{-1}. Increment in nitrogen levels increased the number filled grains $panicle^{-1}$ and decreased number of chaffy grains $panicle^{-1}$ and sterility %. Application of 200 kg N ha^{-1} recorded maximum number of filled grains $panicle^{-1}$ which did not vary significantly with 160 kg N ha^{-1}. Application of 120 kg N ha^{-1} resulted in significantly lesser number of filled grains $panicle^{-1}$ as compared to 160 and 200 kg N ha^{-1} but, comparable with 80 kg N ha^{-1}. Application of 160 kg N ha^{-1} has recorded significantly more filled grains $panicle^{-1}$ over 120 and 80 kg N ha^{-1}. Phosphorus levels and their interaction with nitrogen have shown non-significant response to number of panicle m^{-2}, panicle length and number of filled grains $panicle^{-1}$.

Yield

Grain and straw yields were increased with every increment in nitrogen levels. Maximum grain and straw yields were recorded with 200 kg N ha^{-1} which was comparable with 160 kg N ha^{-1}. As compared to higher levels of nitrogen, application of 120 kg N ha^{-1} resulted in significantly lower grain and straw yield. Application of 80 kg N ha^{-1} recorded significantly lowest grain and straw yield. Inspite of the fact that, the rice could not respond to phosphorus application and its interaction with nitrogen due to high initial soil available phosphorus, there was marginal increase in rice grain and straw yield. Highest grain and straw yield was recorded with the application of 80 kg P_2O_5 ha^{-1} which was comparable with 60 and 40 kg P_2O_5 ha^{-1}.

Economics

Highest cost of production was observed with higher N and P level and it reduced with lower N and P level as it is directly related to the quantity of nitrogen and phosphorus applied in the form of urea and single super phosphate. As the grain and straw yields were significantly increased at higher doses, likewise maximum gross returns, net returns and highest B: C ratio were realized at 200 kg N ha^{-1} which remained at par with 160 kg N ha^{-1} but statistically better returns and B: C ratio over the application of 120 kg N ha^{-1} and 80 kg N ha^{-1}. Gross returns, net returns and B: C ratio shown non-significant differences with phosphorus levels and their interaction with nitrogen levels.

The results revealed that, application of 160 kg N ha^{-1} and 200 kg N ha^{-1} recorded comparable growth parameters, yield attributes, yield and net returns. Hence, application of nitrogen @ 160 kg ha^{-1} was found to be optimum dose for realizing higher yields. As phosphorus levels and their interaction with nitrogen shown non-significant differences in yield and returns due to initial soil phosphorus build up, phosphorus application at lower dose of 40 kg P_2O_5 ha^{-1} can be recommended. Hence, it can be concluded that application of 160 kg N ha^{-1} coupled with 40 kg P_2O_5 ha^{-1} can be recommended for machine transplanted rice under high soil phosphorus build up condition for realizing higher yields and returns during *rabi* for southern agro climatic zone of Andhra Pradesh under mechanized system of rice intensification (MSRI).

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