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Effect of Different Levels, Sources and Methods of Nitrogen Application on Growth and Yield of Rice (*Oryza sativa* L.)

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A B S T R A C T

A field experiment was conducted on alluvial soil to study the effect of growth and yield of rice as influenced by different levels of nitrogen and method of basal and split application of nitrogen at Banaras Hindu University during kharif season of 2016. Crop response to treatment was measured in the terms of various quantitative and qualitative indices of plant growth like plant height, chlorophyll content, Number of tiller, penicle length and grain and straw yield, content of N, P and K in grain and straw were analyzed after harvest of the rice crop. The results revealed that the maximum grain yield (63.86 q ha^{-1}) was recorded significantly in the treatment T_3 (100% of RDN through PCU 3 Split) and the maximum straw yield (109.38 q ha^{-1}) was recorded in the treatment T_{10} (55% of RDN through PCU Single Basal + FYM + PGPR). The total biological yield was tent to slightly decrease with a decrease in fertilizer level and found statistical significance over treatment control T_1.

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops for more than half of the world population, especially for south-eastern Asia, where 90% of the world production of rice is grown and consumed. In India, it occupies 44 million ha of land and produces about 103.41 million tonnes of grain with the productivity of 2.35 tonnes ha^{-1} (Anonymous, 2012-13). However, this is not enough to feed the ever-increasing population, and there is need to increase the production to keep pace with population growth. On the contrary there is very limited scope for further expansion of area under rice and the only alternative left is vertical increase in yield. After onset of green revolution (1965-66), there has been remarkable increasein production of food grains due to intensive cultivation and enhanced use of agrochemicals - mainly fertilizers and pesticides, which has resulted in deterioration of soil quality. Intensive cultivation with high water-demanding crops has led to a decrease in groundwater levels, serious water logging and secondary salinization in large parts of the *Indo-Gangetic* Plain (Rai, 2002; Ladha *et al.*, 2003). Moreover, leveling of the yield increase, declining input factor productivity and even declining soil quality have been reported for parts of the *Indo-Gangetic* Plain

(Narang and Virmani, 2001). Soil quality plays a key role in determining production capacity and thus it is one of the major indicators of sustainability of any cropping system. Soil quality decline is primarily due to nutrient depletion (larger removal than addition of nutrients), nutrient mining (large removal of nutrients and no inputs), acidification (decline in pH and/or an increase in exchangeable Al), loss of organic matter and increase in toxic elements (e.g. Al, Mn). The microbial activities in soil also decrease due to reduced levels of organic matter. These microbial activities play significant role in nutrient availability and recycling. The decreased level of organic matter causes a strong reduction in soil fertility as it plays several roles in soil. Its deficiency results in poor physical, chemical and biological properties of soil.

Nitrogen (N) is often the most important and most limiting nutrient for crop yield in many regions of the world. Nitrogenous fertilizer is one of the main inputs for cereals production systems. Nitrogen is the plant nutrient that is often most limiting to efficient and profitable crop production. Inadequate supply of available N frequently results in plants that have slow growth, low protein levels, poor yield of low quality produce, and inefficient water use. Therefore, application of nitrogen fertilizer at the right rate and time is vital for the enhancement of soil fertility and crop productivity. High levels of N supply results in a higher protein content, but increased efficiency of utilization is realized when concentration in the kernels increases and grain yield remains stable (Ortiz Monasterio *et al.,* 1997).

Polymer-coated urea, also called plastic-coated urea, or PCU, is a slow releasing fertilizers can permit a more precise rate of nitrogen release Normal Urea. A variety of polymers are used to form semi-permeable coatings on soluble N sources, usually urea. Release is regulated by polymer chemistry, coating thickness, soil moisture, and soil temperature. Because of high cost, CRN use in agriculture is limited, accounting for less than 1% of worldwide fertilizer consumption (Englesjord *et al.,* 1997). The disadvantage of polymer-coated urea products is their relatively high cost compared to Normal Urea. Polymer-coated urea fertilizers use a hydrophobic (water insoluble) coating that temporarily isolates the urea prill from the soil environment. These polymer coatings may be resins or mineral-based products that act as semipermeable membranes or impermeable membranes with tiny pores. Nutrient release through these membranes is controlled by the properties of the coating material, i.e., its permeability characteristics as affected by temperature and moisture. Thus, they are not significantly affected by soil properties such as pH, salinity, soil texture, microbial activity, redox potential or cation exchange capacity. Therefore, it is possible to predict and control the nutrient release rate from these products are more accurately than for Normal Urea (Trenkel, 2010).

Materials and Methods

The experiment was carried out during kharif season of 2016 at the Agricultural Research Farm, Department of soil science and agricultural chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India). The experimental trial was conducted in field number A/14 of Agricultural Research Farm, B.H.U. This experiment was conducted with 12 treatments and 3 replications of control, 100 % of RDN through normal urea as a single basal dose and as in 3 split, and 100 %, 85 %, 70 % and 55 % RDN through PCU as single basal doses and as in 3 split under randomized block design (RBD) on rice variety HUR-105 during *kharif* season 2016.

The treatment (T_{12}) was comprising with 55 % of RDN through PCU as basal dressing + 2 tons FYM ha^{-1} + PGPR (mixture of *Azotobacter chroococcum, Pseudomonas aeruginosa, Pseudomonas flurescens, Pseudomonas putida, Bacillus subtilis, Azospirillumbrasilense, Trichoderma harzianum*). The soil of experimental field was low in organic carbon (0.48 %), medium available N (210.50 kg ha^{-1}), medium available P (12.32 kg ha^{-1}) and low available K (198.5 kg ha^{-1}) with pH (7.8) and EC (0.22 dSm^{-1}).

Growth parameters

The height of plant was measured from the surface of soil to the tip of plant with the help of a meter scale at 40, 80 and harvesting stage after transplanting. Chlorophyll content of the plants was measured by the use of Chlorophyll Meter in SPAD units at 40 and 60 days after transplanting. Chlorophyll content of randomly selected 5 sampled leaves from various rice plant in net plot area was measured at 40, 60 DAS coinciding with tillering, booting and panicle emergence stage of the crop. Finally, the average value on chlorophyll content were computed and expressed in SPAD unit.

Yield attributes

Numbers of tillers $plant^{-1}$ were counted at 40, 80 and harvesting days after transplanting of rice seedling. The grains yield obtained from each plot were weighed by pan balance in kg and converted into tons ha^{-1} by multiplying with factor 2.5**.** The grain yield was subtracted from the biological yield per plot to record the straw yield kg $plot^{-1}$. Which was converted into tons ha^{-1} by multiplying with factor 2.5. Biological Yield (kg ha^{-1}) was calculated from all the above ground plants part of each net plot, sun dried and weight in kg $plot^{-1}$ and these values were expressed into kg ha^{-1}.

Plant analysis

The plant and grain samples collected at harvesting were dried at 60+2°C for 48 hrs in a hot air oven and grind to powder. Nitrogen content in plant and grain samples was determined by Modified Kjeldahl Method as per procedure outlined by Gupta (2007). In a digestion tube, 0.5 g of powdered plant straw was taken and 10 mL of diacid solution (9:1, H_2SO_4:$HClO_4$) was added and kept overnight, 10g of sulphate mixture (20 parts K_2SO_4 + 1 part catalyst mixture containing 20 parts $CuSO_4$ + 1 part selenium powder) was added and heating was done in a digestion chamber till a clear colourless solution was obtained. The suspension was cooled and filtered through Whatman No. 42 filter paper in a 50 ml volumetric flask and volume was made up with distilled water. 10 mL of 4% boric acid solution containing bromocresol green and methyl red indicator was taken in a conical flask, outlet of distillation apparatus was dipped into boric acid solution. 5 mL of the aliquot was taken and transferred to distillation flask of micro-kjeldahl distillation apparatus and 10 mL of 40 % NaOH solution was added. After completion of distillation, boric acid was titrated against 0.02 N H_2SO_4. Blank was also run. One gram dried and powdered (20 mesh) plant sample was taken in a 50 ml digestion tube and 10 ml di-acid mixture (4:1 v/v HNO_3: $HClO_4$) was added to it and was kept overnight. It was then digested on a block digester till a colourless solution was obtained. The volume of acid was reduced till the flask contained only moist residue. The flask was cooled and 25 mL of distilled water was added to it. The solution was filtered into a 50 mL volumetric flask and diluted up to mark. 2 ml of digest was taken in a 25 ml volumetric flask and 2 drops of 2, 4 di-nitrophenol indicator was added followed by ammonium solution till appearance of yellow colour. Now 6 N HCl was added drop wise till it became colourless. 5 mL of Vanadate molybdate solution was then added to it and diluted to 25 mL with distilled water, mixed well and the intensity of yellow colour was read on spectrophotometer by using blue filter at 440 nm wave length. A blank was also run without P solution simultaneously. Phosphorus content in straw and grain was calculated using standard curve and expressed as total P-(%).

Same procedure was followed in determination of P content in grain except the weight of sample in case of grain was only 0.2 g (Jackson 1967). Potassium content in plant and grain was determined by Flame Photometer Method (Jackson, 1973). Digested extract was used directly for flame photometric determination of potassium. K content was calculated using the standard curve and expressed as.

Statistical analysis and interpretation of data

The data recorded during the course of investigation were subjected to statistical analysis as described by Panse and Sukhatme (1985). The significant effect of treatments was judged with the help of 'F' (variance ratio) table. The significant differences between of the means were tested against critical differences at 5% probability level.

Analysis of variance for all treatment in Randomized Block Design (RBD) was carried out. The significance and non-significant effect of the different treatments was tested with the help of 'F' variance ratio test. Calculated 'F' value was compared with table value of 'F' at 5% levels of significance.

If calculated value of 'F' exceeds its table value, the effect was considered to be significant. The significant difference between treatment means was tested using critical difference at 5% level of significance.

Results and Discussion

Effect on plant height

The data pertaining to effect of PCU and normal urea on height of plant is presented in Table 1 and depicted in. It is evident from The Table that height of plant (40 DAT) varied from 66.7 to 85.13 cm. It was higher in treatment T_3 (100% of RDN through PCU 3 Split) 85.13 cm followed by T_{12} (55% of RDN through PCU Single Basal + 40 Kg P + FYM @ 2 t ha^{-1} + PGPR) 84.40cm. Significant differences were found between the treatments after application of PCU in the plot. The inoculation with PCU showed significantly higher plant height (85.13 cm) at 40 DAT than normal urea treated plot with three split and single basal dose are 75.33 and 74.07 cm respectively. The treatment T_8 (100% PCU single basal dose) was found 84.20 cm plant height followed by T_4 (85% of RDN through PCU 3 Split) 82.20 cm and treatment T_9 (85% of RDN through PCU Single Basal) was found 81.20 cm followed by T_5 (70% of RDN through PCU 3 Split) 80.60 cm. However, the treatment T_{10} (70% of RDN through PCU Single Basal), T_6 (55% of RDN through PCU 3 Split) and T_{11} (55% of RDN through PCU Single Basal) were found statically at par to each other. Moreover, control plot with RDF showed a lowest plant height of 66.07 cm at 40 DAT. Almost similar trend was noticed with the plant height recorded at 80 DAT and at harvesting.

Effect on chlorophyll content (SPAD value)

Data pertaining to the chlorophyll content (SPAD value) in leaf as influenced by normal urea, PCU, SSP, FYM and PGPR application is give in Table 1. There was a significant increase in chlorophyll content at 40 DAT with the application of normal urea, PCU, SSP, FYM and PGPR. The maximum chlorophyll content (40.60) in leaf was found in treatment T_3 (100% of RDN through PCU 3 Split) followed by T_8 (100% of RDN through PCU Single Basal) having a value 40.33. The minimum chlorophyll content (34.01) was found in treatment T_1 (control). The application of FYM and PGPR with 40 kg P through SSP and 55 % RDN through PCU Single Basal in T_{12}, increase chlorophyll content 18.34% over the Control. Decreasing the percentage of PCU with three split application found at par in T_4 (85%), T_5 (70%) and T_6 (55%) and with single basal dose was found at par in T_9 (85%), T_{10} (70%) and T_{11} (55%). Moreover, with normal urea in T_2 (100% of RDN through Urea 3 Split), T_7 (100% of RDN through Urea Single Basal) it was found similar valued 37.74 and 37.50 respectively. Almost similar trend was observed in chlorophyll content recorded at 60 DAT. GuJia Lin *et al.,* (2009) The nitrogen release characteristic of macromolecule polymer coated urea (PCU) by laboratory method of water dissolve and the effects of applied PCU on tall fescue turf as basal application in spring was studied.

Effect on number of tillers per hill

A critical perusal of the data presented in Table 2 revealed that a significant increase was found in number of tillers at 40 DAT with the three split application of PCU than single basal dose of PCU and normal urea.While a significant increase in number of tillers also noted with single basal application of PCU with FYM, PGPR and SSP. Split application of PCU resulted significant increase in number of tillers (40 DAT) due to minimization of loss and higher nutrient efficiency as compared to single basal dose of PCU and other nutrient sources. The maximum number of tillers (29.33) was noted in T_3 (100 % of RDN through PCU 3 Split) and minimum number of tillers (15.22) in T_1 (control) at 40 DAT. The application of PCU in treatment T_8 (100% of RDN through PCU Single Basal) increases number of tillers 84.95% over the control, whileT_{12} (55 % of RDN through PCU Single Basal + FYM + PGPR + SSP) increased 73.91%, T_4 (85 % of RDN through PCU 3 Split) increased 71.15 %, T_5 (70 % of RDN through PCU 3 Split) increased 67.54% and T_6 (55 % of RDN through PCU 3 Split) increased 59.32 %. However, the treatment T_9 (85 % of RDN through PCU Single Basal), T_{10} (70 % of RDN through PCU Single Basal) and T_{11} (55 % of RDN through PCU Single Basal) and T_{10} (70 % of RDN through PCU Single Basal) were found statically at par to each other. Furthermore, with application of urea at 100 % in single basal and 3 split application found lowest among all the treatment valued 17.73 and 18.01 respectively. Almost similarand increasing trend was noticed with the number of tillers recorded at 80 DAT and a similar but decreasing trend at harvesting as compared to 40 DAT.

Effect on panicle length

Data pertaining to the panicle length presented in table 2 showed that at 80 DAT maximum panicle length of 19.92 cm was recording with split application of PCU in T_3 (100 % of RDN through PCU 3 Split) and minimum panicle length of 15.60 cm in T_1 (control). While an increase in panicle length recorded in T_8 (100 % of RDN through PCU Single Basal) 25.44 % over control, in T_{12} (55 % of RDN through PCU Single Basal + FYM + PGPR + SSP) 24.10 % increase and in T_4 (85 % of RDN through PCU 3 Split) 22.50 % increase. While comparing normal urea treated plot 8.52 % increase over control in T_2 (100% of RDN through Urea 3 Split) and in T_7 (100 % of RDN through Urea Single Basal) an increase of 4.93 %. Moreover, T_5 (70 % of RDN through PCU 3 Split), T_6 (55 % of RDN through PCU 3 Split), T_9 (85 % of RDN through PCU Single Basal), T_{10} (70 % of RDN through PCU Single Basal) and T_{11} (55 % of RDN through PCU Single Basal) found at par. A similar trend was recorded at harvesting for panicle length.

Table.1 Effect of different levels of recommended dose of nitrogen (RDN) through PCU on plant height and chlorophyll content (SPAD value) in leaves of rice at different days of interval

Treatment		Average Plant height $hill^{-1}$ (cm)			Chlorophyll in leaves (µg ml^{-1})	
		40 DAT	80 DAT	At harvesting	40 DAT	60 DAT
T_1	Control	32.82	76.09	81.30	25.83	24.61
T_2	100% of RDN through Urea 3 Split	39.33	96.77	94.20	33.15	31.99
T_3	100% of RDN through PCU 3 Split	41.47	94.73	97.70	38.90	36.69
T_4	85% of RDN through PCU 3 Split	42.57	96.20	96.20	37.36	36.77
T_5	70% of RDN through PCU 3 Split	43.07	91.70	94.57	38.40	36.31
T_6	55% of RDN through PCU 3 Split	40.20	91.43	88.30	35.10	33.30
T_7	100% of RDN through Urea Single Basal	38.67	84.93	89.13	39.35	38.31
T_8	100% of RDN through PCU Single Basal	41.07	95.47	91.50	38.88	37.93
T_9	85% of RDN through PCU Single Basal	41.17	94.83	93.53	40.35	37.60
T_{10}	70% of RDN through PCU Single Basal	42.33	95.00	98.57	39.03	36.00
T_{11}	55% of RDN through PCU Single Basal	40.47	95.53	97.13	36.57	35.08
T_{12}	55% of RDN through PCU Single Basal + 40 Kg P + FYM @ 2 t ha^{-1} + PGPR	36.70	92.43	96.53	36.41	34.17
	SEm±	0.954	1.421	1.089	1.900	1.931
	CD at 5%	1.974	2.941	2.253	3.934	3.998

Table.2 Effect of different levels of RDN through PCU on No. of tillers and Panicle length of rice at different days of interval

Treatment		No. of tillers $hill^{-1}$			Panicle length (cm)	
		40 DAT	80 DAT	At harvesting	80 DAT	At harvesting
T_1	Control	15.22	24.52	23.02	15.60	16.72
T_2	100% of RDN through Urea 3 Split	18.01	26.43	25.11	16.93	17.81
T_3	100% of RDN through PCU 3 Split	29.33	34.96	33.65	19.92	20.90
T_4	85% of RDN through PCU 3 Split	26.05	32.13	31.09	19.11	20.15
T_5	70% of RDN through PCU 3 Split	25.50	31.91	30.27	18.94	19.90
T_6	55% of RDN through PCU 3 Split	24.25	30.40	29.57	18.70	19.53
T_7	100% of RDN through Urea Single Basal	17.73	25.67	24.56	16.37	17.35
T_8	100% of RDN through PCU Single Basal	28.15	34.07	33.60	19.57	20.68
T_9	85% of RDN through PCU Single Basal	25.31	31.67	30.53	18.77	19.59
T_{10}	70% of RDN through PCU Single Basal	25.07	30.20	29.38	18.37	19.79
T_{11}	55% of RDN through PCU Single Basal	23.70	29.47	28.35	17.96	18.93
T_{12}	55% of RDN through PCU Single Basal + 40 Kg P + FYM @ 2 t ha^{-1} + PGPR	26.47	33.11	32.34	19.36	20.20
	SEm±	0.709	0.751	0.859	0.549	0.955
	CD at 5%	2.080	2.203	2.518	1.609	2.802

Table.3 Effect of different levels of RDN through PCU on yield of rice at harvesting

Treatment		Yield (q ha^{-1})		
		Biological	**Grain**	**Straw**
T_1	Control	96.01	33.64	62.36
T_2	100% of RDN through Urea 3 Split	154.12	58.23	95.89
T_3	100% of RDN through PCU 3 Split	157.12	63.86	93.26
T_4	85% of RDN through PCU 3 Split	147.17	59.66	87.50
T_5	70% of RDN through PCU 3 Split	150.90	50.87	100.03
T_6	55% of RDN through PCU 3 Split	149.06	56.29	92.77
T_7	100% of RDN through Urea Single Basal	150.55	48.31	102.23
T_8	100% of RDN through PCU Single Basal	155.22	62.44	92.79
T_9	85% of RDN through PCU Single Basal	161.67	56.26	105.41
T_{10}	70% of RDN through PCU Single Basal	160.96	51.58	109.38
T_{11}	55% of RDN through PCU Single Basal	153.75	57.29	96.46
T_{12}	55% of RDN through PCU Single Basal + 40 Kg P + FYM @ 2 t ha^{-1} + PGPR	164.59	61.77	102.82
	SEm±	2.362	1.773	1.371
	CD at 5%	4.889	3.671	2.837

Table.4 Content of N, P and K levels of recommended dose of nitrogen (RDN) through PCU in grain and straw of rice as affected by different N levels and methods of application through PCU and NU

Treatment		Content in grain			Content in straw		
		N (%)	**P (%)**	**K (%)**	**N (%)**	**P (%)**	**K (%)**
T_1	Control	0.890	0.237	0.131	0.307	0.092	1.092
T_2	100% of RDN through Urea 3 Split	1.122	0.249	0.187	0.341	0.105	1.237
T_3	100% of RDN through PCU 3 Split	1.234	0.316	0.228	0.451	0.148	1.328
T_4	85% of RDN through PCU 3 Split	1.133	0.278	0.219	0.381	0.132	1.303
T_5	70% of RDN through PCU 3 Split	1.128	0.268	0.213	0.364	0.128	1.298
T_6	55% of RDN through PCU 3 Split	1.124	0.261	0.208	0.342	0.125	1.287
T_7	100% of RDN through Urea Single Basal	1.119	0.247	0.185	0.332	0.103	1.232
T_8	100% of RDN through PCU Single Basal	1.231	0.313	0.225	0.449	0.145	1.323
T_9	85% of RDN through PCU Single Basal	1.130	0.273	0.216	0.375	0.129	1.296
T_{10}	70% of RDN through PCU Single Basal	1.126	0.262	0.208	0.353	0.126	1.279
T_{11}	55% of RDN through PCU Single Basal	1.117	0.258	0.202	0.340	0.122	1.268
T_{12}	55% of RDN through PCU Single Basal + 40 Kg P + FYM @ 2 t ha^{-1} + PGPR	1.207	0.302	0.221	0.410	0.136	1.318
	SEm±	0.026	0.004	0.008	0.018	0.007	0.020
	CD at 5%	0.075	0.013	0.024	0.054	0.021	0.059

Effect of different levels of recommended dose of nitrogen (RDN) through PCU and NU on biological, grain and straw yield of rice

A critical perusal of the data presented in table 3 revealed that the grain yield of rice was ranging from 33.64 q ha^{-1} to 63.86 q ha^{-1} and it has increased significantly with the split application of PCU at different levels. The maximum grain yield (63.86 qha^{-1}) was recorded in the treatment T_3 (100% of RDN through PCU 3 Split) which was 9.66% higher than treatment T_2 (100% of RDN through Urea 3 Split) and 2.27% higher than T_8 (100% of RDN through PCU Single Basal). The treatment T_3 (100 % of RDN through PCU 3 Split) was found 89.83% and 3.38 % higher over the treatment T_1 (control) and T_{12} (55 % of RDN through PCU Single Basal+ FYM +PGPR +SSP) respectively. The treatment T_{11} (55 % of RDN through PCU Single Basal) gave 57.29 qha^{-1}grain yield which was 1.77 % higher over the T_6 (55 %of RDN through PCU 3 Split). Treatment T_4 (85 % of RDN through PCU 3 Split) gave 77.34% and 6.04 % higher grain yield over the T_1 (control) and T_9 (85 % of RDN through PCU Single Basal) respectively. However, Treatment T_{10} (70 % of RDN through PCU Single Basal) gave 53.32 % and 1.39 % higher grain yield over the T_1 (control) and T_5 (70 % of RDN through PCU Single Basal) respectively. The total biological yield tent to slightly decrease with decrease the fertilizer level and found statistical significance over treatment control T_1 presented in table 3. It ranges from 96.01 q ha^{-1} and 164.59 q ha^{-1} from treatment (T_1) to treatment (T_{12}) respectively. The treatment (T_{10}) was found significantly 109.82 % higher than the treatment control (T_1). However, among the all the maximum biological yield and straw yield was found in the treatment (T_{12}) and maximum yield value occurred in the treatment (T_1). These treatments are statistically significant over treatment control (T_1). Singh *et al.,* (1995) reported that grain yield of lowland wheat from a single application of polymer coated urea (PCU) was equivalent to or better than 3-4 time split application of urea. Fertilizer recovery with PCU was 70-75% compared to 50% with prilled urea.

Effect of different levels of recommended dose of nitrogen (RDN) through PCU and NU on content of nutrients in grain and straw

Nitrogen, phosphorus and potassium content in grain and straw

A critical observation of the data given in Table 4 marks it clear that effect of application of PCU, UREA, FYM and PGPR on nitrogen content in rice grain varied significantly. The higher N content in grain followed in treatment T_3 (1.23 %) and lower N content in grain followed in treatment T_1 (0.89 %). The maximum content of nitrogen in grain was found in T_3 (100% of RDN through PCU 3 Split), which was 10.27 % higher over T_7 (100% of RDN through Urea Single Basal), 9.98 % higher over T_2 (100% of RDN through Urea 3 Split), 8.91 % higher over T_4 (85 % of RDN through PCU 3 Split), 2.23 % higher over T_{12} (55 % of RDN through PCU Single Basal + FYM + PGPR) and 0.24 % higher over T_8 (100 % of RDN through PCU Single Basal). The higher N content in straw followed in treatment T_3 (0.45 %) and lower N content in straw followed in treatment T_1 (0.31 %). Spilt application of PCU showed significantly higher nitrogen content in straw (0.45 %) over control (T_1). The maximum content of nitrogen in straw was found in T_3 (100 % of RDN through PCU 3 Split), which was 36.36 % higher over higher over T_7 (100% of RDN through Urea Single Basal), 32.35 % T_2 (100% of RDN through Urea 3 Split), 18.42

% higher over T_4 (85 % of RDN through PCU 3 Split), 9.75 % higher over T_{12} (55 % of RDN through PCU Single Basal + FYM + PGPR) and 2.27 % higher over T_8 (100 % of RDN through PCU Single Basal). The maximum P content in grain followed in treatment T_3 (0. 32 %) and minimum P content in treatment T_1 (0.24 %). The treatment T_3 (100% of RDN through PCU 3 Split) 33.33 % was found increase the phosphorus content in rice grain over the treatment T_1 (control) while T_8 (100 % of RDN through PCU Single Basal) showed 29.16 % over the treatment T_1 (control). The inoculation of PGPR (T_{12}) significantly increases the phosphorus content in rice grain 25 % over T_1 but less than that of T_3. The higher P content in straw followed in treatment T_3 (0.15 %) and lower P content in straw followed in treatment T_1 (0.09%). The treatment T_3 (100% of RDN through PCU 3 Split) 66.66 % was found increase the phosphorus content in straw over the treatment T_1 (control). ``The inoculation of PGPR+FYM+SSP (T_{12}) significantly increases the phosphorus content in wheat straw 55.55 % over control (T_1). The higher K content in grain followed in treatment T_3 (0.23 %) and lower K content in grain followed in treatment T_1 (0.13 %). The treatment T_3 (100% of RDN through PCU 3 Split) and T_8 (100% of RDN through PCU Single Basal) 76.92 % was found increase the potassium content in grain over the treatment T_1 (control), 21.05 % higher over T_2 (100% of RDN through Urea 3 Split) and T_7 (100% of RDN through Urea Single Basal) respectively. While T_{12} (55 % of RDN through PCU Single Basal+ FYM + PGPR + SSP) increased the grain K content 0.22 %. The higher potassium content in straw (1.33 %) was obtained with the split application of 100 % PCU in T_3, The lowest potassium content in straw (1.1 %) was recorded in the treatment T_1 (control). The treatment T_3 (100 % of RDN through PCU 3 Split) and T_8 (100 % of RDN through PCU Single Basal) 20.9 % and 82.84 % was found increase the potassium content in straw over the treatment T_1 (control). Among the all the treatment the N, P and K content in grain and straw the maximum content in treatment (T_3) which is significant over the control treatment (T_1).

In the present investigation, the treatment involving three split application of 70 % of RDN through polymer coated urea showed a significant increase in plant height at 40 DAS. The treatment T_2 (100 % of RDN through urea 3 split) showed a significant increase in plant height at 80 DAS. But at harvesting stage maximum height of plant was due to treatment T_3 (100 % of RDN through PCU 3 split). The increases in number of tillers at 40, 80 DAS and harvesting stage was significantly higher over control due to treatment T_2 (100 % Urea three split application). The treatment T_{10} (70 % of RDN through Urea single basal) and treatment T_7 (100 % of RDN through PCU single basal) showed significantly higher SPAD value over control at 40 DAS and 80 DAS respectively. Application of PCU and urea found significantly effective to enhance grain and straw yield of rice. The maximum grain yield (q ha^{-1}) was obtained when 100 % of nitrogen was applied through PCU in split doses (T_3) which registered significant over control and other treatment. Only those treatments which received split application of PCU showed significantly higher N content in the rice grains than the control. N content was varying in grain from 12.34 mg kg^{-1} and in straw from 30.77 to 45.1 mg kg^{-1} significantly higher over control and treatments of receiving split and single basal doses of urea. The result of the present investigation conferred that a significant increase in grain and straw yield of rice along with other growth and yield attribute, N, P and K content and uptake by rice crop can be obtained with application of PCU over urea. Thus, N nutrition via PCU in split application of the rice crop holds immense importance for obtaining better growth and productivity. Increasing N concentration in rice grains is important to address the health problem of nutrient deficient food grain and malnutrition besides better crop production. Split application of PCU in the soil at sowing and at maximum tillering and milking stage was most effective for enriching the grains with N and to obtain the better bioavailability of the polymer coated N. However, for maximum grain yield, 3 split application of 100 % PCU of treatment T_3 hold promise. Therefore, application of treatment 100 % of RDN through PCU 3 split may be recommended to the farmer, after its further testing on their own field, for better growth and yield of rice.

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