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Productivity and Profitability of Transplanted Rice (*Oryza sativa* L.) as Influenced by Split Application of Neem Coated Urea

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Kharif* season 2016 at Research Farm of Birsa Agricultural University, Ranchi, Jharkhand to study productivity and profitability of transplanted rice (*Oryza sativa* L.) as influenced by the split application of neem coated urea. The experiment was done out in a randomised block design with three replications and nine treatments. The result showed that the split application of neem coated urea (NCU) significantly influenced the growth and yield attributes, yields and economics *viz*. plant height, total tillers, dry matter accumulations, CGR, productive tillers/m^2, grains/panicle and 1000 grain weight. Application of 125 % NCU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI was significantly better than all the treatments but was found *at par* with treatment T_3 and T_2. The plant height at 30, 60, 90 and at maturity (31.6, 68.3, 106.2 and 104.4 cm), number of tillers/m^2 (169, 311, 305 and 301), dry matter accumulations (185.27, 616.10, 997.30 and 1311.07) respectively, CGR at 30-60 DAT, 60-90 DAT and 90 to maturity (14.36, 12.71, and 9.96 g/m^2/day) and productive tillers/m^2 (291), grains/panicle (123), fertile grains/panicle (118), 1000 grain weight (24.23 g), maximum grain yield (56.70 q/ha), straw yield (82.10 q/ha), harvest index (40.52), net return (64765Rs/ha) and B: C ratio (2.21) with 125% NCU applied in three splits which was *at par* with T_1, T_2 and T_3.

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Keywords: Neem coated urea; prilled urea, productivity; profitability; transplanted rice.

1. INTRODUCTION

"Rice is Life" for millions of people and one of the most important staple food crops of India [1] for more than half of the world's population. Worldwide, rice is grown on 161 million hectares, with the production of about 713.8 million tonnes with an average productivity of 4.44 tonnes/ha [2]. India is an important centre of rice cultivation. The rice is cultivated in the largest areas in India. In Jharkhand, rice is grown in about 1.68 million ha with a production of 4.99 million tonnes and productivity of 2.97 tonnes/ha [3]. Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with an average composition of these substances being only 8 per cent and fat content or lipids only negligible, *i.e.,* 1 per cent and due to this reason, it is considered as a complete food for eating. The brown rice is rich in some vitamins, especially B1 or thiamine (0.34 mg), B_2 or riboflavin (0.05 mg), niacin or nicotinic acid (4.7 mg). In contrast, white rice is poor in vitamins (0.09 mg of vitamin B_1, vitamin B_2 0.03 mg and 1.4 mg of niacin per 100 grams of rice grain and minerals as they are found mostly in the outer layers of the grain (farmer.gov.in), which are removed by polishing process, or "bleaching" whereas parboiled rice is rich in these vitamins as a result of their particular process. In Jharkhand, generally, rice is grown by transplanting during the wet season from June to October. Nitrogen requirements of rice crop are meet from both the soil and fertilisers. Because of acute N deficiency in most rice soils, fertiliser N must be applied to meet the crop demand. Urea is the major source of nitrogenous fertiliser; N fertiliser applied to rice crops is partially lost through different mechanisms, including ammonia volatilisation, denitrification and leaching. Although plants can use both ammonium-N and nitrate-N with equal ease, ammonium-N is susceptible to lose via ammonia gas, and nitrate-N can escape soil-plant system through leaching below the rooting zone and in gaseous forms via denitrification leading to reduced fertiliser N use efficiency. Besides efficiency N fertiliser sources another approach to increase N fertiliser use efficiency is to achieve synchrony between N needs of the crop and N supply. Since plant growth reflects total N supply from all sources, plant N presumably is the best indicator of N availability to crops at any given time. Nitrification inhibitors temporarily delay/inhibit the bacterial oxidation of the ammonium-N by suppressing over a certain period (4 to 10 weeks) the activity of Nitrosomonas in the soil. Thus nitrification inhibitors control the loss of nitrate by leaching and/or denitrification from the topsoil by keeping N in the ammonium form for the longer duration and thereby increasing the fertiliser N use efficiency and enhance the yield of crops. Neem Coated Urea (NCU) applied to rice can result in high N use efficiency as it contains nitrification inhibition properties. In rice ecosystem, about 60-70% of the applied nitrogen gets lost due to different losses *viz.,* leaching, volatilisation etc. The increase in nitrogen use efficiency by 1% will lead to a substantial increase in rice productivity [4]. Therefore neem oil as an alternative to neem cake has been used to coat urea granules to retard nitrification of ammonium-N in the soil. Keeping all these points in view, the present investigation was planned to study the productivity and profitability of transplanted rice (*Oryza sativa* L.) as influenced by the split application of neem coated urea.

2. MATERIALS AND METHODS

The field experiment was conducted during Kharif season of 2016 at Birsa Agricultural University, Ranchi, Jharkhand. The soil was clay loam in texture, with pH 5.9 having organic carbon 0.40%, available nitrogen 197.0 kg/ha, phosphorus 30.5 kg/ha and potassium 187.1 kg/ha. The climate of the region is subtropical with hot and dry summer, comparatively cool rainy season followed by moderate winter. The experiment consisted of 9 treatment combinations viz. 100 % RDN as PU (3 splits, $1/3^{rd}$ basal + $1/3^{rd}$ MT + $1/3^{rd}$ PI), 75 % RDN as NCU (3 splits, $1/3^{rd}$ basal + $1/3^{rd}$ MT + $1/3^{rd}$ PI), 100 % RDN as NCU (3 splits, $1/3^{rd}$ basal + $1/3^{rd}$ MT + $1/3^{rd}$ PI), 125 % RDN as NCU (3 splits, $1/3^{rd}$ basal + $1/3^{rd}$ MT + $1/3^{rd}$ PI), 100 % RDN as NCU (2 splits, 1/2 basal + 1/2 MT), 100 % NCU (2 splits, $3/4^{th}$ basal + $1/4^{th}$ MT), 100 % NCU (2 splits, $1/4^{th}$ basal + $3/4^{th}$ MT), 100% RDN as NCU (Basal) and Control (NPK:0: 60: 40) and laid out in a Randomised Block Design with three replications.

P and K fertilisers with a uniform dose of 60 kg P_2O_5 and 40 kg K_2O/ha through SSP and MOP were applied as a basal in all the plots. Nitrogen dose was applied as per treatment along with neem coated urea @ 120 kg/ha. Twenty-two days old seedling of rice variety 'Naveen' was transplanted at a spacing 20 cm x 15 cm during the first fortnight of July. Plants sampling was done at 30, 60, 90 days after transplanting and at maturity to record the growth parameters such as plant height, total tiller/m^2, dry matter accumulation/m^2, crop growth rate, while the yield attributes, grain yield and straw yield were recorded at harvest. The crop growth rate was calculated by using the formula given [5].

$$\text{Crop growth rate (g/day)} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{G}$$

Where, W_1 and W_2 represent the dry weights of the plant at the beginning and end of the time interval t_1 and t_2 respectively The G represents the ground area. The data were subjected to statistical analysis as prescribed [6] and significant effects were presented. The economics were computed on the basis of prevailing market rates of produce and agro-inputs. The net return was calculated by subtracting the total cost of cultivation from a gross return. The benefit: cost ratio was calculated by dividing the net return by the cost of cultivation.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Data on plant height as influenced by the application of different rate and time of nitrogen (neem coated urea) at 30, 60, 90 DAT and at maturity are presented in (Table 1). The split application of neem coated urea significantly influenced the plant height throughout the crop period. At initial growth stages *i.e.* 30 DAT, all treatment were at par among themselves and were significantly taller than control (23cm). The maximum plant height at 60, 90 DAT and at maturity was recorded (68.3 cm) (106.27 cm) and (104.4 cm) respectively with 125% NCU applied in three splits which were at par with T_1, T_2 and T_3. At 60 and 90 DAT treatment 125% NCU applied as (1/3rd Basal + 1/3rd MT +1/3rd PI) was again at par with treatment T_5, T_6, T_7 and significantly superior to T_8 and T_9. Excessive plant height leads to shading effect on lower leaves of the plant causing lower photosynthesis. On the other hand a decrease in the plant, height has less number of leaves and ultimately lower photosynthesis at maturity. At early growth stage, i.e. 30 DAT plant height did not differ significantly except control. Probably due to a basal dose of nitrogen has been applied to all the treatments. At subsequent growth stages (60, 90 and at maturity) the plant height was maximum with 125% NCU applied in 3 splits either through NCU or PU. As compared to 100% NCU applied in 2 splits. The finding confirmed with the work of Pushpanathan et al. [7] and Raj et al. [8]. Similarly, Kumar et al. [9] were observed that neem coated urea performed best which increased the growth and yield, plant height, number of tillers/m, numbers of panicle/hill, numbers of grains/panicle.

3.2 Total tillers/m^2

Data about total tiller/m^2 were recorded at various growth stages has been presented in (Table 1). The analysis of variance indicated that differences due to split application of NCU (neem coated urea) on total tillers/m^2 at 30, 60, 90 DAT and at maturity were significant. At 30 DAT the maximum number of tiller/m^2 was maximum with 125% NCU in 3 splits, i.e., 1/3rd Basal + 1/3rd Max. Tillering +1/3rd PI (169), which was on at par with rest of the treatments accept control (131). At 60 DAT maximum number of tillers/m^2 was recorded with 125% NCU in 3 splits (311) which was on at par with 100% NCU in 3 splits (306) and 75% NCU in 3 splits (295). These three treatments were significantly superior to the rest of the treatments. 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering +1/3rd PI) (267), 100% NCU in 2 splits (1/2 Basal + 1/2 Max. Tillering) and 100% NCU in 2 split (1/4th Basal + 3/4th Max. Tillering) (257) were at par among themselves, but significantly superior to 100% NCU as basal (228) and control (203). At 90 DAT maximum number of tillers/m^2 was again observed with 125% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) which were at par with 100% NCU in 3 splits (303) and 75% NCU in 3 splits (284). These three treatments are significantly superior to rest of the treatments. 100% PU in 3 splits (256) produced the similar number of tillers/m^2 with 100% NCU in 2 split application (1/2 Basal + 1/2 Max. Tillering) (251) and 100% NCU in 2 splits (1/4th Basal + 3/4th Max. Tillering) (247) again 100% NCU in 2 splits (3/4th Basal + 1/4th Max. Tillering) (236) and 100% NCU as basal were *at par.* At maturity the maximum number of tillers/m^2 were recorded with 125% NCU in 3 splits, *i.e.* 1/3rd basal + 1/3rd Max. Tillering +1/3rd PI (301) which was significantly superior to rest of the treatments except 100% NCU in 3 split (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (297), 75%NCU in 3 split, *i.e.* 1/3rd Basal + 1/3rd Max. Tillering + 1/3rd

PI (278), 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI). 100% NCU in 2 splits (1/2 basal + 1/2 MT) (247), 100% NCU in 2 splits (1/4th Basal + 3/4th Max. Tillering) (245) again 100% NCU in 2 split application (3/4th Basal + 1/4th Max. Tillering) (233) and 100% NCU as basal were at par among themselves but significantly superior to control (189). Tillering in rice is an important agronomic trait for panicles number/m^2 as well as grain production. Excessive tillering leads to more shading effect on lower tillers and hence which leads more tiller abortion, small panicle size, and lesser weight causing a reduction in grain yield [10]. At 30 DAT there were no significant differences in total tillers/m^2 due to different treatment except control. This might be also due to the basal application of nitrogen which is sufficient to start the tillering at early stages. At subsequent stages of 60, 90 DAT and at maturity 3 splits application of NCU ranging from 75% to 125% NCU recorded maximum tillers per unit area as compared to 100% PU in 3 splits and 100% NCU in applied in 2 splits (1/2 basal +1/2 MT) (3/4 basal +1/4 MT) and (1/4 basal + 3/4MT). The superiority of NCU in 3 splits over PU in 3 splits and NCU in 2 splits accounted for slow release of nitrogen which matches with the nitrogen need of the growing plants. Nitrogen released slowly is absorbed and utilised by the plants, and the lowers loss of nitrogen recorded. This result is also conformities by Bains et al. [11] and Kumar et al. [12]. A similar finding was also reported by [9] he observed that neem coated urea performed best which increased the growth and yield, plant height, number of tillers/m, numbers of panicle/hill, panicle length, numbers of grains/panicle. Prasad et al. [13] also reported that neem-coated urea increased the total number of tillers per hill. The improvement in the formation of tillers with N application in the present experiment might be due to the increase in nitrogen availability which enhanced tillering.

3.3 Dry Matter Accumulation (g/m^2)

The data observed dry matter accumulation in rice at different growth stages has been presented in Table 1. It was observed that the split application of 125% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) produced maximum dry matter accumulation (185.2 g/m^2). At 30 DAT which was significantly more than rest of the treatment under test. Except 100% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (178.20 g/m^2), 100% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) also recorded significantly more dry matter accumulation, is plant than 75% NCU is 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (165.4g/m^2) and 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering +1/3rd PI) (185.27 g/m^2) 100% NCU in 2 splits (1/2 Basal + 1/2 Max.Tillering) (141.4 g/m^2) 100% NCU in 2 splits (3/4th Basal + 1/4th Max. Tillering) (138.37 g/m^2) and 100% NCU (1/4th basal + 3/4 Max. Tillering) (133.17 g/m^2) and 100% NCU as basal (134.17 g/m^2). At 60 and 90 DAT 125% NCU in 3 splits application recorded the maximum dry matter accumulation in the plant (616.1 g/m^2) and (997.3 g/m^2) respectively. These two treatments were significantly superior to the rest of the treatments. At maturity 125% NCU in 3 splits produce maximum dry matter accumulation in plant (1311.0 g/m^2) which was significantly at par with 100% NCU in 3 splits (1291.10g/m^2) and 75% NCU in 3 splits (1276.0 g/m^2) but these three treatments were significantly superior to rest of the treatments. 100% PU in 3 split application (1203.60 g/m^2) and 100% NCU in 2 splits (1/2 Basal + 1/2 Max. Tillering) (1175.20 g/m^2), 100% NCU in 2 splits (1/4th Basal + 3/4th Max.Tillering) and 100% NCU in 2 splits (3/4th Basal + 1/4th Max.Tillering) (1157.40 g/m^2) produced comparable dry matter accumulation in plants, but significantly superior to 100% NCU as Basal (299.27 g/m^2) and control (977.60 g/m^2). Maximum production of total dry matter per unit area is considered the first prerequisite for higher yield. Large and efficient crop assimilating area, adequate supply of solar radiation, carbon dioxide, and other favourable environmental condition enhance the photosynthetic ability of the plant which in turn regulate the total amount of dry matter produced. Finally, the manner in which the net dry matter produced is contributed among different parts of the plant, determines the amount of economic yield. The dry matter accumulation per meter square increased as the growth progressed and the maximum value was observed at maturity. At 30 DAT application of nitrogen in 3 splits either through NCU or PU did not bring any significant changed in dry matter production but showed superiority over 100% NCU in 2 splits, 100% NCU basal and control. At maturity 75%, 100% and 125% NCU in 3 splits produced significantly more dry matter than 100% PU in 3 splits and 100% NCU in 2 splits similar result were also observed by Kumar et al. [12] & Singh and Paikra [1] Dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increase the plant growth with respect to increased plant height results. It might be due to direct, higher availability and translocation of nutrients particularly N and K during the development phase of growth stage which facilitates more photosynthesis process and resulted in higher dry matter accumulation. The effect of the split application of nitrogen fertiliser was statistically significant on the dry matter of roots, stem, and leaves as well as the total dry matter at the three growth stages. These findings are in agreement with Rao et al. [14], Ingram et al. [15]; Upadhyay and Tripathi [16], Kumar and Shivay [17].

3.4 Crop Growth Rate (g/m^2/day)

Data pertaining to crop growth rate has been presented in Table 1. The crop growth rate between 30-60 DAT, 60-90 DAT and 90 to maturity did not brought any significant differences in the treatment of split of NCU in Transplanted rice however, the maximum crop growth rate at 125% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) recorded maximum crop growth rate in the intervals followed by 100% NCU and 75% NCU applied in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI). It was also observed that application of NCU or PU applied in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) exhibited higher crop growth rate than 100% NCU in 2 splits (1/2 Basal + 1/2 Max. Tillering). Data clearly indicated that crop growth rate of transplanted rice did not influence significantly by nitrogen management through NCU and maximum crop growth rate from 30-60 DAT was recorded with application of 125% RDN (recommended dose of nitrogen) in the form of NCU as 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI). However, crop growth rate from 60-90 DAT and 90 DAT to maturity stage were recorded with the application of 100 % NCU (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI). The minimum crop growth rate was recorded in control plot at all the stage of crop growth. This result is also supported by Kumar et al. [18] he found that the crop growth rate (CGR) increased rapidly up to 30-60 days after sowing thereafter decreased with crop age. Similar results were also reported by Kumar et al. [9].

3.5 Yield Attributes

3.5.1 Productive tillers/m^2

The perusal of the data (Table 2) indicated that application of 125% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering +1/3rd PI) produced maximum numbers of productive tillers/m^2 (291.00) which was at par with 100% NCU in 3 splits (284) and 75% NCU in 3 splits (273). These three treatments produced significantly more productive tillers/m^2 than the rest of the treatments. It was also observed that there were no significant differences between 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering +1/3rd PI) (232), 100% NCU in 2 splits, *i.e.* 1/2 Basal +1/2 Max. Tillering (223), 100% NCU in 2 splits (1/4th Basal + 3/4th Max. Tillering) (228), 100% NCU in 2 splits (1/4th Basal + 3/4th Max. Tillering) (230) and 100% NCU as basal (222). All the treatments recorded significantly productive tillers/m^2 than control (180.0). Similar findings were reported by Kumar et al. [9] he observed that neem coated urea performed best which increased the growth and yield, plant height, number of tillers/m^2, numbers of panicle/hill, numbers of grains/panicle.

3.5.2 Number of grains per panicle

The mean data are respected of grains/panicles was significantly influenced by different treatments (Table 2). By the perusal of data it was observe that 125% NCU in 3 splits (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI) produced maximum grains/panicles (123.33) which was statically similar to 100% NCU in 3 splits (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI) (120.70) and 75% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (116.97). All these 3 treatments produced significantly higher number of grains/panicles than rest of the treatments 100% PU 3 split (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI) (108.3) 100% NCU in 3 splits (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI), 100% NCU in 2 splits *i.e.* 1/2 Basal+ 1/2 Max.Tillering (108.90), 100% NCU in 2 splits i.e., (3/4th Basal 1/4th Max. Tillering) (108.23) and 100% NCU in 2 splits *i.e.,* (1/4th Basal + 3/4th Max. Tillering) (107.23) were significantly at par among themselves and significantly superior to 100% NCU as basal (99.03) and control (88.47). This increase was observed due to the application of 75-80% of nitrogen dose at planting and 20-25% N dose during internode elongation to boot leaf stage of rice as an ideal schedule of fertilisation [17]. Similar findings were also reported by Kumar et al. [9] and Raj et al. [8].

3.5.3 Number of fertile grains/panicle

The numbers of filled grains per panicle were significantly affected by the split application of NCU (Table 2). It was observed that 125% of NCU, 100% NCU and 75% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) being at

Table 1. Growth attributes of transplanted rice as influenced by nitrogen management through NCU at different growth stages

Treatments	Plant height (cm)				Total tillers/m^2				Dry matter accumulation (g/m^2)				Crop growth rate (g/m^2/day)		
	30 DAT	60 DAT	90 DAT	At maturity	30 DAT	60 DAT	90 DAT	At maturity	30 DAT	60 DAT	90 DAT	At maturity	30-60 DAT	60-90 DAT	90 to maturity
T_1*	29.50	64.67	98.20	97.60	165.67	266.67	256.00	248.00	158.27	545.17	902.90	1203.60	12.90	11.92	8.59
T_2	31.17	67.67	102.13	101.30	167.00	295.33	284.00	278.00	165.40	567.30	954.60	1276.07	13.40	12.91	9.18
T_3	31.23	67.87	103.17	101.70	168.33	306.33	303.00	297.00	178.20	579.33	967.77	1291.10	13.37	12.95	9.24
T_4	31.67	68.30	106.27	104.40	169.33	311.00	305.33	300.67	185.27	616.10	997.30	1311.07	14.36	12.71	8.96
T_5	28.60	63.70	96.73	94.20	162.67	260.67	250.67	247.00	141.40	527.33	879.77	1175.20	12.86	11.75	8.44
T_6	28.27	61.42	94.60	90.23	160.67	239.33	236.33	233.33	135.17	515.83	864.70	1157.43	12.69	11.63	8.36
T_7	28.40	62.23	95.70	93.23	161.33	256.67	247.33	245.00	138.37	519.67	869.37	1163.57	12.71	11.66	8.41
T_8	29.70	60.47	88.50	87.50	159.00	228.00	229.00	226.00	134.17	460.20	808.17	1099.27	10.87	11.60	8.32
T_9	23.03	54.23	80.70	78.20	130.67	203.00	194.00	189.33	98.87	341.67	686.87	977.67	8.09	11.51	8.31
SEm±	1.34	2.30	3.95	3.69	3.61	6.36	7.42	10.63	9.17	17.49	14.57	17.27	1.91	0.78	0.59
CD(P=0.05)	4.03	6.90	11.83	11.05	10.84	19.08	22.26	31.86	27.49	52.43	43.68	51.79	**NS**	**NS**	**NS**
CV (%)	8.01	6.29	7.10	6.77	3.90	4.19	5.02	7.32	10.70	5.83	2.86	2.53	8.92	11.16	11.73

**T_1- 100 % PU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_2- 75 % NCU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_3- 100 % NCU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_4- 125 % NCU 11/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_5- 100 % NCU 1/2 basal + 1/2 Max. Tillering, T_6- 100 % NCU 3/4th basal + 1/4th Max. Tillering, T_7- 100 % NCU 1/4th basal + 3/4th Max. Tillering, T_8-100 % NCU Basal and T_9- Control*

Table 2. Yield attributes, yield and economics of transplanted rice as influenced by nitrogen management through NCU

Treatments	Productive tillers/m^2	Grain/ panicles	Fertile grains/ panicles	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest yield (%)	Net return (Rs/ha)	B:C ratio
T_1*	232.33	108.33	101.00	23.75	45.67	68.23	40.20	46864	1.66
T_2	272.67	116.97	110.30	24.02	53.30	79.20	40.21	60250	2.12
T_3	283.67	120.70	115.20	24.07	55.60	81.83	40.52	63590	2.20
T_4	291.00	123.33	118.33	24.23	56.70	82.10	40.84	64765	2.21
T_5	223.00	108.90	100.90	23.69	45.33	67.80	40.19	46537	1.67
T_6	228.00	107.23	98.90	23.58	38.17	58.17	39.63	34505	1.28
T_7	230.00	108.23	100.07	23.66	44.57	67.47	39.75	45389	1.63
T_8	222.00	99.03	90.00	23.52	37.27	56.83	39.62	33197	1.24
T_9	180.00	88.47	76.37	23.16	28.20	43.00	39.52	19362	0.84
SEm±	12.80	2.40	2.52	0.70	2.13	3.16	1.37	3173	0.10
CD(P=0.05)	38.37	7.20	7.5	**NS**	6.37	9.46	**NS**	9514	0.30
CV (%)	9.17	3.81	4.31	5.13	8.18	8.14	5.94	11.93	10.77

**T_1- 100 % PU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_2- 75 % NCU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_3- 100 % NCU 1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_4- 125 % NCU 11/3rd basal + 1/3rd Max. Tillering + 1/3rd PI, T_5- 100 % NCU 1/2 basal + 1/2 Max. Tillering, T_6- 100 % NCU 3/4th basal + 1/4th Max. Tillering, T_7- 100 % NCU 1/4th basal + 3/4th Max. Tillering, T_8-100 % NCU Basal and T_9- Control* par among themselves produced (118.33), (115.20) and (110.30) fertile grains/panicle respectively, which was significantly superior to the treatments 100% PU in 3 splits ($1/3^{rd}$ basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (101.00), 100% NCU in 2 splits either (1/2 Basal + 1/2 Max. tillering) (100.90), 100% NCU in 2 splits ($3/4^{th}$ Basal + $1/4^{th}$ Max. Tillering) (100.07) and 100% NCU in 2 splits ($1/4^{th}$ Basal + $3/4^{th}$ Max. Tillering) (98.90) did not differ significantly, however, this treatment was significantly superior to 100% NCU as basal (90.00) and control (76.37). Similarly, Pushpanathan et al. [7] observed that coated fertilisers improved the yield components like productive tillers, panicle length, fertile spikelet's per panicle and 1000 grain weight when applied at a proper time. These results also corroborate with the findings of Kumar et al. [9] and Prasad et al. [13].

3.5.4 1000 grains weight (g)

The effect of different treatments of splits application of NCU on 1000 grain weight was non-significant (Table 2). However, treatments 125% NCU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (24.23 g), produced heavier grains followed by 100% NCU in 3 splits and 75% NCU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (24.2 g), however this treatments did not touch the level of significant but they produced heavier grains than rest of the treatments. Similarly, this result is also supported by the findings of Kumar and Shivay [17] and Pushpanathan et al. [7].

3.6 Yield

3.6.1 Grain yield (q/ha)

The splits application of NCU on transplanted rice had a significant effect on grain yield (Table 2). Treatments 125% NCU in 3 splits, *i.e.* $1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI produced max yield (56.70 q/ha), which was at par with 100% NCU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (55.60 q/ha) and 75% NCU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (53.30 q/ha). There three treatments produced significantly higher grain yield than 100% PU in 3 splits (45.67 q/ha), 100% NCU in 2 splits, *i.e.* 1/2 basal + 1/2 Max. Tillering (45.33 q/ha), 100% NCU in 2 splits ($3/4^{th}$ Basal + $1/4^{th}$ Max. Tillering) (38.17 q/ha), 100% NCU in 2 split ($1/4^{th}$ Basal + $3/4^{th}$ Max. Tillering) (44.57 q/ha), 100% NCU as basal (37.27 q/ha) and control (28.20 q/ha). Treatments 100% PU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI), 100% NCU in 2 splits (1/2 basal + 1/2 Max. Tillering) and 100% NCU in 2 splits ($3/4^{th}$ basal + $1/4^{th}$ Max. Tillering), being at par among themselves but they produced significantly higher grain yield 100% NCU in 2 splits ($1/4^{th}$ Basal + $3/4^{th}$ Max. Tillering), 100% NCU as basal and control. The effect of 100% NCU in 2 splits ($1/4^{th}$ Basal + $3/4^{th}$ Max. Tillering) and 100% NCU as basal was found non-significant regarding grain yield. The lowest grain yield was recorded with the control plot (28.20 q/ha). Sarangi et al. [19] found 100% recommended levels of neem coated urea gave a significantly higher yield in wheat but when NCU was applied at 80% level, the yield was reduced significantly. Similarly Shivay et al. [20], Suganya et al. [21] and Kumar et al. [9] recorded more grain and straw yields from NCU application.

3.6.2 Straw yield (q/ha)

When 125% NCU in 3 split produced maximum straw yield (82.10 q/ha) which was at par with 100% NCU in 3 splits (81.83 q/ha) and 75% NCU in 3 splits (79.20 q/ha) (Table 2). These three treatments produced a significantly higher yield than 100% PU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI) (68.23 q/ha), 100% NCU in 2 splits *i.e.* (1/2 Basal + 1/2 Max. Tillering (67.80 q/ha), 100% NCU in 2 split ($3/4^{th}$ Basals+$1/4^{th}$ Max. Tillering) (58.17 q/ha), 100% NCU in 2 split ($1/4^{th}$ basal + $3/4^{th}$ Max. Tillering) (67.47 q/ha), 100% NCU as basal (56.83 q/ha) and control (43.00 q/ha), treatments 100% PU in 3 splits ($1/3^{rd}$ Basal + $1/3^{rd}$ Max. Tillering + $1/3^{rd}$ PI), 100% NCU in 2 splits (1/2 Basal + 1/2 Max. Tillering) and 100% NCU in 2 splits ($3/4^{th}$ Basal + $1/4^{th}$ Max. Tillering), being at par among themselves but they produced significantly higher straw yield 100% NCU in 2 splits ($1/4^{th}$ Basal + $3/4^{th}$ Max. Tillering) 100% NCU as basal and control. The effect of 100% NCU in 2 splits ($1/4^{th}$ basal + $3/4^{th}$ Max. Tillering) and 100% NCU as basal was found non-significant regarding grain yield. The minimum straw yield was recorded with the control plot (43.00 q/ha). Nitrogen influenced vegetative growth in terms of plant height and number of tillers m^2 which increased straw yield. It might be due to the increased nitrogen use efficiency and continuous supply of nitrogen-boosting vegetative growth. Singh and Shivay [22] and Sarangi et al. [19] found significantly higher grain and straw yield as compared to prilled urea.

3.6.3 Harvest index (%)

There was non-significant effect of splits application of NCU on harvest index of transplanted rice however maximum harvest index was recorded with 125% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (40.84) followed by 100% NCU in 3 splits (40.52), 75% NCU in 3 splits (40.21), 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (40.20), 100% NCU in 2 splits (1/2 Basal + 1/2 Max. Tillering) (40.19), 100% NCU in 2 splits (3/4th basal+ 1/4th Max. Tillering) (39.63), 100% NCU in 2 splits (1/4th Basal+ 3/4th Max. Tillering) (39.75), 100% NCU as basal (39.62) and control (Table 2) [23].

3.7 Economics

3.7.1 Net return (Rs/ha)

125% NCU in 3 splits (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI) recorded the maximum net return of (Rs/ha 64764) which was comparable with 100% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (Rs/ha 63590) and 75% NCU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (Rs/ha 60250) and were significantly superior to rest of the treatment.

100% PU in 3 splits (Rs/ha 46864), 100% NCU in 2 splits (1/2nd Basal + 1/2nd Max. Tillering) (Rs/ha 46537), 100% NCU in 2 split (1/4th Basal + 3/4th Max. Tillering) (Rs/ha 45389) were comparable in terms of net return and were significantly superior with 100% NCU in 2 split (3/4th Basal + 1/4th Max. Tillering) (Rs/ha 34505) 100% NCU as basal (Rs/ha 33157) and control (Rs/ha 19362).

3.7.2 Benefit: Cost ratio

The maximum benefit: cost ratio (2.21) was observed with 125% NCU in 3 splits (1/3rd basal + 1/3rd Max. Tillering + 1/3rd PI) which was *at par* with 100% NCU in 3 splits (2.20) and 75% NCU in 3 splits (2.12), 100% PU in 3 splits (1/3rd Basal + 1/3rd Max. Tillering + 1/3rd PI) (1.66), 100% NCU in 2 split (1/2nd Basal + 1/2nd Max. Tillering) (1.67) and 100% NCU in 2 split (1/4th Basal + 3/4th Max. Tillering) (1.63) did not differ significantly among themselves however these three treatments exhibited significantly higher benefit: cost ratio then 100% NCU in 2 splits (3/4th Basal + 1/4th Max. Tillering) (1.28) and 100% NCU as basal (1.24). The lowest value of benefit: cost ratio was recorded with control plots (0.84).

4. CONCLUSIONS

Based on one year of experimentation it may be concluded that application of 90 kg N through neem coated urea (75 % RDN) as 1/3rd basal + 1/3rd maximum tillering + 1/3rd panicle initiation stage along with 60 kg P_2O_5 and 40 kg K_2O may be economically viable option for transplanted rice variety Naveen.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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