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Bio-efficacy of Polymer Coated Urea on Growth and Yield of Rice (*Oryza sativa* L.) under Lowland Cultivation

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Authors' contributions

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

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ABSTRACT

Aim: To evaluate the effect of polymer coated urea on plant growth and yield of paddy under lowland cultivation.
Study and Design: The experiment consisting five treatments was carried out in Randomized Complete Block Design (RCBD) with four replications.
Place and Duration of study: A pot experiment was conducted in *kharif* season of 2014-15 under open field condition at Agriculture Research Farm of Banaras Hindu University, Varanasi.
Methodology: The research trail was consisted five sources of nitrogen [i.e. Urea Supergranule, polymer coated urea (single layer), polymer coated urea (double layer), Neem coated urea and sulfur coated urea]. Ureas prills (2g) coated with different materials were deep placed at a week after transplanting at the center of four hills. Data regarding all the parameters were taken separately from each pot and analyzed following suitable statistical tools.
Results: The result showed that plant height, tiller number, grain per panicle and grain yield improved by 8.51%, 24.33%, 16.07% and 23.37% respectively, with application of polymer coated urea over uncoated urea at harvesting. The grain and straw yield were found to be highest (24.17 and 31.08 q ha^{-1} respectively) under polymer coated urea (double layer) as compared to urea supergranule with 17.52 and 24.02 q ha^{-1}.

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Conclusion: It was observed that polymer coated urea significantly improved plant growth and yield (both grain and straw) because of its low solubility and synchronized release of nitrogen characteristics. It proved that polymer coated urea is the best fertilizer for paddy cultivation particularly under lowland condition.

Keywords: Growth; polymer coated urea; yield.

1. INTRODUCTION

Rice is the major crop of Uttar Pradesh and is grown in all 72 districts in about 5.90 million hectare which comprises of 13.5% of total area in India. Uttar Pradesh is the leading producer of rice with the annual production of around 12 million tones but still productivity is too low. Nitrogen is fundamental macronutrient in crop nutrition. Plants require nitrogen to thrive well and rapid growth. The occurrence of nitrogen deficiency has been identified as the key to the low productivity of rice in rainfed lowland ecosystem, particularly in Indo-Gangatic region where it is grown in rotation of wheat. Nitrogen fertilizers are not used efficiently because rice is grown in environment subjected to nitrogen losses through nitrification–denitrification, NH_3 volatilization, runoff and leaching [1]. According to Mitsui [2] only 30-40% of applied nitrogen is utilized by rice plant. Therefore, maintaining efficiency level of nitrogen is important for growth; development of yield attributing components and yields [3]. Polymer coated urea has been reported to maintain efficiency level of nitrogen under corn-based cropping systems [4].

Polymer coated urea is newest and technically advanced fertilizer that gradually release nitrogen for longer time, synchronize nitrogen application to crop requirement and induce complete utilization of fertilizer for crop growth [5].Adequate supply of nitrogen at later growth stage improve development of yield attributes like more and longer panicle with healthy grain. Therefore the study was initiated to evaluate response of growth and yield of rice to polymer coated urea under lowland cultivation.

2. MATERIALS AND METHODS

2.1 Experimental Site

The pot experiment was laid out during *kharif* season of the year 2014-15 at the Agricultural Research Farm of Banaras Hindu University, Varanasi which lies in Indo-Gangatic plain zone. It is located on $25^0$18’ N latitude, $83^0$03’ E longitude and at an altitude of 77 meter above mean sea level (MSL).

2.2 Weather and Soil Type

The weather of Varanasi is categorized under moisture deficit index of 20-40% and falls in semi-arid to sub humid climate. During research trail (June 2014-October 2014), the experimental location recorded a maximum and minimum temperature of 43.4^0C and 24.2^0C with a total rainfall of 706.4 mm. The soil of experiment site was sandy clay loam in texture belongs to Inceptisol order.

2.3 Treatment Details

A pot experiment was laid out in a randomized block design (RBD) consisting five treatment each replicated four times. The treatment details have been given in Table 1. The rice cultivar NDR-97 was selected for study. The basal fertilizers DAP (2.5 g) and MOP (2.0 g) was uniformly mixed in each pot to supply phosphorus and potassium respectively. Nitrogen was applied through single application of different N sources (according to treatments) at a week after transplanting. Sowing was performed in the last week of June by transplanting 2-3 healthy seedlings per hill at the spacing of 15×15 cm^2 in each pot. Different urea prills of 2 g were deep placed at the center of four rice hills to supply enough N during entire crop growth period. Pots were irrigated daily to moist soil. All other recommended cultivation practices were uniformly followed.

Table 1. Details of experimental treatments

Treatments	Details
U_0	Urea Supergranules (USG)
U_1	Polymer coated urea (PCU) (Single layered)
U_2	Polymer coated urea (PCU) (Double layered)
U_3	Neem coated urea (NCU)
U_4	Sulfur coated urea (SCU)

Table 2. Physico-chemical properties of the experimental soil

S. N.	Soil properties	Before sowing	After harvesting	Method
1	Textural class	Sandy clay loam		Hydrometer method (Bouyoucos, 1962)
2	pH	7.4	7.5	Glass electrode digital pH meter (Jackson, 1973)
3	EC (dSm^{-1})	0.29	0.29	Conductivity bridge (Jackson, 1973)
4	Bulk density (gcc^{-1})	1.35	1.35	
5	Organic carbon (%)	0.38	0.38	Walkley and Black's method (1934)
6	Available nitrogen ($kgha^{-1}$)	179	188	Alkaline permanganate (Subbiah & Asija, 1956)
7	Available P_2O_5 ($kgha^{-1}$)	18.0	18.4	0.5N $NaHCO_3$ extractable (Olsen *et al.*, 1954)
8	Available K_2O ($kgha^{-1}$)	199.6	199.0	Ammonium acetate extractable flame photometer (Jackson, 1973)

2.4 Soil Sampling and Physico-chemical Analysis

Composite surface (0-15 cm) soil samples were collected from each pot before sowing and after harvesting. NPK nutrient content and all other soil parameters were analysed following standard protocols (Table 2 above).

3. RESULTS AND DISCUSSION

3.1 Plant Growth

The data on various growth parameters indicated significant difference for plant height, tiller per hill and healthy green leaves (Table 3). Plant height with the application of polymer coated urea (double layer) was highest at harvesting (81.35 cm) and 60 DAT (79.89 cm) closely followed by polymer coated urea (single layer). Polymer coated urea (double layer) exhibited significantly more effective tillers (21) whereas effective tillers were reduced under urea supergranule due to N deficiency during later growth stage. Adequate availability of nitrogen at active tillering stage through polymer coated urea resulted in maximum tiller production [6]. As polymer coated urea dissolves slowly and release nitrogen in controlled manner ensures its availability during entire crop duration. Polymer coated urea (double layer) significantly produced more green leaves per hill over all the treatments during the entire crop period. Number of leaves with neem coated urea (87.50) remained at par with sulfur coated urea (85.25) at 30 DAT. This support the well established fact that synchronized and adequate supply of nitrogen through polymer coated urea delayed senescence of crop canopy and continuously produces green leaves upto maturity is beneficial for crop growth and development [7].

3.2 Yield and Yield Attributes

The data in the Table 4 indicated the marked effect of deep placement of polymer coated urea

Table 3. Effect of polymer coated urea on plant growth parameters

Treatments/ N sources	Plant height (cm)		Effective tiller per hill	Green leaves per hill	
	60DAT	at harvest		30DAT	at harvest
Urea Supergranule (USG)	73.41	74.97	16.89	80.50	50.35
Polymer coated urea (single layer)	77.82	79.48	19.25	91.25	60.44
Polymer coated urea (double layer)	79.89	81.35	21.00	95.00	64.29
Neem coated urea (NCU)	76.21	78.28	18.10	87.50	59.15
Sulfur coated urea (SCU)	75.69	78.36	18.03	85.25	53.42
LSD (0.05)	1.45	1.10	1.39	3.11	2.60

Table 4. Effect of polymer coated urea on yield attributing parameters and yield

Treatments/ N sources	Panicle length (cm)	Panicle Weight (g)	Grain/ panicle	Yield (g $hill^{-1}$)		HI (%)
				Straw yield	Grain yield	
Urea Supergranule (USG)	18.26	2.31	93.38	54.46	39.43	42.00
Polymer coated urea (single layer)	19.61	2.56	102.14	64.04	48.85	43.25
Polymer coated urea (double layer)	20.14	2.61	108.39	69.93	54.39	43.75
Neem coated urea (NCU)	19.26	2.50	100.49	60.06	45.16	42.92
Sulfur coated urea (SCU)	18.52	2.42	99.13	59.11	43.60	42.41
LSD (0.05)	0.93	0.07	3.23	3.21	3.60	NS

on panicle length, weight of panicle, grains per panicle, grain and straw yield. About 14-24% increase in number of panicle was noticed under polymer coated urea application. Panicle initiation or reproductive stage is most critical to water and nutrient/fertilizer. Deep placement of polymer coated urea (double coating) at planting continuously supply nitrogen in adequate amount upto the later stage of crop growth because of low solubility and synchronized release of nitrogen from coated urea prill produce healthy and longer panicles.

The examinational data revealed maximum number of grains per panicle with application of polymer coated urea. No significant difference was observed between NCU and SCU regarding grain per panicle. The result confirms the fact that polymer coated urea (PCU) makes sufficient availability of nitrogen (N) during reproductive and grain filling stage produces long and weighted panicles with more number of healthy grain as well as yield [8]. Highest grain and straw yield (24.17 and 31.08 q ha^{-1} respectively) was observed under polymer coated urea (double layer) as compared to urea supergranule with 17.52 and 24.02 q ha^{-1} grain and straw yield. This supports the findings of [9] and [10].

4. CONCLUSION

Low solubility and synchronized release of nitrogen are the important characteristics of polymer coated urea that ensures single (co-situs) application of entire recommended dose of nutrient at a time. At same amount of nitrogen polymer coated urea improved plant height, tiller numbers, grains per panicle and grain yield by 8.51%, 24.33%, 16.07% and 23.37% respectively, over uncoated urea at harvesting. Highest grain and straw yield (24.17 and 31.08 q ha^{-1} respectively) was observed under polymer coated urea (double layer). It is confirmed from the findings of experiment that polymer coated urea is one of the best fertilizer for rice grower for producing higher and sustainable yield with minimum cultivation cost.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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