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Evaluation of Different Sources and Dosage Levels of Slow-Release Urea on Growth, Yield and Quality Parameters of Wet Direct-Seeded Rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was conducted during Kharif, 2022 at research farm of ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad. The experiment was laid out in a randomized block design with ten treatments that consisted of nitrogen management practices allocated randomly and replicated thrice. Slow-release urea fertilizers such as silicon-coated urea and cedar wood oil-coated urea are developed at ICAR-IIRR laboratory were evaluated in wet direct seeded rice under field conditions. Significantly highest plant height at panicle emergence and flowering stages (94.2 and 100.0 cm, respectively), higher number of tillers m^{-2} (395.3 and 384.0), and a similar trend in dry matter production were registered in plots with application of 100 % RDN through silicon coated urea and cedar wood oil coated urea. Significantly, the highest and statistically comparable grain yield (6183 and 6025 kg ha^{-1}) was recorded in plots applied with 100 % RDN @ 120 kg N ha^{-1} through siliconand cedar wood oil-coated urea. The lowest grain yield (2320 kg ha^{-1}) was observed with no application of nitrogen. Among the nitrogen management practices, Si-CU @ 120 kg N ha^{-1} recorded the highest head rice recovery, hulling percentage, milling percentage and amylose content however it was at par with CWOCU @ 120 kg N ha^{-1} and 100% RDN @120 kg N ha^{-1} neem coated urea. While, the lowest values were recorded in control plot with no application of nitrogen. It can be concluded that RDN applied through silicon coated urea and cedar wood oil-coated urea @ 120 kg/ha found to be a suitable alternative source to neem-coated urea in increasing the grain yield and profitability of wet direct seeded rice.

Keywords: *Cedar wood oil-coated urea, Nitrogen use efficiency, Silicon coated-urea, Slow release Urea fertilizers, Urea, Wet direct seeded rice.*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than half of the world's population. Among the rice growing countries, India has the largest area (45.07 m ha) and it is the second largest producer (186.50 m t) of rice next to China (211.86 m t). The rice productivity in India is 4138 kg ha^{-1} while the world average is 4717 kg ha^{-1} [7]. Telangana alone contributes 9.44 per cent of the national rice production from an area of 3.65 m ha, with a production of 12.30 mt and productivity of 3366 kg ha^{-1} [1]. To meet the food requirements of the growing population, rice production has to be enhanced with good management practices with shrinking availability of land and water resources.

Nitrogen (N) is one of the most important nutrient elements for the productivity of cereal crop and its production is hampered due to deficiency of soil nitrogen and poor nutrient use efficiency of applied fertilizers. Leaching losses of urea and nitrate nitrogen, volatilization losses of NH_3 from standing water, and denitrification losses under reduced conditions are some of the losses that occur in transplanted rice. Since rice requires large amount of nitrogen to reach potential yield, it is possible to increase production per unit area by increasing the efficiency of the applied fertilizer nitrogen.About 1 kg of nitrogen is required to produce 15 to 20 kg of grain, but the efficiency of nitrogen use in India is very low [10] and in rice soils it varies from 18 to 40%.

In Telangana 120 kg N ha^{-1} applied at critical crop growth stages have been recommended for conventionally transplanted rice. [18] suggested an urgent need for developing optimum N management strategies for enhancing crop production and nutrient-use efficiency in wet-direct seeded rice.

Urea is the least efficient fertilizer among the ammonium-containing nitrogen (N) sources. High loss and low nitrogen use efficiency demand and the factors responsible for such wastage of expensive input need to be studied. Since the major cause of low Nitrogen use efficiency (NUE) is the high solubility of N fertilizers, attempts have been made to develop slow-release or controlled-release fertilizers by reducing the rate of their dissolution. There are broadly of two types: coated conventional fertilizers or inherently low-solubility fertilizers. Conventional N fertilizers can be coated with pervious or semipervious substances such as sulphur [16], oilseed cakes, polymers or resins to control the release of nitrogen.

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In order to reduce N losses from the soil, various slow-release fertilizers have been developed that would provide a continuous and regular supply of nitrogen during annual cycle. Among these fertilizers, one of the best known is neem oil-coated urea. The nitrification process released nitrogen varies with the type of fertilizer material and other soil conditions. Efforts are being made to retard the nitrification process or make it slow so as to increase its efficiency. The release of nitrogen applied through the slow-release fertilizer as sole or in combination in a ratio of 1:1 released the nitrogen slowly. This process is mainly governed by the urease enzyme and microbial process which was slower than the chemical reactions in soil [13]. Improved timing of N application as one of the factors responsible for restoration of yield in long term trials. Reducing pre-plant N fertilizer and increasing the number of split applications had a greater advantage on increasing yield than increase in the amount of N applied [8]. Split application of N is necessary to maximize grain yield and to reduce N losses [2].

Recently, slow-release urea fertilizers such as silicon-coated urea and cedar wood oil coated urea are developed at ICAR-IIRR laboratory and validation of the efficiency of these slow-release urea fertilizers in field conditions is very much essential. Hence, the present investigation was conducted to find out the Impact of Different Levels and Sources of Slow-release Urea Fertilizers on the Growth, Yield and Quality Parameters of wet direct seeded rice.

2. MATERIAL AND METHODS

2.1. Experimental Location

The field experiment was conducted at the research farm ICAR-Indian Institute of Rice Research (IIRR) Rajendranagar geographically situated at an altitude of 542.3 m above the mean sea level and located at 17°19' N latitude and 78°23' E longitude. It represents the Southern Telangana agro-climatic zone of Telangana state. According to Troll's climatic classification, it falls under semi-arid tropics (SAT).

2.2. Treatment description

Treatments were T_1-The recommended dose of nitrogen (Neem coated urea) (120 kg ha^{-1}); T_2- Silicon Coated Urea (SCU) at 50% of RDN (60 kg ha^{-1}); T_3- SCU at 75% of RDN (90 kg ha^{-1}); T_4- SCU at 100% of RDN (120 kg ha^{-1}); T_5- SCU at 125% of RDN (150 kg ha^{-1}); T_6- Cedar Wood Oil coated urea (CWO) at 50% of RDN (60 kg ha^{-1}); T_7- CWO at 75% of RDN (90 kg ha^{-1}); T_8 - CWO at 100% of RDN (120 kg ha^{-1}); T_9 - CWO at 125% of RDN (150 kg ha^{-1}); T_{10} - Control with no application of urea fertilizer.

2.3. Soil & Varietal characteristics

The soil of the experimental site was clay loam in texture, slightly alkaline in nature, medium in organic carbon, medium in soil available nitrogen (251.3kg ha^{-1}), medium in available phosphorus (34.9 kg ha^{-1}) and potassium (325.5 kg ha^{-1}). The experiment was laid out in a Randomized block design with ten treatments consist of nitrogen management practices were allocated randomly and replicated thrice. Popular short duration rice variety DRR Dhan-55 with 120 days duration was selected for the study. Good quality seed of cultivar DRR Dhan-55 @ 25 kg ha^{-1} was soaked for 24 hours and incubated in a moist gunny bag for 24 hours. The sprouted seed was sown by manual dibbling method on a well-prepared field.

2.4. Fertilizer application

A uniform dose of FYM, P_2O_5 and K_2O was applied @ 10 t ha^{-1} @ 60 and 40 kg ha^{-1}, respectively to all treatments.Except for control 25% of RDN was applied as basal, 25% of RDN each at active tillering and 25% of RDN at panicle emergence and 25% of RDN at flowering stages respectively in 3 equal splits as per treatments.

Silicon and cedar wood oil-coated urea is a type of controlled-release fertilizer that combines urea, a commonly used nitrogen fertilizer, with a silicon and cedar wood oil coating. By coating urea granules with a layer of silicon and cedar wood oil, the release of nitrogen is controlled, reducing the potential for nutrient loss and improving the efficiency of fertilizer use. Dose of silicon and cedar wood oil coated slow-release urea (60, 90, 120 and 150 kg N ha^{-1}) were applied as per the treatment. It was prepared in the lab by mixing the normal urea with silicon (which is obtained from rice husk) and cedarwood-oil coated urea. Complete dose of urea-coated fertilizers were applied in three equal splits.

2.5. Weed Management

Research findings have revealed that in the absence of effective weed control options, yield losses are greater in DSR than in transplanted rice. Weeds in the experimental field were managed by two hand weedings at critical periods of crop weed competition i.e. 15 and 45 DAT to keep the field weed free. Bispyribac sodium herbicide was applied at 2-3 leaf stage of weeds at 15 DAT of rice crop.

2.6. Irrigation Management

Rice crop requires more quantity of water for its growth and survival. At the time of sowing a thin film (2-3 cm) of water was maintained for better establishment of seedlings. A depth of 5 2 cm water level was maintained during the entire crop period except at the time of top dressing of fertilizers. From panicle initiation stage to 21 days after flowering, 5 cm depth of water was maintained. Last irrigation was provided at seven to ten days before physiological maturity stage of the crop.

2.7.Plant protection

To control seed borne diseases, the seeds were treated with carbendazim (50 WP) @ 4g kg^{-1} of seed. The mixture of fipronil (5 SC) @1ml $litre^{-1}$ and carbendazim (50 WP) @ 1g $litre^{-1}$ of water was sprayed at 45 DAS against stem borer and blast management, respectively. No incidence of disease was noticed during the experiment period. However, more incidence of leaf folder and yellow stem borer were observed at 35 and 55 DAT respectively. For the control of the leaf folder, Monocrotophos 36% SL 1.6 ml L^{-1} and Cartap hydrochloride 50% SP @ 2g L^{-1} was sprayed. They were applied in sequence twice at an interval of 10 days, respectively.

2.8. Statistical Analysis

The experimental data will be statistically analyzed using the ANOVA procedure [9]. The level of significance used in 'F' and 't' test was at 5% probability. Wherever 'F' test was found significant, the 't' test was used to estimate critical differences among various treatments.

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant height

Significantly highest plant height at panicle emergence and flowering stages (94.2 and 100.0 cm, respectively) was recorded in the plots applied with 120 kg Si-CU ha^{-1} which was on par with cedar wood oil coated urea (CWOCU) @ 120 kg N ha^{-1} (89.9 and 95.2cm, respectively) and 100 % recommended dose of neem coated urea fertilizer @ 120 kg N ha^{-1} (87.6 and 92.9 cm, respectively). The lowest plant height (38.7 and 41.6 cm) was recorded in control plot with no application of nitrogen. With regard to nitrogen levels tested, plant height was enhanced with an increase in levels of nitrogen up to the highest level. The lowest plant height was observed in the control plots due to the lesser availability of nitrogen at all the crop growth stages. The gradual release of nitrogen from the neem coated urea might have exerted a beneficial effect on the growth characters [17]. The increase in plant height in response to higher nitrogen levels was in conformity with the findings of [4].

3.1.2 Number of tillers m^{-2}

At panicle emergence stage, significantly higher number of tillers m^{-2} (395.3) were registered in plots with the application of 100 % RDN through silicon-coated urea which was on par with 100 % RDN through cedar wood oil coated urea (384.0). These treatments were closely followed by neem-coated urea (375.3). The lowest number of tillers m^{-2} (197.6) were recorded in control plots with no application of nitrogen. Similarly at flowering stage also, plots applied with 100 % RDN through silicon-coated urea maintained its superiority and recorded the highest number of tillers m^{-2} (382.0) which was on par with 100 % cedar wood oil coated urea (370.7). These treatments were closely followed by 100 % RDN through neem coated urea (364.7). On the other hand, the significantly lowest number of tillers m^{-2} at flowering and harvest stages (180.0) were observed in plots with no nitrogen application. Highest number of tillers m^{-2} in plots applied with 120 kg N ha^{-1} might be due to the application of higher nitrogen and thereby higher assimilation rate at different crop growth intervals eventually leading to better utilization of nitrogen towards improved growth and development. Lowest number of tillers in control plot might be ascribed to the inadequate nutrient availability coupled with lower assimilation and development. On the other hand, the decrease in number of tillers m^{-2} after PE stage could be due to the senescence of late formed tillers. Similar results were also reported by [6].

3.1.3 Dry matter production

Similarly at later growth stages of the crop *viz.,* at panicle emergence and flowering also a similar trend in dry matter production was observed and significantly higher dry matter (13768 and 16134 kg ha^{-1}, respectively) was recorded under plots applied with 100 % RDN through silicon coated urea, however, it was on par with 100 % RDN (120 kg N ha^{-1}) through cedar wood oil coated urea (13200 and 15220 kg ha^{-1}, respectively) and 100 % RDN (120 kg N ha^{-1}) through neem coated urea (12947 and 14880 kg ha^{-1}, respectively). The lowest dry matter was observed in control plots (5397 and 6926 kg ha^{-1}, respectively). About nitrogen levels tested, there was a progressive increase in dry matter production at all stages of observation of rice with the corresponding increase in levels of nitrogen. Among the graded levels of nitrogen application, the highest dry matter production of rice was recorded with application of nitrogen @ 120 kg ha^{-1}, over rest of the nitrogen levels. [3] reported that the dry matter partitioning to various parts of the plant is influenced by the amount of nitrogen. The results are in close conformity with the findings of [14].

3.1.4 Leaf area (cm^2 hill^{-1})

Likewise at panicle emergence stage also, a significantly higher leaf area (994.2 cm^2 hill^{-1}) was recorded in plots with the application of 100 % RDN through silicon-coated urea but, it was on par with cedar wood oil coated urea (953.1 cm^2 hill^{-1}) and 100 % RDN through neem coated urea (930.2 cm^2 hill^{-1}). Considerably, lower leaf area per hill (461.0 cm^2 hill^{-1}) was recorded under control plots with no application of nitrogen.At flowering, similar to panicle emergence stage significantly higher leaf area per hill was recorded in plots with application of 100 % RDN through silicon and cedar wood oil coated urea (1226.7 and 1225.1 cm ^{2} hill^{-1}) which is closely followed by 100 % RDN through neem coated urea (1222.8 cm^2 hill^{-1}). While significantly lower leaf area (571.8 cm ^{2} hill^{-1}) was recorded in control plots with no application of nitrogen.The probable cause of the above result might be due to adequate availability of nitrogen through coated urea fertilizer coinciding with critical stages of crop plant resulting into higher leaf area expansion and assimilation. similar results were also observed by [11].

Table 1. Impact of Different Levels and Sources of Slow-release Urea Fertilizers (SRUF) on Growth and Yield of Wet Direct Seeded Rice.

Treatment Details		Plant height(cm)		Number of tillers m^{-2}		Dry matter production (kg ha^{-1})		Leaf area (cm^2 hill^{-1})		Grain yield (kg ha^{-1})	Straw yield(kg ha^{-1})	Harvest index (%)
		PE	FL	PE	FL	PE	FL	PE	FL			
T_1	NCU @120 kg N ha^{-1}	87.6	92.9	375.3	364.7	12947	14880	930.2	1222.8	5649	6507	46.5
T_2	Si-CU@ 60 kg N ha^{-1}	50.7	54.0	246.3	227.7	7432	8701	600.4	724.4	3163	3881	44.9
T_3	Si-CU @ 90 kg N ha^{-1}	62.5	68.2	290.7	278.0	8980	10559	719.0	900.4	4092	4930	45.4
T_4	Si-CU @ 120 kg N ha^{-1}	94.2	100.0	395.3	382.0	13768	16134	994.2	1226.7	6183	7047	46.7
T_5	Si-CU @ 150 kg N ha^{-1}	77.9	79.2	338.7	325.3	10889	13112	827.8	1085.9	5548	6401	46.4
T_6	CWOCU @ 60 kg N ha^{-1}	48.7	51.1	239.0	221.3	6502	8599	550.1	716.3	3094	3752	45.2
T_7	CWOCU @ 90 kg N ha^{-1}	61.4	65.7	279.3	266.3	8777	10452	694.7	886.9	3975	4571	46.6
T_8	CWOCU @ 120 kg N ha^{-1}	89.9	95.2	384.0	370.7	13200	15220	953.1	1225.1	6025	6957	46.3
T_9	CWOCU @ 150 kg N ha^{-1}	73.6	78.6	327.7	315.0	10496	12723	811.8	1047.2	5436	6391	46.0
T_{10}	Control (No nitrogen)	38.7	41.6	197.6	180.0	5397	6926	461.0	571.8	2320	2842	44.9
	SEm (±)	2.3	2.9	9.0	11.0	341	513	28.0	38.8	210	197	1.6
	CD (0.05)	6.9	8.7	29	33	1016	1524	83.3	115.3	625	585	NS

**Note: PE- panicle emergence; FL-flowering*

3.2 Yield parameters

3.2.1 Grain Yield

Significantly, higher and comparable grain yield (6183 and 6025 kg ha^{-1}) was recorded under treatments applied with 100 % RDN at 120 kg N ha^{-1} through silicon and cedar wood oil-coated urea and both were in turn on par with 100 % RDN through neem coated urea (5649 kg ha^{-1}) at 120 kg N ha^{-1}. The improvement in grain yield was liner with the increase in dose of fertilizer application. Whereas, the significantly lowest grain yield (2320 kg ha^{-1}) was observed with no application of nitrogen. The increased availability of nitrogen at distinct physiological phases supported for favorable effect on growth (plant height, tillers and leaf area) and yield attributes (effective tillers, and number of panicles per plant). This might be also due to a maximum number of leaves favored maximum amounts of incident solar radiation intercepted by plant which consequently determines yield of rice. The result was in line with the findings of [15]. Higher grain yield with the application of neem-coated urea was in agreement with [5] and [12].

3.2.2 Straw yield (kg ha^{-1})

It is evident from Table.1 that among the treatments, Si-CU and CWO coated urea at 120 kg N ha^{-1} recorded the highest straw yield (7047 and 6957 kg ha^{-1}). This might be due to adequate and available nitrogen during the critical crop growth stages, which resulted in enhanced dry matter production. However, 120 kg N ha^{-1} applied through silicon and cedar wood oil-coatedurea were on par with NCU at 120 kg N ha^{-1} (6507 kg ha^{-1}). On the other hand the lowest straw yield was recorded in control plot with no application of nitrogen (2842 kg ha^{-1}). Significantly higher straw yield due to adequate supply of nutrients to the crop helps in the synthesis of carbohydrates, which are required for the formation of protoplasm, thus resulting in highest cell division and cell elongation which is account of overall improvement in the vegetative growth of the plant. The results are in line with the findings of [15]. The increased growth and yield parameters have contributed for increasing the yield.

3.2.3. Harvest index (%)

The varying levels and source of slow-release urea fertilizers did not influence the harvest index significantly. Harvest index values ranged from of 44.9 to 46.4 % across the different treatments.

3.3. Quality parameters

The data pertaining to head rice recovery (%) revealed that there was no significant difference in head rice recovery, hulling percentage, milling percentage and amylose content due to varying levels and source of slow-release urea fertilizers across the treatments (Table 2). Meanwhile, the values of head rice recovery ranged from 64.3 to 71.3 %, hulling percentage from 75.6 to 80.4%, milling percentage from 70.3 to 72.2% and the amylose content from 66.5 to 73.0%.

Table 2. Impact of Different Levels and Sources of Slow-release Urea Fertilizers (SRUF) on quality parameters of Wet Direct Seeded Rice

Treatments		Head Rice Recovery (%)	Hulling (%)	Milling (%)	Amylose content (%)
T_1	100% RDN (Neem coated urea) @120 kg N ha^{-1}	66.2	78.3	71.9	68.9
T_2	Silicon coated urea (Si-CU) @ 60 kg N ha^{-1}	64.8	77.6	71.0	67.1
T_3	Silicon coated urea (Si-CU) @ 90 kg N ha^{-1}	68.0	78.0	71.3	69.0
T_4	Silicon coated urea (Si-CU) @ 120 kg N ha^{-1}	71.3	80.4	72.2	73.0
T_5	Silicon coated urea (Si-CU) @ 150 kg N ha^{-1}	66.6	79.4	72.1	70.1
T_6	Cedar wood oil coated urea @ 60 kg N ha^{-1}	64.4	79.2	71.1	68.7
T_7	Cedar wood oil coated urea @ 90 kg N ha^{-1}	67.6	77.8	70.7	69.9
T_8	Cedar wood oil coated urea @ 120 kg N ha^{-1}	69.1	80.3	71.7	72.0
T_9	Cedar wood oil coated urea @ 150 kg N ha^{-1}	68.3	78.9	71.5	71.1
T_{10}	Control (No nitrogen)	64.3	75.6	70.3	66.5
SE(m)±		2.3	1.5	0.8	0.4
CD (p=0.05)		NS	NS	NS	NS

Conclusions

From the results of the present study, it can be concluded application of 100 % RDN @ 120 kg^{-1} either through silicon-coated or cedar wood oil coated urea registered significantly higher growth parameters, yield attributes and grain yield. There were no significant differences in quality parameters hulling, milling, head rice recovery, and amylose content across the treatments. Amongst the three nitrogen sources evaluated (silicon-coated urea, cedar wood oil-coated urea and neem-coated urea), concluded that silicon-coated urea and cedar wood oil-coated urea at 100% of RDN (120 kg ha^{-1}) resulted in higher growth, yield attributes, yield and energy indices apart from monetary returns.

Considering the nitrogen release patterns observed in coated fertilizers, it is advisable to carry out switch-over to field experiments on larger areas. These experiments would help determine the most effective coated urea fertilizers, focusing on aspects like nitrogen use efficiency, sustainable crop yield and cost-effectiveness and also studying emphasis on GHG's emission with different coated fertilizers under field conditions.

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AUTHOR DECLARATIONS

Conceptualization, methodology, writing-original draft preparation writing-review and editing, visualization, supervision, funding acquisition. All authors have read and agreed to the published version of the manuscript. We declare that this manuscript is original and has not been published or submitted elsewhere.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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