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Effect of nitrogen management practices on productivity and nitrogen use efficiency in rice crop

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Abstract
The investigation entitled "Effect of nitrogen management practices on productivity and nitrogen use efficiency in rice crop." was carried out under field conditions during *kharif* 2017 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G). The soil of the experimental field was vertisol. Rice variety "Rajeshwari 1" was used as a test crop. The experiment was laid out in randomized complete block design with seven treatments and three replications. The treatments comprised of T_1 (N_0:P_{60}:K_{40} control), T_2 (N_{100}:P_{60}:K_{40} N through prilled urea),T_3 (N_{100}:P_{60}:K_{40} , 90 Kg/ha. N through PU +10 Kg/ha. foliar spray), T_4 (N_{100}:P_{60}:K_{40} , N through urea briquettes), T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes), T_6 (N_{80}:P_{60}:K_{40} 70 Kg/ha. N through UB +10 Kg/ha. foliar spray), T_7 (N_{60}:P_{60}:K_{40} , 50 Kg/ha. N through UB +10 Kg. foliar spray).
The experiment was laid out in a randomized block design with three replications. Prilled urea was applied in three equal splits. USG were applied in between 7- 10 DAT and the briquettes were placed at 5-7.5 cm depth between four hills 15 X 15 cm (plant spacing). 2% of urea solution applied in as a foliar spray. The yield and yield attributing characters of rice responded significantly superior with T_4 (N_{100}:P_{60}:K_{40}) N through urea briquettes i.e. 53.68 q/ha. Grain yield over GRD T_2 (N_{100}:P_{60}:K_{40} N through prilled urea). Nitrogen (N) content and N uptake was recorded significantly superior in T_4 (N_{100}:P_{60}:K_{40} N through urea briquettes) i.e. 1.25, 0.47 grain & straw content respectively & 104.5 kg/ha. total uptake of nitrogen.
Nitrogen use efficiency (NUE) and benefit cost ratio is higher in the T_6 (N_{80}: P_{60}: $K_{40,}$ 70 Kg/ha. N through UB +10 Kg/ha. foliar spray) followed by T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes) and T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes). This results indicate that application of USG in rice field decreases the losses of N and save the fertilizer, leading to efficient uptake and utilization of applied N. Nitrogen use efficiency also influence by foliar spray to rice plant.

Keywords: urea briquette, Foliar Spray, Nitrogen Use Efficiency.

Introduction
Rice (*Oryza Sativa L.*) is the most important and extensively cultivated food crop that has been referred as global grain because of its use as prime staple food in about 100 countries of the world. Rice is a major crop of Chhattisgarh, near about 70% of area is under cultivation each year. Chhattisgarh popularly known as "Rice Bowl of India."
Nitrogen (N) is one of the most yield-limiting nutrients in rice production around the world, The efficient use of N fertilizer is recognized as an important factor for rice cultivation, but it has always been a problem to raise the N utilization rate of the rice plants and to increase the efficiency of absorbed N for grain production irrespective of the amounts of N being applied. Lo The low efficiency of N fertilizers is mainly due to loss of applied N through leaching, volatilization, surface runoff, and denitrification in the soil-flood water system. Many strategies have been developed to increase the efficiency of applied fertilizers through proper timing, rate, deep placement, modified forms of fertilizers. Among them deep placement of fertilizers is one of the most effective methods in reducing loss of nutrients in the flood water and is likely to minimize losses through different processes. Deep placement involves placement of large granules or briquettes of fertilizers at 8-10 cm. below the surface. Urea deep placement (UDP) is a proven technology that reduces N losses by up to 50% when compared with the conventional broadcast application of urea **.** Urea can also be supplied to plants through the foliage, facilitating optimal N management, In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application.

Materials and Methods
A field experiment was conducted to evaluate the Effect of nitrogen management practices on productivity and nitrogen use efficiency in rice crop (Var. Rajeshwari-1). The experiment was

conducted during Kharif season of 2017-2018 at the Instructional Cum Research Farm, Indira Gandhi Agricultural University, Raipur (Chhattisgarh).

Climatic and weather conditions

The general climate of this region is dry moist, sub humid and the region receives 1200-1400 mm rainfall annually, out of which about 88 per cent is received during rainy season (June to September). The temperature during the summer months reaches as high as 48°C and drop to 5°C during December to January.

Soil characteristics

The soil of experimental site is represented as a Typic chromesterts (Vertisols). It is locally called Kanhar. The soil occurs on mid land position of landscape in Chhattisgarh, is deep and hence has good water holding capacity. The soil is characterized by clay loam texture and moderate to slow internal drainage, medium to deep depth, and brownish gray in surface color, sub angular to angular blocky structure and neutral in reaction.

In this experiment urea briquette are applied by two method -

1. This method was applied with in the treatment- 4 [100 N: 60 P: 40 K, N through urea briquette] and treatment – 7 [50 N: 60 P: 40 K, N through urea briquette + 10 kg. Foliar spray in two split.]

V		V	V		V	V		V
	0			0			0	
V		V	V		V	V		V
V		V	V		V	V		V
	0			0			0	
V		V	V		V	V		V
V		V	V		V	V		V
	0			0			0	
V		V	V		V	V		V

Fig 1: Here - v - Transplanted Rice plant , 0 – urea briquette, Briquette size – 2.5 gm. (Big size) , Plot size – 90 m^2 Plant spacing – 15 × 15 cm. Urea Briquette Placement time - 7-10 DAT and depth - 5-7.5 cm.

This method was applied with in the treatment – T5 [80 N : 60 P : 40 K, N through briquette] and treatment – T6 [70 N : 60 P: 40 K, N through urea briquette + 10 kg. foliar spray in two split.]

V		V		V		V		V		V
	0		0		0		0		0	
V		V		V		V		V		V
V		V		V		V		V		V
	0		0		0		0		0	
V		V		V		V		V		V
V		V		V		V		V		V
	0		0		0		0		0	
V		V		V		V		V		V

Fig 2: Here – **v** - Transplanted rice plant , **0** – urea briquette, Briquette size – 1.13 gm. (Small size), Plot size – 90 m^2 Plant spacing – 15 × 15 cm., Urea Briquette Placement time 7-10 DAT and depth - 5-7.5 cm.

All the intercultural practices like weeding and disease control was done in all treatments.

Methods of analysis

Soil analysis

The initial soil sample and plot wise samples collected after harvest. All the samples collected were analyzed for physico-chemical and chemical properties and contents of NPK by standard procedures.

Plant analysis

Plant samples collected at the harvest of rice were dried at 55ºC in an oven for 24 hrs and were grinded and used for the analysis of N, P, K, content in grain and straw.

Observation are recorded

1. Initial and final nutrient status in soil.
2. Number of effective tillers/ hills.
3. Number of grains /Panicles.
4. Grain yield (q/ha.)
5. Straw yield (q/ha.)
6. Evaluation of major nutrient uptake in plant at harvest.

Number of total and effective tillers

Number of total and effective tillers was counted randomly from five places with the help of quadrate in each plot and than mean was calculated.

Panicle length (cm)

Ten panicles were randomly selected from tagged plants and the length was measured from the neck node to the tip of the upper most spikelet and average length was recorded.

Filled grains panicle^{-1}

Grains of ten randomly selected panicles from each plot were separated and counted and their mean value was expressed as number of grains per panicle.

Grain yield (q/ ha)

The harvested produce from the net plot area was sun dried and threshed to obtain grain yield in kg plot-1. Thereafter, it was computed to q ha-1.

Straw yield (q/ ha)

The straw yield was worked out by subtracting the grain yield from total biological yield and finally it was computed to q ha^{-1}

Nutrient Uptake

N, P and K uptake by the rice crop were computed from their respective elemental concentration in seed and straw of the crops.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Yields (kg ha}^{-1}) \text{ x content (\%)}}{100}$$

Nutrient use efficiency(NUE) :-

It was calculated by using the following formula for nitrogen, phosphorus and potassium nutrients.

$$\text{NUE (\%)} = \frac{\text{Uptake from treated plot} - \text{Uptake from control plot}}{\text{Total nutrient applied}} \times 100$$

Relative economics

Studies on economics of production was made by keeping a record on operations carried out, number of labours engaged, power and input utilized. The standard cost of cultivation was calculated as per rates fixed by government and IGKV. Gross

returns hectare^{-1}, Net return hectare^{-1} and benefit: cost ratio were worked out as per the following formula (Tomar and Tiwari, 1990)

Total gross return (ha^{-1})

Gross return = Yield (q ha $^{-1}$) x Price of yield (q^{-1})

Net return (ha^{-1})

Net return (ha^{-1}) = Gross return (₹ ha^{-1})-Cost of cultivation (₹ ha^{-1})

Benefit cost ratio

Economics of all treatment combinations was worked on the basis of yield. The cost of input and output was estimated as per prevailing market rates at the time of experimentation. The benefit cost ratio was determined as:

$$\text{Benefit: cost ratio} = \frac{\text{Gross Income (₹ ha}^{-1})}{\text{Total cost of cultivation (₹ ha}^{-1})}$$

Statistical analysis

The experiment was laid out in Randomized Block Design (RBD). The data obtained from various characters under study were analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The level of significance used in "F" test was given at 5 per cent. Critical difference (CD) values are given in the table at 5 percent level of significance, wherever the "F" test was significant at 5 percent level. The skeleton of analysis of variance and formula used for various estimations are given below:

Table 3.11: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	Fcal	Ftab	SEm±	CD 5%
Replication(r)	(r-1)= 2	RSS	RMS	RMS/ EMS			
Treatment(t)	(t-1) = 6	TrSS	TrMS	TrMS/EMS			
Error	(r-1)(t-1) = 12	EMS	ESS				
Total	rt-1= 47						

The following formula was used for standard error, critical difference and coefficient of variance estimation.

a. SEm± = √ E R

b. CD = SEm± x √2 x t7 DF at 5%

c. CV (%) = √ EMS x 100GM

Where,

R = Number of replication,

DF = Degree of freedom

T = Number of treatment,

SS = Sum of square

CD = Critical difference,

CV = Coefficient of variance

MSS = Mean sum of square,

EMS = Error mean square,

SEm ± = Standard error of mean,

GM = Grand mean.

Results and Discussion

The results revealed that the yield components effective tillers hill^{-1} and grains panicle^{-1} except 1000-grain weight of rice responded significantly due to application of PU, USG and foliar spray. The treatment T_4 (N_{100}:P_{60}:K_{40} , N through urea briquettes) 7.49 produced highest effective tillers hill^{-1} and the lowest value was obtained in T_1 (N_0:P_{60}:K_{40} control), 4.11. The number filled grains panicle^{-1} varied from 79.47 to 119.07 with the highest value in T_4 – 119.07. The 1000-grain weight was not influenced non significantly by the treatment. The highest grain yield (53.68 qha^{-1}) was observed in T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) followed by 51.76 qha^{-1} in T_6 (N_{80}:P_{60}:K_{40} 70 Kg/ha. N through UB +10 Kg/ha. foliar spray) and the lowest value 20.84 qha^{-1} was recorded in T_1. Based on grain yield the treatments may be ranked in order of T_4>T_6>T_5>T_3>T_2>T_7>T_1.

The highest grain yield recorded in treatment T_4 (N_{100}:P_{60}:K_{40} N through urea briquettes), recorded 16.54% higher grain yield as compared with RDF T_2 (N_{100}:P_{60}:K_{40} N through prilled urea) followed by treatment T_6 (N_{80}:P_{60}:K_{40} 70 kg/ha. N through briquettes & 10 kg/ha. through foliar spray) recorded 13.44% higher grain yield over RDF plot. Than over RDF 8.75% higher grain yield recorded in T_5 (N_{80}:P_{60}:K_{40} N through urea briquettes). T_3 (N_{100}:P_{60}:K_{40} 90 kg/ha. N through briquettes & 10 kg/ha. through foliar spray) recorded 4.63% higher grain yield as compared with RDF & the lowest grain yield recorded in T_7 (N_{60}:P_{60}:K_{40}) where 50 kg. N through briquettes & 10 kg. through foliar spray, that is decrease -5.75% as compared with RDF treated plot T_2.

Table: Effect of deep placement of urea briquette, prilled urea (PU) & foliar spray on grain & straw yield of rice

	Treatment	Rice yield (q/ha.)	
		grain yield	straw yield
T1	control	20.84	31.67
T2	100 kg/ha. N through prilled urea	44.80	56.96
T3	90 Kg/ha. N through PU +10 Kg/ha. foliar spray	46.97	59.48
T4	100 Kg/ha. N through urea briquettes	53.68	77.70
T5	80Kg/ha. N through urea briquettes	49.10	69.67
T6	70 Kg/ha. N through UB +10 Kg/ha. foliar spray	51.76	71.50
T7	50 Kg/ha. N through UB +10 Kg/ha. foliar spray	42.36	53.92
	CD (P = 0.05%)	4.2	7.0
	SEm	1.3	2.2

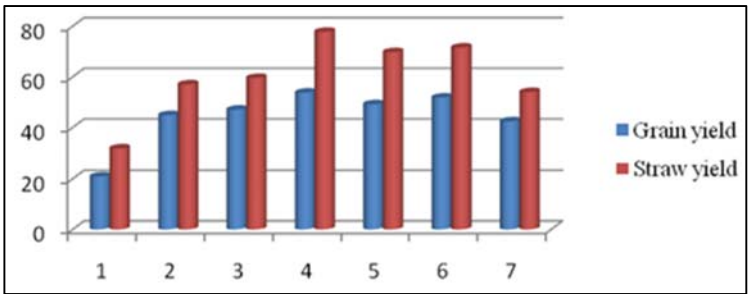

Fig :- Effect of deep placement of urea briquette , prilled urea (PU) & foliar spray on grain & straw yield of rice

Table : Percentage grain yield increase over RDF

	Treatment	% Grain yield increase over RDF
T1	control	---
T2	100 kg/ha. N through prilled urea	----
T3	90 Kg/ha. N through PU +10 Kg/ha. foliar spray	4.63
T4	100 Kg/ha. N through urea briquettes	16.54
T5	80Kg/ha. N through urea briquettes	8.75
T6	70 Kg/ha. N through UB +10 Kg/ha. foliar spray	13.44
T7	50 Kg/ha. N through UB +10 Kg/ha. foliar spray	-5.75

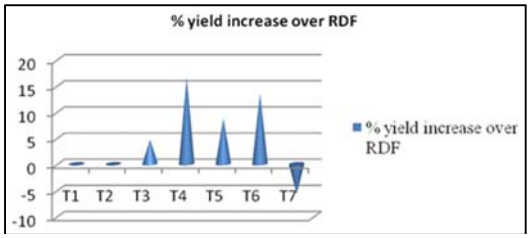

Fig 4.1.3: Percentage grain yield increase over RDF

The Nitrogen (N), phosphorus (P), and potassium (K) content in grain and straw was non significant by the application of of PU, USG and foliar spray. The highest N content in grain and straw was recorded in T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) 1.25 and 0.47% respectively and the lowest value in grain and straw was noted in T_1 (N_0:P_{60}:K_{40}) 1.12, 0.40% respectively. The P and K content in grain and straw superior in T_4 (N_{100}:P_{60}:K_{40}) N through urea briquettes where P percent is 0.29%, 0.059% & K percentage is 0.42% 1.37% respectively. And the lowest value in grain and straw was noted in T_1 (N_0:P_{60}:K_{40}).

While the total nitrogen uptake both in grain and straw was significantly superior in treatment T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) 104.05 kg/ha. The lowest values were recorded in T_1 (N_0:P_{60}:K_{40}) 37.82 kg/ha .

Total P uptake by grain and straw ranged from 6.59 to 20.15 kg/ ha. The P uptake by grain significantly superior was recorded in T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) 20.15 kg/ha. at par to T_6 (N_{80}:P_{60}:K_{40} 70 Kg/ha. N through UB +10 Kg/ha. foliar spray) 18.37 kg/ha. and T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes) 16.57 kg/ha. compared with T_2 N through prilled urea (N_{100}:P_{60}:K_{40}) 13.90 kg/ha. The lowest total P uptake by grain and straw was recorded in T_1 (N_0:P_{60}:K_{40}) 6.59 kg/ha.

Total K uptake by grain and straw ranged from 48.84 to 128.99 kg/ha. The K uptake by grain significantly superior was recorded in T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) 128.99 kg/ha. at par to T_6 (N_{80}:P_{60}:K_{40} 70 Kg/ha. N through UB +10 Kg/ha. foliar spray) 115.93 kg/ha. and T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes) 155.27 kg/ha. compared with T_2 N through prilled urea (N_{100}:P_{60}:K_{40}) 92.17 kg/ha. The lowest total P uptake by grain and straw was recorded in T_1 (N_0:P_{60}:K_{40}) 48.84 kg/ha.

Nitrogen use efficiency represents the response of rice plant in terms of grain yield to N fertilizer. The highest value 30.67% of NUE was obtained in T_6 (N_{80}:P_{60}:K_{40}, 70 Kg/ha. N through UB +10 Kg/ha. foliar spray), followed by 27.31% NUE recorded in T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes) and the lowest value (4.59%) was found in T_2 (N_{100}:P_{60}:K_{40}) N through prilled urea treatments. The briquettes + foliar spray treated plots T_6 (N_{80}:P_{60}:K_{40}, 70 Kg/ha. N through UB +10 Kg/ha. foliar spray), T_5 (N_{80}:P_{60}:K_{40}, N through urea briquettes) and T_4 (N_{100}:P_{60}:K_{40}, N through urea briquettes) N through urea briquettes had much higher nitrogen use efficiency compare to the PU treated plot T_2 (N_{100}:P_{60}:K_{40}) N through prilled urea. This results indicate that application of USG in rice field decreases the losses of N and save the fertilizer, leading to efficient uptake and utilization of applied Nitrogen use efficiency also influence by foliar spray to rice plant.

Table: Effect of deep placement of urea briquette, prilled urea (PU) & foliar spray on Nitrogen use efficiency in rice

	Treatment	Nitrogen use efficiency (NUE)	NUE over RDF
T1	N0: P60: K40	-----	-----
T2	100 kg/ha. N through prilled urea (PU)	40.26	-----
T3	90 Kg/ha. N through PU +10 Kg/ha. foliar spray	44.85	4.59
T4	100Kg/ha. N through urea briquettes (UB)	66.24	25.98
T5	80Kg/ha. N through urea briquettes	67.57	27.31
T6	70 Kg/ha. N through UB +10 Kg/ha. foliar spray	70.93	30.67
T7	50 Kg/ha. N through UB +10 Kg/ha. foliar spray	54.09	13.83

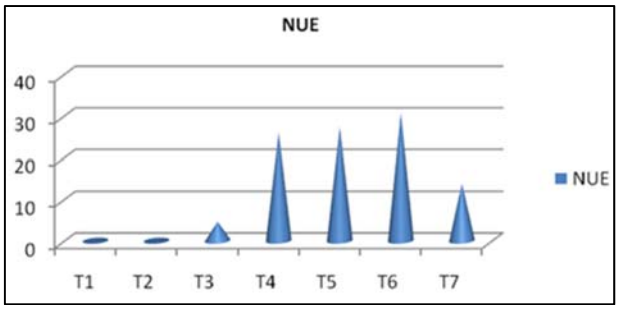

Fig: Effect of deep placement of urea briquette, prilled urea (PU) & foliar spray on Nitrogen use efficiency in rice

B: C RATIO

The highest cost of cultivation was 29693 Rs. recorded in treatment T_4 (N_{100}:P_{60}:K_{40}) N through urea briquettes followed by T_6 (N_{80}:P_{60}:K_{40}, 70 kg. N through briquettes & 10 kg. through foliar spray) recorded 29126 Rs. And the B:C ratio was highest under the treatment T_6 (N_{80}:P_{60}:K_{40}) where 70 kg/ha. N through briquettes & 10 kg/ha. through foliar spray obtain 1.81, followed by T_4 (N_{100}:P_{60}:K_{40}) N through urea briquettes that is 1.80 , that was superior as compare with T_2 GRD (N_{100}:P_{60}:K_{40}), the lowest value was recorded in T_1 (N_0:P_0:K_0) control that is 0.13. Overall, the treatments involving urea briquette application + foliar application expressed higher benefit cost ratio as compared with treatment T_2 (N_{100}:P_{60}:K_{40}) where 100 kg. N through prilled urea. These result indicate that application of urea briquettes can be useful in saving N fertilizer.

Table : Assess the economics of different N management practices

	Treatment	Total cost of cultivation (Rs. ha^{-1})	Gross Income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
T1	N0: P60: K40	22660	25750.5	3090.5	0.13
T2	100 kg/ha. N through prilled urea (PU)	28293	75030	46737	1.65
T3	90 Kg/ha. N through PU +10 Kg/ha. foliar spray	28527	77943	49416	1.73
T4	100Kg/ha. N through urea briquettes (UB)	29693	83434.5	53741.5	1.80
T5	80Kg/ha. N through urea briquettes	29126	81045	51919	1.78
T6	70 Kg/ha. N through UB +10 Kg/ha. foliar spray	28846	81345	52499	1.81
T7	50 Kg/ha. N through UB +10 Kg/ha. foliar spray	28279	69093	40814	1.44

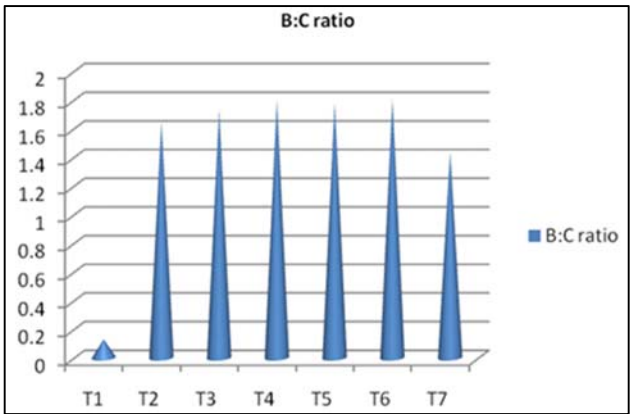

Fig: B:C RATIO

Conclusion

- From the study it can be concluded that the deep placement of briquettes and foliar spray gives higher yield and yield attributing. It was recorded significantly higher under treatment T_4 (100Kg/ha. N through urea briquettes), followed by T_6 (70 Kg/ha. N through UB +10 Kg/ha. foliar spray) as compared with T_2 GRD (N_{100}:P_{60}:K_{40}) N through prilled urea and the minimum was recorded under T_1 (control plot).
- Further application of T_6 (70 Kg/ha. N through UB +10 Kg/ha. foliar spray) showed higher impact on nitrogen use efficiency in rice.
- The treatment T_6 (70 Kg/ha. N through UB +10 Kg/ha. foliar spray), followed by T_4 (100Kg/ha. N through urea briquettes), expressed higher benefit:cost ratio compared to treatment T_2 (N_{100}:P_{60}:K_{40}). These results indicate that application of urea briquettes can be useful in saving N fertilizer.

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