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Influence of different application techniques of nitrogen at seedling stage and different top dressing method on yield of rice (*Oryza sativa* L.)

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Abstract
Field experiment to determine "influence of different application techniques of nitrogen at seedling stage and different top dressing method on yield of rice" was conducted at the Research Farm of College of Agriculture, Central Agriculture Imphal, Manipur during the Kharif season of 2018. The experiment consisted of three different method of nitrogen fertilizer application at seedling stage i.e. soil application, root dipping and foliar spray method and three different top dressing methods of Nitrogen i.e. broadcasting, mudball placement and pellet placement. The results revealed that among different method of nitrogen application at seedling stage foliar spray was the most effective method in yielding highest grain yield and yield attributing characters, however higher plant height and higher leaf area index were recorded by soil application method. Among the different top dressing method mudball placement was the most effective method, however taller plants and higher leaf area index were recorded by broadcasting method. It was also evident that the interaction of foliar spray with mudball placement recorded higher grain yield and yield attributing characters.

Keywords: Soil application, foliar spray, root dipping, top dressing, mudball placement, pellet placement, yield

Introduction
Rice is possibly the oldest domesticated grain (10000 years) and is central to billions of people around the world. It is a staple food for 2.5 billion people and provides 15% of capital protein and 21% of global human per capita energy. Rice provides vitamins, minerals and fiber. All the constituents present in rice grain are reduced in milling except carbohydrate. World's average consumption of rice was 58 kg in 1999. Over 125 million ha land which equals roughly 9% of entire earth's arable land is covered by rice fields. Proper research in the crop has led to doubling world's rice production from 260 million tons to 600 million tonnes. (Maclean *et al.* 2002) [19]. Lindt (1953) [18] referred nitrogen as king pin in paddy fertilization due to almost universal response to its application under most geo-physical condition. Nitrogen is one of the important primary nutrient for crop production and application of nitrogen fertilizer could increase the yield of rice by 70-80%. Indian soils mostly lack the available nitrogen (less than 125 mg kg^{-1}soil) due to low organic matter content in soil and high temperature. (Anonymous, 2015) [2]. It is also the most limiting nutrient in rice production and there are heavy losses of Nitrogen when applied from inorganic sources in puddled soils (Filery *et al.* 1984) [8]. The efficiency of N fertilizer applied also depend on N sources, application method, rate of N as well as management practices revealed by tracer studies of 15N (Wang *et al*. 2011 Chen *et al*. 2010, Wang *et al*. 2008) [31, 7, 32]. Nitrogen use efficiency of conventional chemical fertilizers is as low as 30 to 35% (Galloway and Cowling, 2002, Ladha *et al*. 2005) [9, 15]. Nitrogen when applied to transplanted rice under anaerobic conditions is often subjected to losses by leaching, run-off and denitrification etc. (Reddy and Reddy, 1986) [27]. Improving Nitrogen use efficiency of the fertilizers will be a major challenge to the researchers. Many researches has been conducted in the past which shows us a clear indication that deep placement of urea has a significant influence in reducing the loses of Nitrogen from flooded soils. Urea super granules when placed 6-10cm depth in wetland rice field saved 30% of nitrogen compared to broadcasted prilled urea. (Hoque *et al.* 2013) [12]. Mud ball was a technique of urea fertilizer application developed in china where the fertilizer was placed inside of a mud ball by making a hole and closing it, then the mudball was injected in soil and

applied in between rice hills. To overcome the laborious time of making mud balls urea super granules was developed which were of convenient sizes to be deep placed in transplanted rice soils for having effective use. (Power and Prasad, 1997) [24]. Urea can also be supplied to plants through the foliage, facilitating optimal nitrogen management, which minimizes nitrogen losses to the environment without affecting yield (Millard and Robinson, 1990) [21]. Foliar spray of fertilizer not only reduces the quantity of fertilizer applied through soil but also increases crop yields. It can also reduce lag time between fertilizer application and fertilizer uptake (Ahmad and Jameen, 2005) [3]. Parvin *et al*. (2013) [23]. concluded that foliar spray of fertilizer did not only increase the crop yields but also reduced the quantities of fertilizer applied in the rice field. Lee and Datta (1976) [17a] reported that placement of urea mudball 10-12 cm deep produced significantly higher grain yield with the same amount of nitrogen (60kg/ha) compared to other conventional application methods.

Materials and Methods

The present investigation was conducted Research farm, College of Agriculture, Central Agricultural University, Imphal (Manipur) during *Kharif* season of 2018. The experimental site is located at 24.45^0 N latitude and 93.56^0 E longitudes with an elevation of 790 m above mean sea level. Soil is clayey and acidic in nature (pH5.52), high in organic carbon (1.15%), medium in available nitrogen and phosphorous (322kg/ha) and (17.59kg/ha) respectively with high available potassium (287.17kg/ha). The experiment was laid out in Factorial randomised block design (FRBD) with 9 treatments and 3 replications. Treatments consisted of 3 method of nitrogen application at seedling stage i.e. soil application, root dipping and foliar spray with three nitrogen top dressing methods i.e. broadcasting, mudball placement and pellet placement at main field. Seedling nursery was laid out in three sub plots consisting of soil application, root dipping and foliar spray. Basal dose of required P and K were supplied through SSP and MOP respectively. and N was supplied only in soil application sub plot as per the treatment. later foliar spray was done @ 2% urea in one of sub plot and finally root dipping was done in one of sub plot as per the treatment @ 2% urea solution for 24 hrs before transplanting. The main field for transplanting was prepared and divided into 27 plots where equal doses of NPK: 60-40-30 kg/ha was applied. doses of which P_2O_5 @40kg/ha and K_2O @ 30kg/ha was commonly applied to all the plots whereas Nitrogen was applied in split doses at active tillering and panicle initiation stage. CAU- R1 seedlings were transplanted at spacing of 20×20 cm with two seedlings per hill in 10 m² plot. The mudball with fertilizer, weighed 30 gm and contained 209 mg urea/ball was applied @ 1 mudball in centre of 4 hills of rice 10-12cm deep at active tillering and panicle initiation stage. Broadcasting of Urea was done @ 130g/ plot at tillering and panicle initiation stage. Data was recorded at 30,60 and 90DAT. Leaf area index in rice was worked out as suggested by Palaniswamy and Gomez (1974) [22] as:

$$LAI = \frac{L \times W \times \text{Number of leaves/ hill} \times K}{\text{Plant spacing (cm)}}$$

Where,
L=Length of third leaf from the top in a tiller (cm)
W= Maximum width of the same leaf (cm)
K= Constant factor, (0.75)
The data obtained were subjected to analysis of variance (ANOVA) for testing the significance of treatment effects and interpretation of results (Gomez and Gomez, 1984) [10].

Result and Discussions

Influence of application method at seedling stage on growth parameters

Plant height increased from 30 Dat to 90 DAT. Soil application of urea in seedling stage recorded taller plant height at 30, 60, 90 Dat which were 67.75cm, 113.09cm, 136.44cm respectively and were significantly higher than foliar spray of urea at all the stages. However, they were at par with root dipping at all the stages. Significantly Shorter plants were recorded in all the stages with foliar spray (61.31cm, 98.58cm and 130.96cm) at 30,60 and 90 DAT respectively except for 30 DAT where it was at par with root dipping treatment. Taller plants were produced by soil application of Nitrogen on Nursery seedling over root dipping and foliar spray. This may be due to higher vegetative growth facilitated by application of urea at soil which is readily available and easily taken up by roots of plants and further the urea applied through foliar spray may be reduced due to decreased uptake from foliage of plants also supported by (Islam *et al.*, and Hasanuzzaman *et al.*, 2009) [13, 11]. Nitrogen application method at seedling stage had a profound significant effect on leaf area index of plants at all stages (30,60 and 90 DAT). Leaf area index increased from 30 DAT to 60 DAT and decreased from 60 DAT to 90 DAT. Soil application of nitrogen at seedling stage recorded significantly higher leaf area index of 1.25, 1.64 and 1.33 at 30,60 and 90 DAT respectively over foliar spray however was at par with root dipping. Foliar spray of nitrogen at seedling stage recorded significantly lowest leaf area index of 1.05,1.42 and 1.23 at 30,60 and 90 DAT respectively. Higher impact of soil application of urea over foliar spray and root dipping treatment may be due to fact that soil applied urea which is readily available at young age for plant roots to absorb lead to faster growth of seedlings over foliar spray and root dipping treatments. Similar findings were reported by (Adhikari *et al* 2013) [1]. Early vigorous growth of seedlings was recorded by soil applied nitrogen, this may have led to better height of plant and leaf area index at main field. Begum *et al.* 2002 [4], Rakotson *et al*. 2021 [25], Ros *et al.* 2003 [27]. findings also suggested, Nitrogen as main limiting factor for seedling growth in nursery and application of nitrogen at seedling stage led to better growth of seedlings.

Influence of different top dressing method of nitrogen on growth parameters

Top dressing methods differed significantly. Broadcasting urea as top dressing method recorded taller plants measuring 66.32cm, 113.99cm and 137.30cm at 30,60 and 90 DAT respectively which were significantly higher than mudball placement and pellet placement at all the growth stages except for 30 DAT where it was at par with pellet placement. Shorter plant height was recorded with mudball placement at all the stages (61.31cm, 102.55cm, 132.82 cm) at 30,60 and 90 DAT respectively. Urea applied through mudball are slowly available and slowly released therefore it may not be available to be readily taken up by the roots for higher vegetative growth as reported Ventura and Yoshida (1978) [30]. Different top dressing methods also influenced the leaf area index

significantly at 30 and 90 DAT. At 30 DAT higher leaf area index value of 1.27 was recorded with broadcasting that was significantly higher than both mudball placement and pellet placement. Mudball placement recorded significantly lowest leaf area index of 1.05. At 60 DAT however, the difference among methods were not significantly different. Highest and lowest leaf area index at 60 DAT were recorded by pellet placement (1.58) and mudball placement (1.53) respectively. At 90 DAT the difference among methods were significant, where pellet placement recorded significantly highest leaf area index of (1.34) over mudball placement (1.22) and was at par with broadcasting treatment (1.33). Higher leaf area index of broadcasted urea is due to availability of urea for absorption by plant root with coincided at time of application at active tillering stage.

Influence of application method at seedling stage on yield attributes and yield

It is evident from the results that foliar spray recorded longest panicle length of (27.19 cm) which was significantly higher than root dipping (24.88 cm) and was at par with soil application (26.24 cm). Foliar spray at seedlings stage produced significantly longer panicles over root dipping and were similar with soil application. This may be due to enhanced rate of photosynthesis which contributed to formation of longer panicles later on the plant growth. Similar findings were also reported by (Bhuyan *et al.*, 2012) [5a] and (Manik *et al.*, 2016) [20] where they reported longer panicle formation by foliar spray method. At seedling stage highest number of filled grains per panicle was recorded by foliar spray (146.89) and the lowest number of filled grains per panicle was recorded by soil application method (125.56). The treatment foliar spray (146.89) was at par with root dipping (134.44) and the treatments soil application (125.56) was at par with root dipping treatment (134.44). Seedlings applied with foliar spray of nitrogen recorded highest number of filled grains/panicle over root dipping and soil application methods. This is due to better improvement of photosynthetic ability of plant which attributed to better number of filled grains production per plant which was also supported by (Bhuyan *et al.* 2015) [6a]. The results revealed that there was a significant difference among different methods of nitrogen application at seedling stage where foliar spray recorded highest yield (5.21t/ha) and lowest was found at soil application (4.52 t/ha). The treatments Foliar spray (5.21t/ha) was at par with root dipping (5.13 t/ha). Foliar spray of seedlings out yielded soil application and root dipping methods. Similar findings were reported by (Manik *et al.*, 2016), [20b] (Bhuyan *et al*., 2012) [5b] where foliar spray improved crop yields over conventional methods of fertilizer application. (Jagatjothi *et al.*, 2012) [14] findings also supported the notion of improving grain yield by spray of 2% urea solution in rice.

Influence of different top dressing method of nitrogen on yield attributes and yield

Different top dressing method also differed significantly where mudball placement recorded longest panicle length (27.36cm) which was significantly higher than pellet placement (25.08cm) but was at par with broadcasting (25.86cm) further the panicle length of pellet placement (25.08 cm) was at par with broadcasting method (25.08cm). Mudball placement significantly produced longer panicles over pellet placement which may be due to fact that urea applied in mudballs releases nitrogen slowly which ensures sufficient N at panicle formation stage with better results. The finding was being in conformity with (Hasanuzzaman *et al.*, 2009) [11b] who reported deep placement of USG yielding longer panicles. Similar findings were also reported by (Lee and De datta1976) [17b] who reported longer panicles in mudball applied rice fields. Different top dressing methods were not significantly different with respect to number of filled grains per panicle. With mudball placement producing highest number of filled grains per panicle (139.67) and the lowest being (132.78) produced by pellet placement. Better performance of mudball placement may be due to higher uptake and higher recovery of nitrogen when applied at panicle initiation stage. Further the coincidence of grain formation and fertilizer application coupled with reduced losses of nitrogen at times of crop need may lead to formation of good number of filled grains per panicle. The findings of (Lee and De Datta 1976) [17c] also supported the theory of mudball placement of urea having recorded highest number of filled grains. Further the finds of Xuan *et al.* (1980) [33] also supported similar results. There was also significant difference among different top dressing methods of nitrogen application where highest yield was obtained at mudball placement (5.35 t/ha) and lowest by pellet placement (4.53t/ha). The treatments broadcasting (4.98t/ha) and pellet placement (4.53t/ha) were at par with each other. It can be noted that mudball placement leads to increase uptake of fertilizer by reducing losses as shown by (Shiga *et al*.,1977). [28] Similarly, (Lee and De Datta 1976) [17d] also found out that yield of rice from mudball is higher than other top dressing methods. Similarly, (Simsiman *et al*., 1967) [29] reveals that yield improvement by mudball placement may be due to high recovery of applied N as compared to other Incorporation method. (Ventura and Yoshida 1978) [30b] also supported the importance of mudball placement over other application method in terms of losses of N form puddled soil. Importance works of (Lawal *et al.*, 2003) [16] also implicated the importance of mudball placement.

Interaction effect on growth and yield parameters

Taller plants were recorded by the interaction of soil application with broadcasting 72.77cm,121.17 cm and 140.71 at 30, 60 and 90 DAT respectively. Shorter plants were recorded by foliar spay with mudball placement 59.2cm at 30DAT but at 60 and 90 DAT the interaction of foliar spray with pellet placement recorded shorter plants 93.16 cm and 126.28 cm at 60 and 90 DAT respectively. Higher values of leaf area index were recorded by soil application with broadcasting 1.36, 1.72 and 1.43 at 30, 60, 90 DAT respectively. Lower values of leaf area index were recorded by foliar spray with mudball placement 0.92, 1.39,1.14 at 30,60, 90 DAT respectively. These higher values of interaction of soil application at seedling stage and broadcasting as top dressing method is evident due to their superiority independently over other methods. The interaction of foliar spray with mudball placement recorded longest panicle length (30.14cm) and the interaction of root dipping with broadcasting recording lowest panicle length (23.73 cm). It was evident that due to foliar spray and mudball placement recording longest panicle length individually the interaction of both recorded longest panicle length. Number of filled grains per panicle was recorded highest with foliar spray with mudball placement (160) significantly over all other treatment interaction and was only statically similar with foliar spray

with broadcasting. Lowest number of filled grains per panicle was recorded by soil application with broadcasting (117). The interaction effect of treatment also yielded significant differences where highest yielded was recorded by a treatment combination of (foliar spray with mudball placement) (6.42t/ha) and lowest yield was recorded by treatment combination of (soil application with pellet placement) (4.15t/ha). Here all the treatment combination was found to be at par with each other except for (soil application with mudball placement) recording the yield value of (5.25t/ha) and (soil application with pellet placement method) (4.15t/ha).

Table 1: Effect of different method of Nitrogen application at seedling stage and different top dressing method on growth of Rice variety CAU-R1

Treatment	Plant height			Leaf Area index		
	30 DAT	60DAT	90DAT	30DAT	60DAT	90DAT
Nitrogen application method at seeding stage (SN)						
Soil application	67.75	113.09	136.43	1.25	1.64	1.33
Root dipping	64.18	108.25	135.85	1.23	1.62	1.32
Foliar spray	61.07	98.58	130.96	1.05	1.42	1.23
SE d(±)	1.58	2.62	1.54	0.02	0.04	0.02
CD(P=0.05)	3.34	5.65	3.27	0.05	0.09	0.05
Top dressing method (TD)						
Broadcasting	66.36	113.99	137.30	1.27	1.57	1.33
Mudball placement	61.31	102.55	132.82	1.05	1.53	1.22
Pellet placement	65.34	103.39	133.13	1.16	1.58	1.34
SE d(±)	1.58	2.62	1.54	0.02	0.04	0.02
CD(P=0.05)	3.34	5.65	3.27	0.05	NS	0.05
Interaction SNXTD						
SE d(±)	2.73	4.53	2.68	0.04	0.08	0.04
CD(P=0.05)	5.79	9.61	5.68	0.09	0.16	0.09

Table 2: Effect of different method of Nitrogen application at seedling stage and different top dressing method on yield attributes and yield of Rice variety CAU-R1

Treatments	Panicle length (cm)	No. of filled grains/panicle	Grain yield (t/ha)
Nitrogen application method at seeding stage (SN)			
Soil application	26.24	125.55	4.52
Root dipping	24.88	134.44	5.13
Foliar spray	27.19	146.88	5.21
SE d(±)	0.05	6.24	0.26
CD(P=0.05)	1.82	13.24	0.56
Top dressing method (TD)			
Broadcasting	25.86	134.44	4.98
Mudball placement	27.36	139.66	5.35
Pellet placement	25.08	132.77	4.53
SE d(±)	0.05	6.24	0.26
CD(P=0.05)	1.82	NS	0.56
Interaction SNXTD			
SE d(±)	1.48	10.82	0.46
CD(P=0.05)	3.15	22.93	0.97

Conclusion

The findings of the study revealed that, application of nitrogen as soil applied method in seedling nursery improved the growth of plants through rapid utilization of available nitrogen through roots at short time. Foliar spray application method at seedling stage improved panicle length, filled grains per panicle and yield of plant. Whereas broadcasting of nitrogen as top dressing method improved height and leaf area index of plant, panicle length, number of filled grains per panicle and yield of the plants were improved by application of nitrogen in form of mudballs and seem promising for the lowland rice. Thus the interaction of foliar spray at seedling stage and mudball placement as top dressing method can be used to enhance the yield of rice variety CAU-R1. Further investigations and studies are necessary to conclude the present findings with improved technology for foliar spray and mudball application technique.

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