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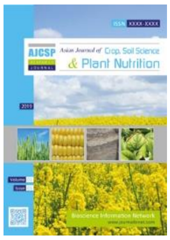

Comparative assessment of applicators for urea deep placement in transplanted rice fields

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka from December 2015 to April 2016 to evaluate the performance of urea deep placement applicators and observe the yield of boro rice. The experiment consisted of a single factor and the treatments were N_0 = Control; UDP-hand = Hand deep placement of urea briquette; SRP-Battery = Deep placement of urea briquette by battery-powered applicator; PU- applicator = Prilled urea deep placement by BRRI applicator; Injector = Deep placement of Urea briquette by injector type applicator; SRP = Deep placement of urea briquette by push- type applicator; PU-broadcast = Prilled urea application by broadcast method. The experiment was laid out in randomized complete block design with three replications. The plant height, number of effective tillers hill^{-1}, grain and straw yield were significantly affected by nitrogen sources and application methods. The application of PU-applicator treatment showed the highest grain and straw yield. Nitrogen sources and application methods significantly affected NH_4^+ concentration in standing water and soils. Higher levels of soil ammonium concentrations were seen in the treatment of prilled urea applicator during 1–7 days of soil sample collection, while higher levels of water ammonium concentrations were identified in the PU-broadcast treatment. Significantly favorable associations between rice grain production and soil ammonium were found. The findings demonstrated that deep application of pelleted urea using a BRRI applicator outperformed other nitrogen sources and application techniques to increase boro rice grain production.

Key Words: *Urea briquette, Prilled urea, Applicators, Ammonium and Rice yield*

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I. Introduction

Urea is the main nitrogen fertilizer used in rice cultivation since nitrogen is crucial to crop productivity. In Bangladesh, rice cultivation uses almost 80% of all urea produced. Urea is often administered via the broadcasting method. When fertilizer is administered using the traditional broadcasting method, the nitrogen utilization efficiency is relatively poor. Typically, the nitrogen given to the rice plant is utilized between 30 and 50 percent, with the remainder being lost from the soil via various mechanisms (Prasad and Datta, 1979; Iqbal, 2009; Amit, 2011). Ammonia volatilization, denitrification, surface runoff, seepage and leaching are the major nitrogen losses. In order to enhance rice yield and lower cultivation expenses, nitrogen usage efficiency (NUE) must be increased. Due to significant nitrogen losses, Bangladeshi farmers have been unable to utilize fertilizer more efficiently to raise rice yields (Hoque et al., 2013).

Different strategies are available to improve NUE and one of the practical- strategy is urea deep placement (UDP). In UDP, urea placed into the soil, close to plant's root zone. UDP is recognized as an effective strategy to increase the NUE of wetland rice and reduce the adverse effects of fertilizers on the environment (Bautista et al., 2001). Therefore, UDP is considered an environment-friendly technique of fertilizer management (Ahamed, 2012). By adopting UDP, much effort must be taken to improve fertilizer use efficiencies in lowland rice production. In UDP, for ease of deep placement, granular or prilled urea is compressed into a larger size, commonly called urea super granule (USG), which is deep placed at 7-10 cm depth at the center of four rice hills. UDP can save urea fertilizer by up to 50% with an average of 33% and increase grain yields up to 50% with an average of 15% to 20% compared to broadcast application of prilled urea (Savant and Stangel, 1990). While UDP saves fertilizer and increases NUE and rice yields, the deep placement process needs more labour than the conventional broadcasting method. One man day could deep place about 0.07 to 0.12 ha (Savant et al., 1992). Farmers have to face labour shortage problems in rice production due to labor out-migration to cities and increasing industrialization. Also, hand placement of USG is laborious work and causes health problems. This scenario suggests an immediate need for mechanization for deep placement of urea so that NUE and rice yield could be improved (Mohammada et al., 2011). A low-cost, efficient fertilizer application technique must be developed for using the fertilizer at required depth to improve fertilizer use efficiency and increase yield. However, minimum efforts have been made in the county to develop effective and efficient fertilizer applicators for deep placement.

To address these issues and find an alternative of manual application of USG, the applicators were developed by different institutions in Bangladesh. Most of the manually operated applicators are push, pull and injector types. A push type fertilizer applicator has been developed by Farm Machinery and Postharvest Process (FMP) Engineering Division of Bangladesh Agricultural Research Institute (BARI) (Wohab et al., 2009). Similarly, an applicator was designed and developed by Bangladesh Agricultural University (BAU) (Ahmed et al., 2012), which is operated by a DC electric motor. When the machine operated in the unpuddled land, distance between two USG was 38.76 cm against the targeted distance of 40cm. The machine performance could be improved by using a more powerful motor. Bangladesh Agricultural Research Institute (BARI) designed another push type applicator during 2011–2015 (Hoque et al., 2016). Earlier, the Bangladesh Agriculture Research Institute created a push type design. To achieve the precise placement of USG to 5-7 cm soil depth and coating of the briquettes with soil, certain modifications were made to the width of the furrow opener and skid. In addition, Bangladesh Rice Research Institute created a different sort of manually driven injector-type applicator (BRRI). This applicator has four mechanics: feeding, measuring, delivery and positioning. Its 1.5 kg weight makes it simple to handle in the countryside. The push-type applicator dramatically decreased the labor required to 15-20 h/ha compared to the hand placement (28-50 h/ha), according to field tests conducted across several sites and seasons. Consistently, the applicator applied USG at the correct depth (7 to 8 cm). A push-style USG applicator was created and developed by the Bangladesh Rice Research Institute (BRRI) in 2008 (Hossen et al., 2013). In the middle of four rice-growing hills, this applicator spreads USG to a depth of 6 to 7 cm below the soil's surface. Hand application of USG takes 28 hours per acre, whereas using an applicator only takes 10 hours.

The International Fertilizer Development Center (IFDC) has long worked to spread awareness of USG technology among many nations. However, owing to the briquette's inadequate size, two USGs might fall simultaneously. As a result, when the hopper is completely loaded, the USG machine will not operate as intended. Additionally, the correct size of USG was not readily accessible on the market, and some urea was wasted during USG synthesis. The USG briquetting machine's installation cost was likewise significant. As a result, the push type applicator was created in 2013 by the Farm Machinery and Postharvest Technology Division of BRRI scientists to simultaneously deep distribute prilled urea between two rows of plants (Rahman et al., 2014).

Although every applicator is claimed to be effective, their effectiveness on deep placement of USG, yields and NUE was not compared. In addition, every model may require technical knowledge and specific field conditions for effective operation. Accordingly, their performance may differ from each other. Studies are lacking to compare the performance of different applicators, particularly for effective placement of USG and their impacts on rice yields. Therefore, this experimental work was conducted to compare the field performance of available applicators for USG with objectives i.e., i. To find an appropriate applicator for deep placement of USG or prilled urea in appropriate depth and retaining N in the sub-soils as ammonium form, and ii. To determine the impact of different applicators on rice yield.

II. Materials and Methods

Description of the experimental site

During the boro season, the experiment was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 (dry season, Jan-April 2016). The region is located at 23.77 N latitude, 90.33 E longitude and has a height of 8.2 m above sea level. It is part of the Tejgaon soil series of the Madhupur Tract (AEZ 28). In the Kharif season (April to September), the experimental location experiences high temperatures, high relative humidity and significant rainfall with sporadic gusty winds, whereas the Rabi season experiences minimal rainfall and somewhat low temperatures (October-March). The soil of the experimental field classified as Deep Red Brown Terrace Soils. Soil samples from 0-15 cm depths were collected before transplanting the rice seedling and analyzed for physico-chemical properties of soil. The soil is a silty clay loam with 5.7 pH, 1.12% organic matter (Walkley and Black, 1934), 0.08% total N (Micro Kjeldahl method; Bremner and Mulvaney, 1982), 12.0 μg g^{-1} available P (0.5M $NaHCO_3$ extraction; Olsen and Sommers, 1982) and 22.5 μg g^{-1} exchangeable K (1MNH_4OAc extraction; Page et al. 1982).

Experimental Design and Treatment

The experimental treatments consist of different types of applicators for deep placement of USG and prilled urea, including N_0: Control, UDP-hand: application of USG by hand, SRP-Battery: application of USG by single-row push-battery powered applicator, PU- applicator: Prilled urea application by BRRI applicator, injector: application of USG by injector type applicator, SRP: application of USG by single row push- type applicator, PU-broadcast: Prilled urea application by broadcast method. These treatments were arranged in a randomized complete block design with three replications. Each experimental plot size was 12 m x 2.4 m. The distance between block to block and plot to plot was 1 m and 0.75 m, respectively.

The experimental plot was ploughed and cross-ploughed with the help of a power tiller, followed by laddering to obtain a good tilth and puddled condition. The area was then leveled and experimental plots were created according to each plot's dimensions. As sources of P, K, S and Zn, respectively, the triple super phosphate, muriate of potash, gypsum and zinc oxide were used during the final land preparation. The treatment-wise applied Fertilizer doses are shown in table 01.

Table 01. Treatment details and nutrient Doses applied for each treatment

Treatment	Treatment description	Treatment abbreviation	Kg/ha							
			N rate	P rate	K rate	Basal N	2nd top dress N	3rd top dress N	S rate	Zn rate
1	Control (no nitrogen)	N0	0	28	65	0	0	0	20	3
2	Manual deep placement by hand	UDP-hand	78	28	65	78	0	0	20	3
3	Single-row push type battery operated applicator	SRP-Battery	78	28	65	78	0	0	20	3
4	PU deep placement by BRRI applicator	PU-applicator	78	28	65	78	0	0	20	3
5	Injector type applicator (Indian version)	Injector	78	28	65	78	0	0	20	3
6	Single row push type applicator	SRP	78	28	65	78	0	0	20	3
7	Prilled urea broadcast	PU-broadcast	112	28	65	38	37	37	20	3

Rice seedlings (32 days old) of BRRI dhan28 were transplanted into the plots on 23 January 2016 by maintaining plant to plant and row to row distance of 20 cm. Gap filling was made up to 7 days after transplanting to maintain similar plant population density for each plot.

Deep placement of USG

Deep placement was done using method as per treatments. In manual application by hand, USG was deep placed by hand at 7-10 cm depth at 40 cm x 40 cm spacing. With this spacing, one USG was placed at the center of four hills. In case of BRRI applicator, push-type applicator and battery powered applicator; the skids of the applicator were placed between two rows of rice and pushed forward at a constant speed. The USG was taken in half of the fertilizer hoppers. This made the cage wheel and the metering devices rotate. During rotation of the metering devices, it carries USG into the pockets and delivers them to the furrow openers. During forward movement of the applicator, the skids helped float the machine. The applicator dropped the USG at 40 cm distance and at 5-6 cm depth. For the injector type applicator, it places the USG at a depth of 7–10 cm below the soil surface. The funnel and feeding pipe are filled with the USG. One USG is applied by placing the applicator at the center of four rice hills and pushing the stick downward. For PU applicator, total amount of prilled urea was applied by using BRRI push type applicator. This applicator was calibrated to drop PU continuously in a row at 5-7cm depth. One third of prilled urea was applied at 7 DAT, another one third of urea was applied at 30 DAT and last one third was applied at 55 days after transplantation of rice.

Measurement of ammonium -N in soils and floodwater

After application of USG and prilled urea, floodwater samples were collected from each plot for seven days. During this period, irrigation water was applied regularly to maintain floodwater depth of 2-3 cm. In addition to floodwater samples, soil samples were collected from just above USG application site. Then, soil samples were extracted by KCl solution for extracting ammonium. Finally, ammonium concentration in floodwater and soil extract was determined by phenolhypochloride method (Solorzano, 1969).

Recording of yield and yield components

After harvest, the plant height, panicle length, tillers hill^{-1}, number of filled grains panicle^{-1}, 1000 grain weight, grain and straw yields were recorded. Ten hills were selected randomly from each plot at maturity to record the yield contributing characters. The plants of 1 m^2 were harvested from the middle area of each plot to obtain grain and straw yields of rice.

Statistical analysis

Analysis of variance for all the response variables was done by Mstat-C. The mean grouping was done by Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

III. Results and Discussion

Ammonium concentration in floodwater

N application methods had significant ($p<0.05$) effects on the concentration of floodwater ammonium nitrogen (Table 02). The higher levels of floodwater ammonium were obtained in PU-broadcast and SRP-Battery (application of urea briquette by battery power applicator) treatments. When PU is applied with broadcast method, it gets dissolved faster in the floodwater and the level of floodwater ammonium could be increased more rapidly compared to other deep placed treatments. The highest floodwater ammonium of 1st (6.47 ppm), 2nd (6.88 ppm) and 4th (9.17 ppm) days were recorded in PU-broadcast treatment which were statistically similar to the water sample of SRP-Battery.

The lower concentration of ammonium in the floodwater was observed in UDP-hand and injector type applicators. In the water samples of different DAT, moderate and similar levels of ammonium concentrations were noticed in PU- applicator (prilled urea deep placement by BRRI applicator) treatment, where highest rice yield was obtained. On the other hand, lower levels of water ammonium concentrations were observed in the UDP-hand, and Injector type treatments due to slow release of ammonium from deeply placed urea briquette and prilled urea and plant accumulated higher amount of ammonium nitrogen and the growth and yield of boro rice increased. These results suggest that injector applicator is as practical as manual application by hand and the SRP-battery was less effective compared to deep placement by hand and by injector type applicator.

Table 02. Effect of nitrogen sources and methods of application on soil solution ammonium during 1st to 7th DAT of boro rice

Treatment	Floodwater NH_4^+ concentration (ppm)						
	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT
N_0	0.89 d	1.07c	1.29c	0.93 c	0.86 d	0.73d	0.72 c
UDP-hand	2.04 cd	2.54bc	3.26bc	4.10 b	4.14c	2.34c	1.84 b
SRP-Battery	4.64 ab	6.19ab	8.57a	8.51a	8.85a	4.83 b	4.44a
PU- applicator	2.71 bc	5.05ab	4.63abc	4.81 b	4.95bc	6.20 a	1.55b
Injector	2.20 cd	3.25abc	2.72 bc	2.81b	2.81c	1.05d	1.23bc
SRP	4.08 bc	5.46ab	7.36ab	5.98b	5.88bc	2.85c	1.42b
PU-broadcast	6.47 a	6.88a	7.19ab	9.17a	6.84b	5.56ab	3.77a
$LSD_{(0.05)}$	2.187	3.373	4.837	2.387	1.994	1.124	1.115
CV (%)	26.66	31.27%	39.21	19.05	16.77	13.54	20.68

In a column, means followed by different letter (s) are significantly different at 1% probability level.
Note: N_0 = Control; UDP-hand = Deep placement of urea briquette by hand; SRP-Battery = Deep placement of urea briquette by battery- powered applicator; PU- applicator = Prilled urea deep placement by BRRI applicator; Injector = Deep placement of urea briquette by injector applicator; SRP = Deep placement of urea briquette by push- type applicator; PU-broadcast = Prilled urea application by broadcast method

Ammonium concentration in soil

Nitrogen application methods significantly affected convention of ammonium N in soils (Table 03). In the deep placement of urea briquette treatments (UDP-hand, SRP-Battery, Injector and SRP-Battery) and deep placement of prilled urea (PU- applicator), the levels of potassium extractable ammonium increased maximum level at 2 or 3 days after application of urea and maintained a plateau up to 7th days after application. In treatment PU-broadcast (Prilled urea application by broadcast method), the levels of potassium extractable ammonium in soils increased upto 3 DAT and then decreased. Among the treatments, higher levels of potassium extractable ammonium were observed in the PU- applicator treatment soils where prilled urea was applied through deep placement. The higher ammonium N could be due to continuous application of urea in a row and more soil was in contact with urea compared to point application of briquette. On day 1, the highest soil ammonium concentration was recorded in the treatment UDP-hand (Urea briquettes application by hand placement method), which was statistically similar to PU- applicator and SRP-Battery powered applicator and the lowest ammonium was in control (N_0). In the samples of second to fifth days, the highest soil ammonium concentration was recorded in PU- applicator (prilled urea deep placement by BRRI applicator) treatment which was statistically similar to SRP-Battery (deep placement of urea briquette by battery-powered applicator), Injector (deep placement of urea briquette by injector applicator), SRP-Battery (Urea briquette application by push type applicator) treatments and the lowest ammonium was recorded in control (N_0) treatment. When urea briquette was in the soil by BRRI applicator, soil ammonium level increased and plant accumulated a higher amount of ammonium nitrogen to increase the growth and yield of boro rice.

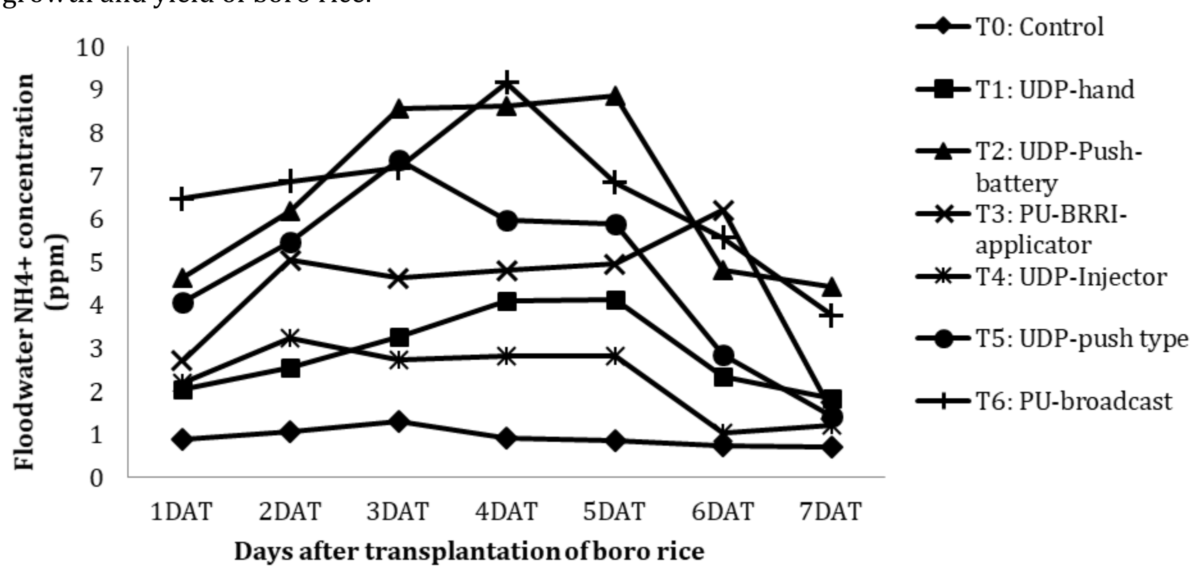

Figure 01. Floodwater ammonium concentration (ppm) with different days after transplantation of boro rice

The water ammonium concentrations were increased using prilled urea by broadcast method (PU-broadcast). However, dissimilarly soil ammonium concentrations were increased in PU- applicator, Injector and SRP-Battery treatments where urea briquettes or prilled urea briquette were placed in the deep soil. In the soil samples on sixth and seventh days, the highest ammonium concentration was recorded in the treatment SRP-Battery (application of urea briquette by battery powered applicator), which was statistically similar to PU- applicator and SRP treatments and the lowest ammonium was recorded in control (N_0) treatment. From the seven days of soil analytical results, higher levels of soil ammonium concentrations were recorded in PU- applicator, Injector, SRP-Battery and SRP treatments (Table 03 and Figure 01), where higher grain and straw yields were found may be due to higher accumulation of available ammonium nitrogen from soil.

Table 03. Effect of nitrogen sources and methods of application on soil ammonium during 1st to 7th DAT of boro rice

Treatment	Soil NH_4^+ concentration (ppm)						
	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT
N_0	40.7 b	44.40d	46.40b	42.30b	40.4c	39.60c	39.90b
UDP-hand	86.77a	85.03bc	112.30a	82.97a	103.9a	84.77b	96.00a
SRP-Battery	62.27a	78.03c	114.60a	92.77a	93.43ab	109.2a	111.1a
PU- applicator	83.63a	154.30a	120.30a	101.5a	116.0a	108.8a	99.93a
Injector	73.93a	101.50bc	91.86a	82.43a	91.90ab	71.93b	100.2a
SRP	78.40a	120.50ab	102.6a	92.73a	111.5a	90.00ab	103.9a
PU-broadcast	65.77a	72.57c	110.9a	77.03a	66.27b	88.07ab	86.4a
$LSD_{(0.05)}$	31.88	37.69	43.01	32.17	30.88	21.97	22.45
CV (%)	18.09	16.13%	17.34	15.75	13.83	10.33	9.53

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance.
Here, N_0 = Control; UDP-hand = Urea briquette deep placement by hand; SRP-Battery = Deep placement of urea briquette by battery-powered applicator; PU- applicator = Prilled urea deep placement by BRRI applicator; Injector = Deep placement of urea briquette by injector applicator; SRP = Deep placement of urea briquette by push- type applicator; PU-broadcast = Prilled urea application by broadcast method

Effect of prilled urea and urea briquettes application methods on growth and yield of boro rice

Nitrogen fertilizer application methods affected yield and yield component (number of effective tillers hill^{-1}, plant height, panicle length and thousand-grain weight) (Table 04). At harvest, the highest number of effective tillers hill^{-1} (17.20) was recorded in the PU- applicator and the lowest effective tillers was N_0 (control) treatment. In the PU- applicator treatment, the plant accumulated more nitrogen and the effective tillers number, resulting in increased grain yield. The highest plant height (98.55 cm) and panicle length (22.73 cm) were recorded in UDP-hand (Urea briquette application by hand placement) treatment and plant height was statistically similar to PU- applicator (prilled urea deep placement by BRRI applicator) and the lowest plant height (74 cm) was recorded in N_0 (control) treatment. When urea briquette was placed in the soil by hand placement and BRRI applicator, plant accumulated higher amounts of nitrogen and increased plant height. Hoque et al. (2016) found higher plant height with the application of urea briquette.

The highest 1000 grain weight was recorded in the treatment PU- applicator (deep placement of prilled urea by BRRI applicator), which was statistically similar to UDP-hand (Urea briquette application by hand placement), PU-broadcast (Prilled urea application by broadcast method) and the lowest 1000 grain weight (20.66 g) was in N_0 (control) treatment (Table 04). The 1000 grain weight was increased when urea briquette was applied by BRRI applicator.

Straw yield of boro rice was significantly influenced by nitrogen application methods (Table 04). The highest straw yield (7.28 ton ha^{-1}) was obtained in the treatment PU- applicator (Prilled urea deep placement by BRRI applicator), which was statistically similar to Injector (Application of urea briquette by injector applicator) and the lowest straw yield (4.00 ton/ha) was found in N_0 (control) treatment. Meena et al. (2003) observed similar results on straw yield due to nitrogen application through prilled urea. Grain yield of boro rice was significantly influenced by nitrogen sources and application methods (Table 04). The highest grain yield (5.82 ton/ha) was obtained in the treatment PU- applicator (Prilled urea deep placement by BRRI applicator), which was statistically similar to

Injector (application of urea briquette by injector type applicator), UDP-hand (Urea briquettes application by hand placement), SRP-Battery (Urea briquette application by push type applicator). The lowest grain yield (2.39 ton/ha) was found in N_0 (control) treatment. When urea was placed in the soil by BRRI applicator, higher levels of soil ammonium concentrations were obtained in PU- applicator treatment and plant accumulated higher amounts of nitrogen and the grain and straw yield increased. Both the PU-broadcast and SRP-Battery gave lower yields in comparison to other treatments due to rapid dissolve of applied prilled urea (PU-broadcast) and urea briquette (SRP-Battery) in standing water and increased the level of ammonium in standing water and may be lost more applied nitrogen through standing water and decreased the boro rice yield.

Table 04. Effect of nitrogen sources and application methods on growth and yield of boro rice

Treatment	Effective tillers /hill	Non effective tillers/hill	Plant height (cm)	Panicle length (cm)	1000 grain weight (gm)	Straw yield (ton/ha)	Grain yield (ton/ha)
N_0	8.67c	0.47	74c	19.5c	20.66d	3.996c	2.39 c
UDP-hand	15.07ab	0.60	98.55a	22.73a	22.67ab	6.32 ab	5.49a
SRP-Battery	11.87 b	0.20	86.30b	19.97b	21.67bc	4.80b	4.52b
PU- applicator	17.20 a	0.20	96.87a	20.77ab	23.33a	7.28a	5.82a
Injector	13.67 b	0.27	94.57ab	20.63b	21.33c	7.08a	5.75a
SRP	17.13 a	0.47	90.03ab	21.22ab	21.67bc	6.45ab	5.28a
PU-broadcast	11.67 b	0.74	89.50ab	21.30ab	22.67ab	6.22ab	4.28b
LSD value$_{(0.05)}$	3.263	NS	9.04	1.85	1.18	1.64	0.707
CV (%)	14.07	111.69	5.65	4.98	2.98	15.30	8.30

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.
Here, N_0 = Control; UDP-hand = Deep placement of urea briquette by hand; SRP-Battery = Deep placement of urea briquette by battery-powered applicator; PU- applicator = Prilled urea deep placement by BRRI applicator; Injector = Deep placement of urea briquette by injector applicator; SRP = Urea briquette deep placement by push- type applicator; PU-broadcast = Prilled urea application by broadcast method

Correlation between soil Ammonium and Grain Yield

In order to examine the relationship between yield and soil ammonium concentration, a correlation analysis was done. Grain yield was significantly correlated with the soil ammonium concentration 1st day after application (R=0.77**). Similar significant correlations were observed between the grain yield and soil ammonium concentrations on 2nd day after application (R= 0.72**), 3rd DAT(R= 0.65**), 4th days after application (R=0.71**). The above observation of the present experiment correlation analysis indicates that the rice yield was significantly correlated with the soil ammonium concentration. A negative relationship was found between rice yield and standing water ammonium concentration and it indicates that rapid dissolve of large amounts of urea in standing water could not show a positive impact on increasing rice yield (Figure 02 and Figure 03).

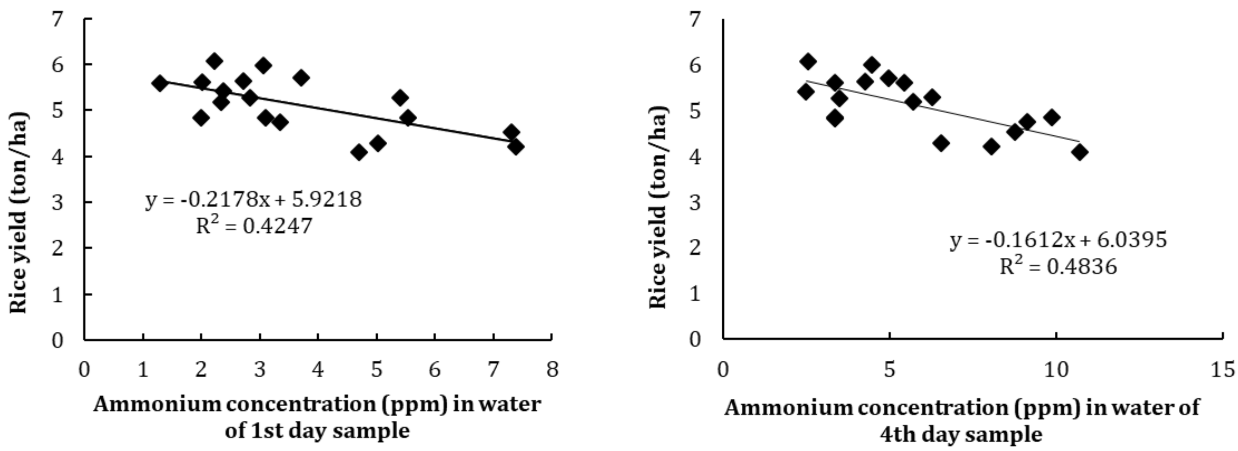

Figure 02. Relationship between grain yield and water ammonium concentration in 1st and 4th DAT.

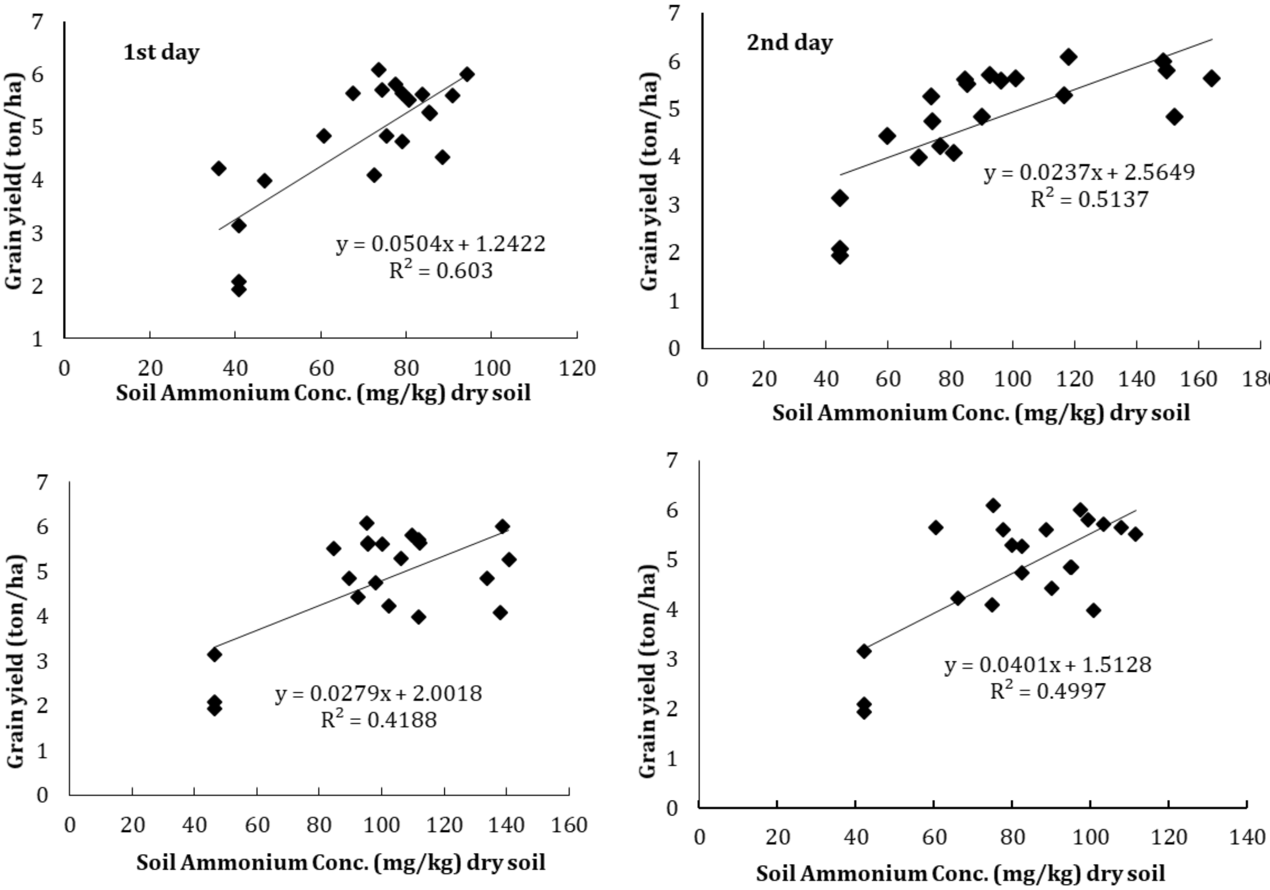

Figure 03. Relationship between grain yield and soil ammonium concentration in 2nd DAT

V. Conclusion

The higher water ammonium levels were found in SRP-Battery and PU-broadcast treatment compared to other treatments. The highest levels of soil- ammonium concentrations were found in PU- applicator where prilled urea deep placed by BRRI applicator. The highest number of effective tillers hill^{-1}, thousand-grain weight, grain and straw yields were obtained in PU- applicator. Significant correlations were observed between the grain yield and soil ammonium concentrations. Prilled Urea- applicator was found as a suitable urea application method, increasing rice yield.

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