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Improvement of BRRI USG applicator

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Abstract

BRRI USG applicator was re-designed for incorporating the adjustable mechanism with the facility of 18, 20 and 22 cm line to line spacing transplanted rice field. Design the modified applicator using AutoCAD Programming tools. To reduce the total weight of the applicator, skid and drive wheels were converted from metallic to plastic materials. Prototype was fabricated in the Farm Machinery and Postharvest Technology (FMPHT) divisional research workshop. Length and width of the skid was critically selected 81.00 and 12 cm respectively that was 92 cm length excluding furrow covering device in the first version. In the modified version, covering device was attached to the close vicinity (16.0 cm) of granule dispensing path to overcome the problem of 1st version of granule displacement due to water flows. Because of plastic materials using, total weight is reduced from 10 kg to 7.5 kg. The field capacity and dispensing efficiency of the modified applicator was found 32.5 decimal/hr and 99% respectively which is almost similar with previous applicator. Average depths of placement of the granule were 5-6 cm for both type applicator whereas 4-5 cm for manual placing. Fertilizer dose was varied with three adjustments. Normally 168 kg urea for Boro and 112 kg urea for Aman season is recommended as granules form. In 18, 20 and 22cm adjustment, 187, 168 and 153 kg fertilizer per hector was delivered in the field respectively whereas 168 kg is recommended using 2.7gm size granules. On the other hand, 125, 112 and 102 kg fertilizer was delivered per hector for three adjustments respectively using 1.8 gm size granules.

Key words: USG applicator, Urea mega granule, field capacity and dispensing efficiency

1. Introduction

Nitrogen is one of the major essential nutrient elements for crop production. In Bangladesh, rice is the main staple food crop. It covers about 80% of the total cropped area of the country (AIS, 2008). Farmers use fertilizer to increase the yield of crops. Farmers of Bangladesh, use urea as a source of nitrogen of which major portion is imported. The government of Bangladesh has set a target to procure some 15 lakh tones of urea out of total demand of 25 lakh tones ahead of the Boro season of 2012-13 fiscal year (2012, BSS). Annual requirement of urea of the country is about 28 lakh ton of which 50% is met by the domestic production. The rest amount of urea needs to be imported by spending a large amount of foreign currency (BBS, 2008). Farmers apply urea in rice field mainly on the soil surface. As urea is a highly water-soluble and quick release fertilizer, its application to the soil surface may result in a significant loss in various ways (as ammonia volatilization, nitrification, de-nitrification, surface run-off and leaching) thus, reducing its efficiency. It is reported that the efficiency of urea nitrogen in wetland rice is only about 30% of the applied urea and even less in many cases (Prasad and De Datta, 1979). However, the nature and magnitude of nitrogen loss largely depends upon the sources of nitrogenous fertilizer and its methods of application. Rymar et al. (1989) reported that slow release fertilizers i.e., nitrogen as encapsulated urea, granular oxamide and oxamide powder are more effective than the conventional fertilizers as ammonium sulphate or urea. On the other hand, the efficiency of granular urea is more than prilled urea because of slow releasing. Deep placement of USG in rice field instead of broadcasting of conventional prilled urea can increase the efficiency of applied nitrogen by improving absorption to a certain extent. Thus, the total requirement of urea of the country can be reduced which will ultimately save our foreign currency needed to import urea. On the other hand, USG is now easily available to the farmers. But, the deep placement of USG/UMG by hand after transplanting is a slow field operation thus require much time and labor. The time and labor intensiveness, drudgery of placing manually have seriously limited the adoption of USG/UMG by rice farmers. To overcome the problem of hand placement of the USG/UMG granules, a manually operated applicator was developed by BRRI which has some limitation of total weight, proper placing and covering and fabrication of different

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components. Under the present circumstances, an initiative has been taken to improve the existing USG applicator with the following objectives.

Objectives

- To improve the BRRI USG applicator with adjustable mechanism
- To modify the covering mechanism of BRRI USG applicator.
- To re-design the drive wheel and skid for using plastic materials
- To observe the performance of developed BRRI USG applicator.

2. Materials and Methods

BRRI USG applicator was re-designed for incorporating the adjustable mechanism with the facility of 18, 20 and 22 cm line to line spacing transplanted rice field. To reduce the total weight of the applicator, skid and drive wheels are converted from metallic to plastic materials. Prototype was fabricated in the Farm Machinery and Postharvest Technology (FMPHT) divisional research workshop. Design the modified applicator using AutoCAD Programming tools and Prototypes was fabricated in the FMPHT divisional research workshop.

2.1 Design considerations for improvement of the BRRI USG Applicator

Improvement was done on the adjusting mechanism of the applicator. During design, the following criteria were collected:

- Ease of adjusting
- Minimum time of adjusting
- Ease of operations

Skid, covering mechanism and drive wheel of the USG Applicator were re-designed using plastic materials and converted from metallic to plastic one. AutoCAD Program was used to design the Skid and drive wheel. During design, the following criteria were taken in consideration:

- Enough strength for muddy soil
- Ease of operations
- Proper coverage of the dispensed granules

2.2 Performance test of the improved applicator

Improved prototypes of BRRI USG applicator was tested using urea mega granules (UMG: 2.7gm) in both laboratory and field condition to observe the performance. During test, the following data were collected:

- USG/UMG dispensing efficiency (%)
- Depth of placement (cm)
- Accuracy of placement between rows (%)
- Walking speed (km/hr)
- Field capacity (ha/hr)

2.3 Design of the improved applicator

The applicator was designed with the help of AutoCAD engineering tools considering the design consideration. The complete design view of the modified version is given in Fig. 1.

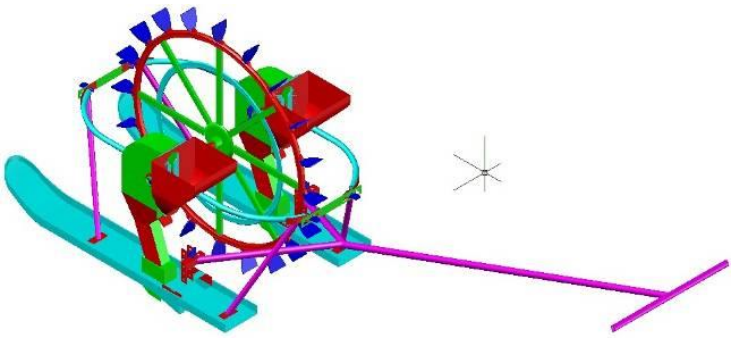

Fig. 1. BRRI modified USG Applicator

2.4 Metering device

In both 1st and modified version of the applicator, cup type metering device was used to collect USG/UMG from tank and dispense to the output channel. The outer diameter of the metering plate is 17.9 cm. Five cups is used in each round plate considering the diameter of the drive wheel. Diameter and depth of the holes of the cup were maintained 2.0 cm and 0.5 cm respectively based on size and diameter of the granules (Fig. 2). Metering device was connected directly to the drive wheel.

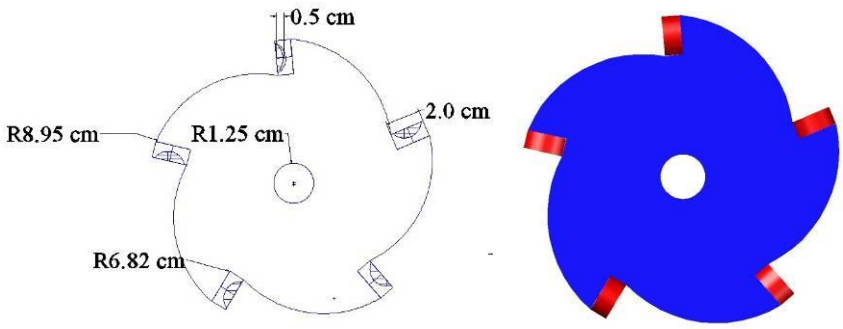

Fig. 2. Metering plate of the modified applicator

2.5 Granule tank

Granules holding tanks of the applicator were designed to supply the granules to the cups of the metering device properly considering the angle of repose of the USG granules. Angle of repose of the USG granules (2.7 gm size) was found 30 degree. The angle of inclination and length of the sliding side, height and width of the tank was 46 degree, 22 cm, 18 cm and 15 cm respectively (Fig. 3). Granule tank is same in both type applicators.

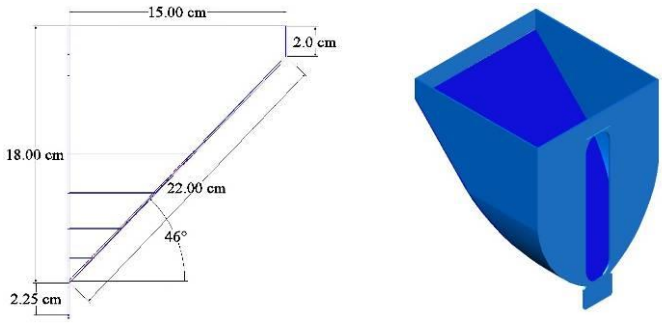

Fig 3. Side and isometric view of the granules tank

2.6 Skid

Penetration of the applicator was protected due to use of skid and helps to skidding. As per design, drive wheel and skid was made by plastic materials. In the first version, metallic skid was used for operating in the muddy filed. Total weight was more, size was large and fabrication in the workshop was difficult of the skid of 1st version. The skid was re-designed based on cone penetration resistance of the soil. Length of the skid was reduced critically from 100.00 cm to 81.00 (Fig. 4).

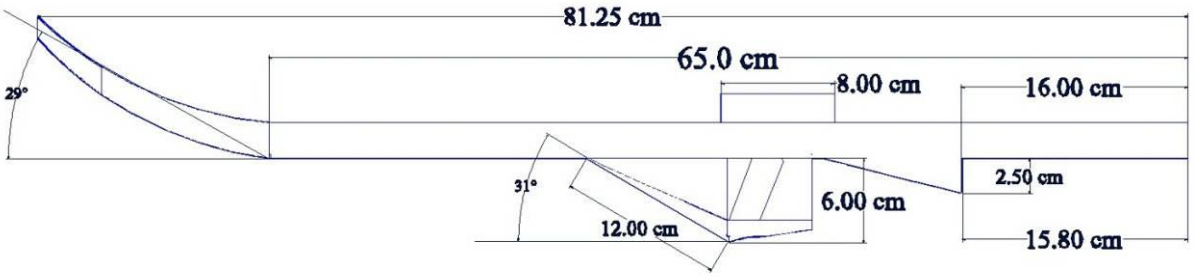

Fig 4. Side view of the skid and furrow opener of the modified applicator

29 degree skidding angle was used in the apex of the skid. Furrow opener of the applicator was connected at the bottom of the skid maintaining the sliding angle 31 degree. Height (6.0 cm) and length (12.0 cm) of the sliding side of the furrow opener was designed in such way that the granules dispensed easily to the field without clogging and protected muddy soil from entering into the opener (Fig. 4).

2.7 Furrow covering mechanism

Additional plate was added as covering device at the rear of the skid in the first version. Depth of the covering device was maintained 4.5 cm which was shorter than the depth of USG placement into the soil. As a result, the placed granules were not disturbed by the covering device. But there was problem of entering water into the furrow before covering. The water flows displaced the placed granules before covering. Considering this problem, covering device was used at the vicinity of the granule dispensing path (Fig. 5). The distance between covering device and granule dispensing path is 16.0 cm which was 35.0 cm in the first version. As a result, dispensing granule is not displaced from the point by counter water flow.

2.8 Driving wheel

As per design, drive wheel was made by plastic materials. The comparative view of the drive wheels is given as follows. Because of plastic conversion, it is easy to fabrication, more durable and less weight compare to metallic one which untimely helps to reduce total weight of the applicator (Fig. 6).

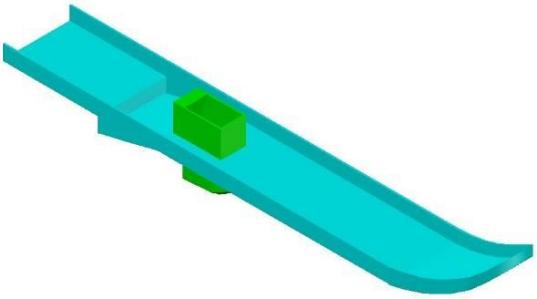

Fig 5. Plastic made Skid of the modified applicator

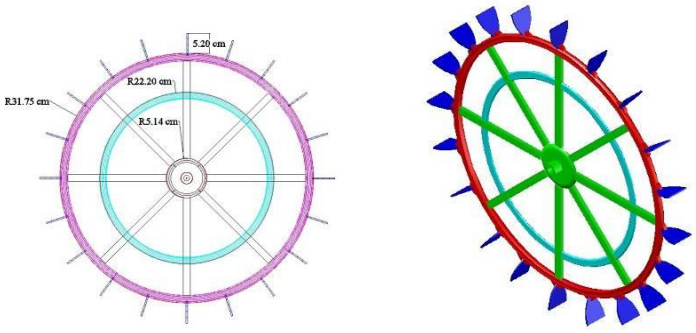

Fig 6. Plastic made drive wheel of the modified applicator

2.9 Fabrication of the applicator

As per design, the applicator was assembled in the divisional workshop. Total weight of the applicator was reduced from 10.0 kg to 7.5 kg. As a result, it was found suitable to carry to the field, turning at the end of field and operating in the muddy field. Complete views of the modified and 1st version of applicator are shown in Fig 8 & 9.

2.10 Applicator operation

There have three options to adjust the spacing of the applicator considering the line to line distance of the transplanted rice. Two nuts of the main axle, four nuts of the frame and two nuts of the handle have to be adjusted among the three options of 18 cm, 20 cm or 22 cm considering the existing line spacing of the transplanted rice before field operation (Fig. 7). Handle height also have to be adjusted in such way that the operator feels comfort to operate the applicator and covering device remain in contact with the soil horizontally. It is always operated by pushing force. If it is pulled during operation, the dispensed channel becomes blocked by muddy soil. As a result, granule will not be placed.

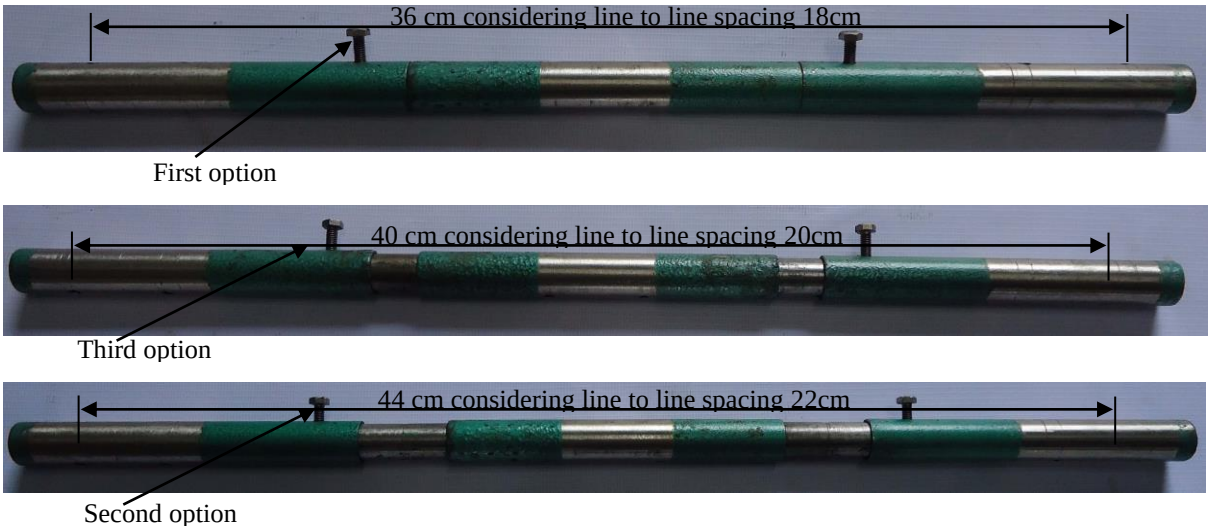

Fig. 7. Three options in the main axle to adjust the width of the applicator

2.11 Complete view of the fabricated applicator

As per design, the applicator was assembled in the divisional workshop. Total weight of the applicator was reduced from 10.0 kg to 7.5 kg. As a result, it was found suitable to carry to the field, turning at the end of field and operating in the muddy field (fig. 8 & 9).

Fig.8. BRRI modified USG Applicator

Fig.9. BRRI USG Applicator (1st version)

3. Results and discussion

3.1 Laboratory test of the improved applicator

During test, applicator was setup at upper position in such a way that the drive wheel moves easily. Two third portion of the tank was filled with granule. The drive wheel was rotated for 20 times continuously at normal speed and then the dispensed granules were collected from the bottom of the output channel. Dispensing efficiency was calculated by counting the number of dispensed granule. In laboratory test conditions, dispensing efficiency was found around 99 percent. The result of the laboratory test is given in table 1.

Table 1. Laboratory tests result of improved applicator, 2012

No. of trial	Number of rotation	Number of UMG dispensed	% of dispensed UMG
1	20	102	100
2	20	100	100
3	20	97	97
4	20	98	98
5	20	99	99
6	20	100	100
Average			99

3.2 Field test of the improved applicator

Modified BRRI USG was operated in BBRI Gazipur research plot to observe the performance and compare with tradition placement method of USG. Field capacity of the modified version also compared with the previous version of BRRI USG Applicator.

During field operation of the applicator, average walking speed of the operator was found 1.90 km/hr for modified applicator, 1.75 km/hr for 1st version. Field capacity were about 32.5 decimal/hr and 31.8 decimal/hr for modified and first version applicator respectively whereas manual USG application capacity was found 4.5 decimal/hr. Average depth of placement of the granule were 5-6 cm for both type applicator and 4-5 cm for manual placing (Table 2).

Table 2. Field performance of the improved Applicator, 2012

Items	BRRI USG Applicator (adjustable type)	BRRI USG Applicator (fixed type)	Traditional application
Time of application[1], min	43	41	133
Area covered, decimal	25	25	10
Walking speed, km/hr	1.90	1.75	-
Field capacity, decimal/hr	32.5	31.80	4.5
Depth of of placement, cm	5-6	5-6	4-5
Wt. of dispensed USG, Kg/ha	165	168	165

[1] Time of operation is the total time including turning, USG filling, machine setting and other losses.

Fertilizer dose was varied with different adjustment. Normally 168 kg urea for Boro and 112 kg urea for Aman season is recommended as USG form. There are possibilities of under and over dose of fertilizer for 18 and 22 cm adjustment respectively. Therefore it is recommended to use the applicator for standard 20 cm line to line spacing.

Table 3. Amount of dispanced granules for three different adjustment of the improved applicator

Season	Recommended size of granules	Spacing 18 cm x 20 cm	Spacing 20 cm x 20 cm	Spacing 22 cm x 20 cm
Boro	2.7 gm	187 kg	168 kg	153 kg
Aman	1.8 gm	125 kg	112 kg	102 kg

4. Conclusion

Modified USG applicator was re-designed, fabricated and tested with adjustable facilities for 18 cm, 20 cm and 22 cm line to line and 20 cm plant to plant spacing. The depth of placement was 6-7 cm. The weight and average field capacity of the modified USG applicator is about 7.5 kg and 32.5 decimal/hr respectively. Urea fertilizer was saved 112 and 55 kg/ha using the applicator in Boro and Aman season respectively. The labor of 7 man-day/ha was also saved. The modified applicator is suitable to place USG in the line transplanted rice field.

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