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Evaluation of a Versatile Multi-Crop Planter to Establish Sprouted Direct-Seeded Rice

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Abstract

Mechanization is rapidly being taken up by smallholders in South Asia, but there are still few options for mechanized planting, especially for the adoption of conservation agriculture (CA). A Versatile Multi-crop Planter (VMP) was recently developed for mechanized planting when attached to a 12-16 hp two-wheel tractor (2-WT), but its performance for crop establishment still needs more evaluation. This experiment was conducted to estimate the damage of radicle and plumule of sprouted seeds during mechanized sowing. The seed treatments were: dry seed (T1); soaking overnight (T2); soaking overnight and 24 hours incubation (T3); soaking overnight and 48 hours incubation (T4); and soaking overnight and 72 hours incubation (T5). The fluted type seed meter was used to dispense incubated seed in strip tillage condition in dry soil. Plumule and radicle were not broken and whole seed was also not damaged. Except in *Aman* season, radicle length of 72 hrs incubate seed was longer than others. In some cases, tip of radicle was broken but total radicle was not detached from the seed during dispensing through the fluted type seed meter. Seedling emergence was not significantly affected by incubation although, same seed rate was used in both seasons. Tiller mortality was higher in *Aman* season compared to *aus* season. At maturity, total tiller and effective tiller was not significantly affected by incubation period. In *aus* season, incubation period under investigation had shown a wide range of variability among them in respect of grain yield but in *Aman* season, no significant variation was observed on grain yield. Sprouted seed has no effect on the crop duration but takes longer time to sprout. Partly broken plumule in *Aman* season has no effect on grain yield. Sprouted seed has no yield advantage over non-sprouted seed indicating that flute type seed meter safely dispensed sprouted seed.

Key words: Planter, Radicle, Plumule, Seedling emergence, Strip tillage, Yield

1. Introduction

Wet and dry seeding methods are often referred to as direct seeding (Pandey and Velasco, 1999). Wet seeding refers to sowing of pre-germinated seeds in wet and puddle soils. Most of the developed countries establish rice by wet seeding bec*aus*e of high wages and scarcity of labour (Smith and Show, 1996). Farmers in developing countries have increasingly adopt wet seeding bec*aus*e of the migration of farm labour to non-farm jobs and the consequent labour shortage and high wage rates for manual transplanting (Ho, 1995 and Pandey, 1995). Seeds may be broadcasted in rows on dry/moist/puddle soil, whereas only broadcasting is used for seeding on water (Balasubr*Aman*ian and Hill, 2002). Satter and Khan (1994) reported that direct-wet-seeded rice was grown initially under saturated condition and they could withstand drought better. In Bangladesh, direct seeding using either broadcast or line sowing gave significantly higher grain yield than transplanting under proper management (Elahi *et al.,* 1997 and Hussain *et al.,* 2000). Khan *et al.* (2001) and Balasubr*Aman*ian *et al.* (2003) reported that dry-seeded rice on flat land with reduced or zero tillage produced rice yields similar to higher than that of transplant rice on puddled soil. Santhi (1999) reported that crop established through broadcasting of sprouted seeds had 7 days earlier flowering than a transplanted crop. The crop sown in line manually using sprouted seeds had 7 day earlier flowering than transplant crop in both dry and wet season. The delay in flowering by around a week in transplanted rice might be due to pulling and transplanting shock of rice seedlings. Islam (2008) observed that radicle and plumule length was increased with the increase in incubation period and seed rate was reduced when sown by drum seeder with incubated seed. Islam (2008) also reported that significantly higher grain yield was obtained with 96 hours incubate seed. However, insignificant difference was observed among 24, 48 and 72 hours incubate seeds.

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Many machines have been developed in rice-growing countries and international institutes suitable for direct seeded rice (DSR). Rickman *et al.* (1999) reported that crop lodging is a significant problem in dry seeded rice in Cambodia, particularly with traditional varieties with full conventional tillage systems but machine drilling of seeds could reduce lodging to less than 10%. Chinese engineers have developed a two-wheel tractor operated seeder that provides tillage, seeding and leveling in one operation (Hobbs *et al.,* 1997). The main components were shallow rotovator, six-row seeding system and soil compaction roller. Bell *et al.* (1999) evaluated several commercial seeder systems for reduced and zero-tillage seeding of rice, including the Chinese seeder, and reported that rice seed flow was a problem for the tractor-mounted seeders. Residue management was difficult for the tyne based no tillage systems, as none of the seeders had trash cutters. Many of the seeders required a well-leveled and relatively clean surface to work properly. For the small farm holders, the Versatile Multi-crop Planter (VMP) was developed to overcome some of the DSR constraints (Islam *et al.,* 2010 and Haque *et al.,* 2011). The VMP has facilities to sow seed and place basal fertilizer simultaneously in a single pass operation under different tillage systems. To obtain the direct-seeded rice establishment benefits, the VMP was evaluated to assess the performance of sprouted rice seed sowing. Therefore, the present study was undertaken to estimate the damage of radicle and plumule of sprouted seeds during mechanized sowing and to determine the optimum seed incubation period for seeding by planter.

2. Materials and Methods

This experiment was conducted in a farmer's field, Godagari, Rajshahi during *aus* 2010 and *Aman* 2010. The seed treatments were: dry seed (T_1); soaking overnight (T_2); soaking overnight and 24 hours incubation (T_3); soaking overnight and 48 hours incubation (T_4); and soaking overnight and 72 hours incubation (T_5). The treatments combinations were arranged in a randomized complete block (RCB) design with three replications. Seeds were cleaned by immersing them in clean water and removing the floated seeds. Seeds were soaked in tap water. Equal dry weights of uniform seeds were put into fresh water, soaked overnight and removed from water in the morning. The soaked rice seeds were kept in gunny bags at an ambient temperature for incubation. During *aus* season, seeds of *BRRI Dhan42* were soaked with fresh water in the evening on 25, 26, 27 and 28th April, 2010 and removed from water in the next morning. Presoaked seeds were kept in a gunny bag for incubation upto 26, 27, 28 and 29th April, 2010. During *Aman* season, seeds of *BR11* were soaked with fresh water in the evening on 14, 15, 16 and 17th June, 2010 and removed from water in the next morning. Presoaked seeds were kept in a gunny bag for incubation upto 15, 16, 17 and 18th June, 2010. Before sowing, seeds were removed from the gunny bag and air dried in the shade for two hours. The length of plumule and radicle was measured from 15 randomly selected rice seeds in all treatment samples. Slide caliper was used to measure the length of plumule and radicle from their junction with the seed. Dry weight of all rice seeds having germination over 95% were taken and put into fresh water for soaking. Final weight of the incubated seeds was taken after completion of incubation. Seeds were sown in dry land in strip tilled condition by VMP as it was appeared as a fuel saving tillage technology in crop production (Islam *et al.*, 2010). In *aus* season, *BRRI Dhan42* was sown on 29th April, 2010 and in *Aman* season BR11 was sown on 18th June 2010. Pressing roller attached with VMP was used to cover the seed (Photo 1). Before seeding, flute type seed meters were calibrated for each treatment to get the recommended and uniform seed rate. Seeds were poured into the hopper. In each trial, sample was collected from the seed dispensing tube in polythene bag from 10 revolution of drive wheel. Sample seeds were spread on a sheet to count the damaged seeds and taken weight. Uniform seed rate in each flute type seed meter was maintained by adjusting gap of seed meter. Seed adjusting level was placed in such a position to get recommended rate. The seed rate of different types of seed for seeder machine was calculated using the following formula.

$$\text{Seed rate, kg ha}^{-1} = \frac{\text{Seeds obtained by 10 revolution of drive wheel, g}}{\text{Width of seeder, m} \times \text{Circumference of drive wheel, m}} \quad (1)$$

Photo 1. Planter in operation for seeding sprouted seed

In *aus* season, rice was grown after harvesting potato. Farmers usually use excess fertilizers in potato cultivation. Farmers did not apply basal or top dressed fertilizer after potato cultivation to grow *aus* rice. In *Aman* season, fertilizers were applied at 175, 80, 110, 100 and 10 kg ha^{-1} as urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. Irrigation water was applied to the plots just after sowing of sprouted seeds. In *aus* season, land was irrigated at night and excess water was drained out in the morning due to high ambient temperature. Some crops were damaged due to high water temperature in *aus* season. Subsequent irrigations were applied as when required uniformly in all plots. In both seasons, irrigation water was applied five times in all the plots. In *Aman* season, non-selective herbicide roundup (glyphosate) was applied @ 7.5 l ha^{-1} one day before seeding in all the plots. In *aus* season, pre-planting herbicide was not used and the weed infestation was severe in all plots. Hand weeding was done on 26 days after seeding (DAS) to keep the field weed free. During *Aman* season, weed infestation was less due to application of pre-planting herbicide. In addition, hand weeding was done twice at 35 and 60 DAS. Insecticide was not applied during *aus* season. During *Aman* season, however, insects were controlled by a single application of Basudin 10G at vegetative stage. Number of tillers in the selected area was counted at each growth stage. Tiller mortality was calculated based on successive tiller count data as:

$$\text{Tiller mortality,\%} = \frac{(\text{Maximum number of tillers m}^{-2} - \text{No. of panicles m}^{-2})}{\text{Maximum number of tillers m}^{-2}} \times 100 \qquad (2)$$

Grain yield was recorded from pre-selected 10 m^2 area and was adjusted to 14% moisture content. Panicle number in each unit area was counted to determine the panicle number per m^2. Border areas of all sides of the plot were excluded from samples to avoid edge effects. A simple economic analysis was done based on total production. Production cost included rental charge of the land and input cost. Price of the produce was collected from the local markets to compute total production cost, gross return, gross margin and benefit-cost ratio. Statistical analysis as a one way analysis of variance was done according to Gomez and Gomez (1984). Data were analysed by using statistical software Mstat-C. Means were compared with least significant difference (LSD) test.

3. Results

3.1 Effect of incubation period on plumule and radicle elongation

Radicle length was increased with days of incubation in both season (Table 1). Radicle length was longer in BR11 than in BRRI Dhan42.

3.2 Effect of incubation period on seed damage

Breakage was not observed in plumule, radicle and whole seed due to rotation of seed metering device. Except in the *Aman* season, in the case of 72 hrs of incubation, very few radicles were broken from the tip due to rotation of seed metering device. Moreover, the whole radicle was not detached from the seed contact.

Table 1. Effect of incubation period of seeds on radicle and plumule growth and weight increased after incubation period

Soaking and incubation period	Plumule (mm)		Radicle (mm)		Weight increased (%)	
	Aus (BRRI Dhan42)	*Aman* (BR11)	*Aus* (BRRI Dhan42)	*Aman* (BR11)	*Aus* (BRRI Dhan42)	*Aman* (BR11)
Dry seed (T_1)	-	-	-	-	-	-
Soaking overnight (T_2)	-	-	-	-	19.0	4.2
Soaking overnight and 24 hours incubation (T_3)	1.5	1.5	3.0	2.1	38.0	5.8
Soaking overnight and 48 hours incubation (T_4)	2.5	2.5	8.7	7.1	50.0	5.8
Soaking overnight and 72 hours incubation (T_5)	3.0	3.0	11.1	21.2	40.0	8.3

N.B. Values are the means of three replicates

3.3 Effect of incubation period on seedling emergence

Seedling emergence at different DAS is given in Fig. 1-2. Seedling emergence started from 7 DAS. In *aus* season, seedling emergence was significantly affected by seed incubation.

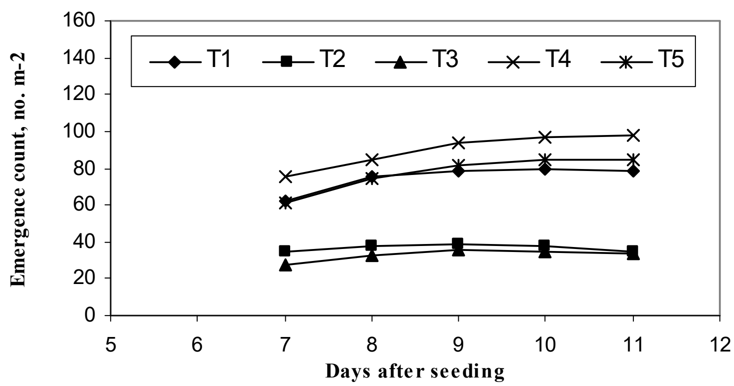

Fig. 1a. Effect of incubation period on seedling emergence in *aus* season

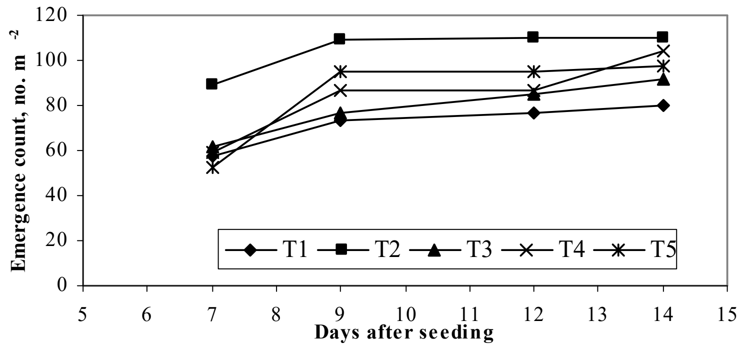

Fig. 1b. Effect of incubation period on seedling emergence in *Aman* season

3.4 Effect of incubation period on agronomic performance of rice

3.4.1 Tillering dynamics

In *aus* season, tillering pattern followed increasing trend upto 50 DAS and then decreased gradually due to tiller mortality (Fig. 2a). Maximum tiller (487 m^{-2}) was produced at 50 DAS in dry seed. At maturity, incubation period had no effect on tiller production. In *Aman* season, tillering pattern followed the increasing trend upto 75 DAS. Tiller production was not significantly affected by incubation period throughout the production cycle. Maximum tiller (597 m^{-2}) was observed in 24 hrs incubated seed. Tiller production decreased gradually after 75 DAS due to tiller mortality (Fig. 2b). At maturity, incubation period did not give significant effect on tiller production.

3.4.2 Tiller and panicle production

Tiller and panicle production at maturity stage is shown in Table 2. Incubation of seed did not significantly affect tiller production and panicle intensity at maturity stage. The highest tiller was produced in dry seed followed by 24 and 48 hr incubation of seed in *aus* season. In *Aman* season, the highest tiller number was produced in dry seed followed by 24 and 48 hr incubation seed. There was no statistical difference on panicle intensity among the treatments in both the seasons. In *aus* season, the highest number of panicle was observed in dry seed (381 m^{-2}) followed by 48 hr (319 m^{-2}) incubation of seed. Lowest panicle number was obtained in 24 hr incubation of seed. In *Aman* season, the highest number of panicle was observed in 72 hrs (256 m^{-2}) incubation seed followed by 48 hr (232 m^{-2}). Panicle intensity was the lowest (193 m^{-2}) in dry seed.

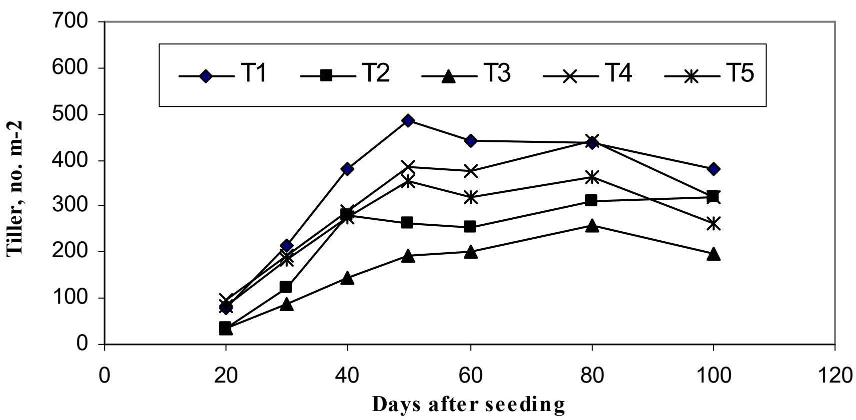

Fig. 2a. Effect of incubation period on tiller production of *aus* rice

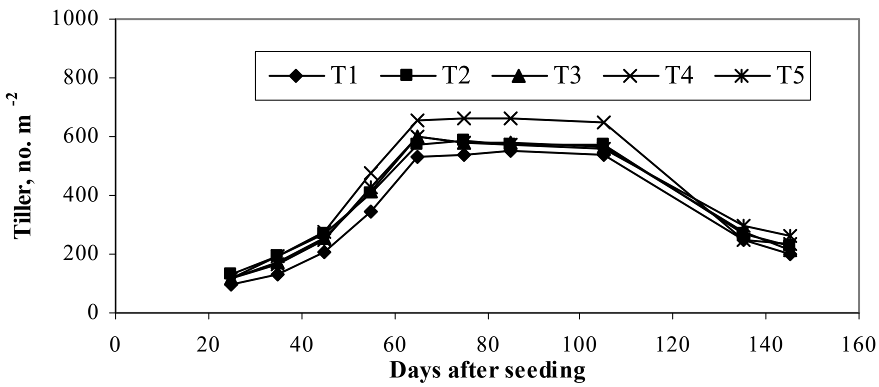

Fig. 2b. Effect of incubation period on tiller production of *Aman* rice

3.5 Grain yield

Grain yield of *aus* and *Aman* rice is shown in Table 3. Irrespective of seed incubation period, crops were matured in 100 days in *aus* season. Grain yield was significantly affected by incubation period. The highest grain yield was obtained in 72 hrs incubation seed. There was no statistical difference on yield between dry seed and 72 hrs incubation seed. It was also noticed that there was no statistical difference among 24 hr soaked seed, and 24 and 48 hr incubated seed. In *Aman* season, irrespective of incubation period, crops were matured in 145 days.

Table 2. Tiller and panicle production in *aus* and *Aman* rice as affected by different soaking and incubation period

Treatment	Tiller (no. m^{-2})		Panicle (no. m^{-2})	
	Aus	*Aman*	*Aus*	*Aman*
Dry seed (T_1)	298	198	250	193
Soaking overnight (T_2)	256	230	223	213
Soaking overnight and 24 hours incubation (T_3)	227	217	207	206
Soaking overnight and 48 hours incubation (T_4)	288	234	273	232
Soaking overnight and 72 hours incubation (T_5)	248	259	211	256
CV (%)	11.3	19.6	11.7	21.4
$LSD_{0.05}$	NS	NS	NS	NS

N.B. Values are the means of three replicates

Table 3. Grain yield of *aus* and *Aman* rice

Treatment	*Aus* (t ha^{-1})	*Aman* (t ha^{-1})
Dry seed (T_1)	3.52	4.24
Soaking overnight (T_2)	2.48	3.25
Soaking overnight and 24 hours incubation (T_3)	2.25	3.31
Soaking overnight and 48 hours incubation (T_4)	2.9	3.94
Soaking overnight and 72 hours incubation (T_5)	3.80	3.57
CV (%)	10	12.4
$LSD_{0.05}$	*	NS

N.B. Values are the means of three replicates

3.6 Economic analysis

Table 4 showed the economic productivity of sprouted seed from land preparation to harvest operations including transportation. Seed, fertilizer and irrigation water was applied equally in all the plots. Variable costs were similar in all the treatment plots due to equal inputs. In *aus* season, gross margin was the highest in 72 hrs incubation of seed and lowest in 24hrs soaked seeds. The gross margin for 72 hrs incubation and dry seed was the highest due to the highest grain yield compared with other treatment. BCR was the highest in 72 hrs seed incubation and lowest in 24 hrs incubation. In *Aman* season, gross margin was the highest in dry seed and lowest in 24hrs soaked seeds. The gross margin for dry seed and 48 hrs incubation was the highest due to the highest grain yield compared with other treatment. BCR was the highest in dry seed and lowest in 24 hrs incubation.

Table 4. Economic productivity of rice as affected by seed incubation period

Treatment	*Aus*			*Aman*			BCR	
	Variable cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Gross margin ((Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Gross margin ((Tk ha^{-1})	*Aus*	*Aman*
T_1	41,162	64,319	23,157	45,330	76,839	31,509	1.56	1.70
T_2	40,937	44,304	3,367	45,099	58,898	13,799	1.08	1.31
T_3	40,919	42,745	1,826	44,993	59,985	14,992	1.04	1.33
T_4	41,006	52,790	11,783	45,141	71,402	26,262	1.29	1.58
T_5	41,055	68,845	27,791	44,573	64,697	20,124	1.68	1.45

N.B. Values are the means of three replicates

4. Discussion

During *aus* and *Aman* season, plumule length of incubated seed did not increased as radicle with the incubation period. Similar results were obtained by Islam (2008). During *aus* season, some seeds might be placed deeper and buried under soil c*aus*ing poor seedlings emergence. Similar results were reported by Yoshida (1981) and Islam (2007). The highest emergence was found with 48 hrs of incubation (98 no. m^{-2}) at 11 DAS. In *Aman* season, the effect of seed incubation on seedling emergence was insignificant although few radicles were broken from the tip due to rotation of seed meter. Partly broken radicle did not restrict the seedling emergence. Seedling emergence indicated that flute type seed meter satisfactorily dispensed incubated seed without damaging plumule, radicle and whole seed. Tiller mortality was higher in *Aman* season than *aus* season. It might be due to varietal difference and sometimes mortality depends on water management. Partly broken radicle in *Aman* season has no effect on grain yield. Grain yield was not significant among the incubated seed. Islam (2007) also observed that seed incubation had no significant effect on grain yield.

5. Conclusion

Incubate seed required more days to sprout but matured the rice crops in the same duration. Sprouted rice seed did not reduce the field duration and could not provide yield advantage over non-sprouted seed. It can be concluded that sprouted rice seeds can be dispensed safely through the seed meters of VMP with no significant damage of radicle and plumule.

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