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Effect of seedbed solarization on plant growth and yield of two rice varieties–BR11 and BRRI Dhan33

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Abstract

An experiment was carried out at RDRS Farm in Rangpur during the 2014 T. aman rice season to determine the impact of seedbed solarization on plant growth and yield of rice varieties, BR11 and BR33. Solarization was achieved by covering the seedbeds with transparent polythene sheet for four weeks prior to sowing. Seedlings of both varieties were raised on solarized and non-solarized seedbeds and later transplanted into the main field for comparison of growth and yield. Emergence, seedling height and weight, root length and weight were higher with seedlings raised on solarized seedbeds compared to seedlings from non-solarized seedbeds. Also root knot nematode galls decreased significantly on seedlings from solarized seedbeds compared to those from non-solarized seedbeds for both the varieties tested. The increase in height and weight of solarized seedlings enabled easy access for uprooting and transplanting seedlings in the main field within the recommended 20-25 days after sowing. When transplanted in untreated main fields, plants grown from the solarized seedlings of both the rice varieties had significantly less infestation of stem borer as compared to non-solarized plants. Grain yields obtained from solarized seedlings were 7% higher for BR11 and 9% higher for BR33 relative to normal seedlings.

Keywords: Soil solarization, Healthy seedlings, Rice yield

Introduction

Soil solarization is a method for controlling soil borne pest and diseases, which involves in-situ solar pasteurization of soil using transparent polythene sheet and solar heat. Solarization as a pre-treatment for pest and disease-free healthy crops was originally described by Katan *et al*. (1976). It is an alternative and inexpensive technique as compared to chemical soil disinfection methods. It is an eco-friendly management option to control soil borne pathogens and pests, since no pesticides are required. Soil solarization also has been found to suppress weeds, insect pests, to release some plant nutrients and to have a sustained effect of up to 2 years (Katan 1981; Horiuchi 1984; Elmore, 1991; Gerson *et al*., 1991; S.P. Banu, personal communication).

In Bangladesh, transplanted rice is a common practice under irrigated and lowland conditions. Widespread use of polythene for soil solarization of rice main fields is not likely to be economical. However, the technique could be of potential use on seedbeds to grow healthy rice seedlings. Although the recommendation for short duration rice varieties is to transplant young seedlings of 20–25 days in age, most farmers keep their rice seedlings in the seedbed up to 50 days. This delay is not only due to lack of awareness by farmers but also because of their dependence on water availability to prepare the land and on banks/NGOs to provide credit/funds to purchase fertilizers and other necessary inputs. Old seedlings are more likely to suffer transplant shock and/or become infected with soil borne pathogens resulting in diseased plants and low yields. On the other hand, farmers face problems in uprooting rice seedlings of short duration varieties within the recommended time due to their small size. Previous studies on solarization, (Baksh *et al*., 2004; Banu *et al*., 2005; Culman *et al*., 2006) indicate that rice seedlings from solarized seedbeds are larger and taller than normal seedlings of the same age. Thus farmers will be encouraged and feel comfort in uprooting seedlings of the recommended age from solarized seedbeds, because of adequate height, weight and vigour of the seedlings.

The level of pesticides Bangladeshi farmers use year after year to increase rice production and to control diseases and insects is quite high. The production cost is increasing although production is not increasing according the farmers' expectations. The solarization technology has scope to reduce chemical pesticides and input costs.

Summers in the rice growing areas of Bangladesh are generally hot especially in April and May when hot, dry and intense sunny weather is common. These conditions are favorable for effective soil solarization. During this season soil temperatures can be increased as high as 58°C within the top 10 cm under solarized conditions (Banu *et al*., 2005). Maintaining the soil at these high temperatures for 2 to 4 weeks essentially pasteurizes the soil thereby killing soil borne pathogens and weed seeds in the seedbed. Others have also noted that short term increases in nutrient availability occurs with solarization (Chen and Katan, 1980).

For the rice-potato-mungbean cropping pattern in Northwest Bangladesh, the mungbean crop is harvested in May, and short duration T. aman rice nurseries are sown in mid to late June in order to obtain seedlings for transplanting in July. Solarization for up to four weeks in May–June before sowing seed in the nursery is possible for soil disinfestation and controlling nematodes, fungi and weeds.

With these facts in view, the present study was undertaken to compare the effects of seedbed solarization on seedling height, plant growth and yield performance of two T. aman rice varieties used in Northwest Bangladesh.

Materials and Methods

The experiment was conducted in a field of RDRS Rangpur Farm during the 2006 Kharif season. BRRI Dhan33, a short duration variety (116–119 days), and BR-11, a traditional variety (140–145 days), were tested for their performances under two treatments viz, solarized seedbed and non-solarized (normal) seedbed. The experiment was laid out in a paired-plot design with five replications. The treatments were randomly assigned to the experimental plots for both the varieties tested. The seeds of these two varieties were obtained from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

The soil of the experimental site has a silt loam texture and is acidic in nature with a pH of 5.3. The experimental site was on medium highland and belongs to the Tista Meander Flood plain under agro-ecological zone-3.

The size of each seedbed was 2m × 1m. In between two beds, a distance of 50cm was maintained for proper drainage. One of the two beds in each replicate for a variety was solarized and the other was kept non-solarized as a normal seedbed. Prior to treatment the seedbed soil was lightly tilled and wetted to field capacity to promote deep soil heating. The seedbeds then were covered by transparent polythene sheets of approximately 0.03–0.05mm in thickness. The edges of the polythene sheet were buried in the soil to prevent loss of heat and moisture. The seedbeds under solarization remained covered for 28 days during which time weed seeds germinated but then quickly died as the temperature rose. By the end of the solarization period, the soil underneath the polythene sheet had turned black.

After four weeks of soil solarization, the polythene sheet was removed from the soil, and the beds were loosened and left for two days. Then both seedbeds (solarized and non-solarized) were prepared for seed sowing through proper irrigation and puddling. Pre-germinated seeds of BR-11 and BRRI Dhan33 were sown at the rate of 96 g/m^2 in both seedbed treatments on the same day.

Water was applied whenever necessary to the seedbeds to maintain normal growth of the seedlings. Transplanting of seedlings was done in the main field at the age of 25 days following the same experimental design and with the same number of replications as used for the seedbeds. An individual plot size in the main field was 5m × 5m. The seedlings were transplanted in hills at the rate of two seedlings per hill with hill to hill and row to row spacing of 15 and 25 cm, respectively. Recommended doses of fertilizers (Urea:100 kg/ha; Triple Super Phosphate: 37 kg/ha; Muriate of Potash: 50 kg/ha; Gypsum: 33 kg/ha; Zinc sulphate 2.50 kg/ha) were used and regular intercultural operations were done for normal plant growth.

Seedling data were recorded on number of seedlings/m^2, seedling height, seedling weight, root length, root weight and number of root galls/plant. The number of seedlings/m^2 was obtained from seedling counts in 0.25 m^2 quadrate placed randomly at three spots in each seedbed. Data on seedling height, seedling weight, root length, root weight and number of galls/plant were collected on 20 seedlings, which were uprooted randomly from each seedbed along with some soil to avoid root damage. Before taking notes on these parameters, the roots were washed gently in water contained in a bucket. Rice root knot nematode galls were counted from individual root systems using a hand lens. From the main field, data were recorded on number of stemborer/5m^2, plant height, number of tillers/hill, number of panicles/hill, number of filled grain/panicle, number of empty grain/panicle, 1000 grain weight and grain yield Stem borer infestation/5m^2 was recorded by counting the number of white heads in a 1 m^2 quadrate placed randomly in five spots in each of the plots. Plant height, number of tillers/hill and number of panicles/hill were recorded from 10 hills selected randomly in each plot. Number of filled and empty grains/panicle was based on counts from 10 panicles taken randomly from each plot. Grain was collected from five random samples of 1 m^2 harvested in each plots and the yields were adjusted to a standard 14% moisture content.

Results and Discussion

A significant increase in emergence and growth of seedlings and a reduction in the number of rice root knot nematode root galls were observed due to solarization of seedbed for the two rice varieties (Table 1). For BR-11, seedbed solarization brought about a 40% increase in the number of seedlings/m^2, a 57% increase in seedling height, a 152% increase in seedling weight, a 37% increase in root length and a 36% increase in root weight over the non-solarized treatment. The increases in those characters for BRRI Dhan33 were: 11%, 49%, 200% 36% and 50%, respectively. Reductions in number of root galls in solarized seedbeds compared to non-solarized ones were 75 and 50% for BR-11 and BRRI Dhan33, respectively.

Table 1. Effect of soil solarization on seedling growth and incidence of root knot nematode galls in two rice varieties BR-11 and BRRI Dhan33

Character	Variety							
	BR11				BRRI Dhan33			
	Solarized	Non-Solarized	Paired-t	% Increase (+)/ decrease(-) over non-solarized	Solarized	Non-Solarized	Paired-t	% Increase/ decrease(+/-) over non-solarized
No. of seedlings/m^2	3008	2154	**	40	3846	3481	**	11
Seedling height (cm/plant)	32.9	21.0	*	57	28.4	19.0	**	49
Seedling weight (g/plant)	0.14	0.06	**	152	0.14	0.05	**	200
Root length (cm/plant)	7.7	5.7	*	37	8.1	5.9	**	36
Root weight (g/plant)	0.015	0.011	**	36	0.015	0.010	**	50
No. of galls/plant	0.6	2.4	*	-75	1.0	2.0	*	-50

Note: ** and * Significant at 1% and 5% level.

In the main field, significantly lower stem borer infestation was recorded for both rice varieties transplanted with seedlings from solarized seedbeds compared those transplanted with seedlings from normal seedbeds (Table 2).

Table 2. Effect of soil solarization on stem borer infestation, yield and yield contributing characters of two rice varieties BR-11 and BRRI Dhan33

Character	Variety							
	BR11				BRRI Dhan33			
	Solarized	Non-Solarized	Paired-t	% Increase/ decrease(+/-) over non-solarized	Solarized	Non-Solarized	Paired-t	% Increase/ decrease(+/-) over non-solarized
Stem borer infestation/5m^2	1.2	3.6	*	-67	0.4	3.6	*	-89
Plant height (cm)	113.2	110.8	ns	2	102.8	97.6	*	5
No. of tillers/hill	14.6	12.8	ns	14	11.4	9.8	ns	16
No. of panicles/hill	11.6	10.0	ns	16	10.4	9.0	ns	16
No. of filled grains/panicle	164.4	139.6	**	18	124.2	102.0	**	22
No. of empty grains/panicle	35.6	46.2	ns	-23	45.4	49.0	ns	-7
1000-grain wt. (g)	24.1	23.6	ns	2	24.1	23.8	ns	2
Yield (t/ha)	4.98	4.66	ns	7	4.41	4.04	*	9

Note: ** and * Significant at 1% and 5% level, ns = Non-significant

However, the percent reduction in infestation was more pronounced in BRRI Dhan33 than BR-11. Plant height of BRRI Dhan33 recorded in the solarized treatment was significantly higher than the non-solarized treatment but for BR-11 no significant variation in plant height was observed between the two treatments. The number of tillers/hill, number of panicles/hill, number of empty grain/panicle and 1000-grain weight did not differ significantly between the solarized and non-solarized treatments for either of the two varieties. But the number of filled grains/panicle was significantly higher in solarized treatment compared to non-solarized treatment for both the varieties. The percent increase in the number of filled grain/panicle due to solarization was 18 and 22 for BR-11 and BRRI Dhan33, respectively. Grain yields obtained from the solarized treatment were found higher than those recorded in non-solarized treatment for both the varieties, but the increase was statistically significant only for BRRI Dhan33. The increases in grain yield over non-solarized treatment were 7% and 9% for BR-11 and BRRI Dhan33, respectively.

Less root galls on seedlings from solarized seedbeds were due to a reduction in the population of root-knot nematodes (*Meloidogyne graminicola*) in the solarized seedbeds resulting from the pasteurization heating effect on the soil. Kallel and Schiffers (1991) observed that simulated soil solarization appeared to be very efficient against root-knot nematodes larvae. It has also been reported that soil solarization technology was found effective against other nematodes in many different crops (Katan, 1981; Gaur and Perry, 1991; Stapleton and De Vary, 1986; Braun *et al*. 1987; Patel *et al.* 1987, 1995a, 1995b).

In the present study, a significant reduction in stemborer infection was observed in the main field transplanted to seedlings obtained from solarized seedbed for both rice varieties. This was possibly due to increased growth response and plant vigour of solarized seedlings, which might have imparted a kind of defence against attack by the insect pests.

The grain yields of BR-11 and BRRI Dhan33 increased by 320 and 370 kg/ha, respectively for the solarized treatment relative to normal seedlings. The higher grain yields of the solarized treatment are attributed to a higher number of filled grains in the panicles. Chandel *et al*. (2002) reported that rice seedlings raised on solarized nursery beds gave a 49.4% higher grain yield when transplanted in the untreated main field. Similar rice grain yield increases of 18–42% from solarized seedlings compared to normal seedlings were reported from farmer trials in Gazipur and Dinajpur (Banu *et al*., 2005).

Conclusion

To overcome the difficulty of uprooting small seedlings especially for short duration rice varieties (where the recommended age for transplanting is 20–25 days), farmers can adopt the solarization technology to obtain healthy and larger seedlings within the recommended period. Rice seedlings produced from solarized nurseries also have the potential to increase rice yields compared to using normal seedlings.

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