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EFFECT OF SOIL SOLARIZATION ON PLANT GROWTH AND YIELD OF (*Oryza sativa* L.) RICE

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ABSTRACT

Sarker MB, Sarker MAI, Sarkar MN, Rahman MW, Masud MZ (2023) Effect of soil solarization on plant growth and yield of (*Oryza sativa* L.) rice. *Int. J. Sustain. Crop Prod.* 18(2), 01-06.

A field experiment was conducted at Rangpur Dinajpur Rural Service (RDRS) Bangladesh, Sadar, Rangpur, during the period May 2007 to October 2007 to investigate the effect of soil solarization on plant growth and yield performance of BR11 and BRRI dhan33 seedlings. Solarized seedlings were raised in a seedbed covered with transparent polythene for two months before sowing. The experiment was laid out in a RCBD with five replications. The experiment was conducted under rainfed conditions. Solarization effect significantly influenced the crop characters, yield components and yield of rice. The seedling height (cm), root length (cm), shoot weight of seedling (g), root weight of seedling (g), number of galls (1 x 1 m seedbed), plant height (cm), number of tillers (hill^{-1}), number of the effective tillers (hill^{-1}), panicle length (cm), number of unfilled grain (panicle^{-1}), filled grain (panicle^{-1}), grain yield (t ha^{-1}) straw yield (t ha$^{-1)}$ harvest index (%) were significantly greater in solarized treatment then non-solarized ones variation observed were in crop characters and yield contributing characters between two rice genotypes. Solarized seedlings produced the highest yield (4.9 t ha^{-1}) while non-solarized seedlings produced the lowest yield (4.19 t ha^{-1}). The interaction effect of solarization and varieties, Solarized seedlings produced the highest yield (4.92 t ha^{-1}) in BR11 and lowest yield (3.80 t ha^{-1}). This is an eco-friendly technique for raising healthy rice seedlings which has an excellent potential to use an IPM practice for rice cultivation. By practicing this technique, farmers can manage nematode and root disease to grow healthy plants resulting in rice yield increasing significantly.

Key words: *soil solarization,plant growth, variety,yield*

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of Bangladesh and the crop belongs to the cereal crop under the Gramineae family. Rice ranks in the first position among cereal crops and is the main source of carbohydrates. It has a large effect on human nutrition and food security all over the world. It is one of the major and most extensively cultivated cereals of the world including Bangladesh that provides feed to half of the world's population. The six major rice-producing countries in Southeast Asia (Cambodia, Indonesia, Myanmar, Philippines, Thailand and Vietnam), which together account for 97% of total rice production in the region (FAO 2021). The contribution of the agriculture sector to GDP is 19.29%. The crop sub-sector dominates with 13.44% from which rice contributes 46%. Almost 47.5% of the manpower is directly involved in agriculture. In Bangladesh, almost 66% of the labour force depends on agriculture for employment (BBS 2012). Rice occupies about 76% of the total cropped area from where modern varieties cover 84.67% and local varieties cover 15.33%. The present status of the area and production of rice is 11.42 million ha and 34.43 million MT (BBS 2012).

Out of the total rice production in our country, about 38% comes from Aman and the rest 7% and 55% from Aus and Boro crops respectively (Risingbd 2014). It is cultivated in an area of about 11.5 million hectares of land with an annual production of 38.4 million metric tons (FAO 2022). Farmers are cultivating rice year after year in the traditional method. Farmers are using chemical pesticides for the control of diseases and insects. For this, production cost is increased although production is not increased accordingly. Farmers don't know how to manage disease and insects without chemicals. Solarization is a technique by which soil-borne diseases can be reduced by using natural solar radiation.

Soil and solarization is a method of heating soil by covering it with a transparent polythene sheet to kill soil-borne disease organisms. The effects, advantages and limitations of this technique have been reviewed by Horiuchi (1984). Although the major benefit of solarization is the reduction of soil-borne pathogens by heating effects, many other possible additional beneficial effects could result in an increased growth response (IBR) of plants. Thermal killing due to heat buildup from the sun has been considered the primary way solarization and tarping work, i.e., deplete the weed seedbank by killing weed seeds and seedlings (Rubin and Gamliel, 2018). In Bangladesh, usually farmers prepare their seedbed through a pudding of soil. Sometimes farmers keep their rice seedlings in those seedbeds for up to 2 months. This delay does not only mean a lack of farmers' awareness but also their dependence on irrigation to prepare main lands for transplantation. Although farmers are always encouraged to use short-duration seedlings to transplant, but delayed transplantation of seedlings (aged seedlings) causes the prevalence infected of seedlings through different types of soil-borne disease while in the seedbed. On the other hand, especially for the aman season, farmers are not getting good quality interns of seedlings height/length etc. However, they could get their desired seedlings easily if the seedlings are solarized.

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Considering the above facts in mind, the present study was undertaken to assess the following objectives through the use of the solarization technique. The objectives of the current study were to compare the growth and yield performance of two rice genotypes as affected by solarization; and to identify the suitable combination of rice genotype with solarization technique.

MATERIALS AND METHODS

Experimental site and soil

The present experiment was carried out on farmers' field at RDRS, Rangpur Sadar, during the period from May 2007 to October 2007. The soil of the experimental site was silty loam in texture and belongs to the Tista Meander Floodplain (UNDP and FAO 1988) under the Agro-ecological Zone-3. The selected site was a medium-high land and the soil pH was 5.7, which was slightly acidic. The analytical data of the soil sample from the experimental area was determined in the Humboldt Soil Testing Laboratory, Department of Soil Science, Bangladesh Agricultural University, Mymensingh, which is presented in (Table 1).

Table 1. Soil analysis data in the research field

A. Mechanical analysis		B. Chemical analysis	
Constituents	**Percent**	**Soil properties**	**Results**
Sand	35	pH	4.8
Silt	35	Organic carbon	1.27
Clay	30	Total nitrogen	0.072
Textural classification	Silty loam	Phosphorus	15.43 ppm
		Potassium	0181 me%
		Zinc	0.54 ppm
		Boron	0.288 ppm

Source: Agricultural University Humboldt soil Testing Laboratory, Department of soil Science, Bangladesh Agricultural University, Mymensingh.

Climate of the experimental site

The experimental area was situated in the sub-tropical climatic zone, Information regarding monthly temperature, relative humidity and rainfall data recorded during the period of the present study were collected from the weather station at Rangpur (Table 2).

Table 2. Records of meteorological observation (weekly) during the period of the experiment from May 2007 to October 2007

Months	Average temperature (^oC)			Rainfall (mm)	Relative humidity (%)	Sunshine (hrs.)
	Maximum	Minimum	Average			
May	33.93	24.62	29.27	100.86	80.41	220.46
June	32.61	25.37	28.99	332.70	74.32	101.00
July	30.56	26.10	28.33	787.20	82.50	119.00
August	32.60	26.80	29.70	253.40	84.50	164.10
September	31.41	26.10	28.75	269.70	87.00	65.10
October	31.18	21.80	26.49	788.30	78.23	200.90

Source: Weather station at Rangpur

Plant materials

The rice cultivars used in the experiment were BR11 and BRRI dhan33.

Raising of seedlings

Rice seedlings were raised in four seed beds situated on a relatively high land. The size of each seedbed was 1 m x 1 m. The area was well prepared with spades, and made into loose friable and dried mass to obtain fine tilth. Half-seed soil was prepared by solarized technique (Katan 1981). The soil solarisation practice (variously known as solar heating, plastic or polyethene mulching, and solar pasteurization) has been developed as a method of soil disinfestation. Thin polythene sheets (0.03-0.05 mm) are found to be more effective for solarization than thick ones due to better transmission of radiation. The solarized seedbeds were covered by polythene for 21 days. Other seedbeds were prepared by conventional methods. Complete germination of the seeds took place 6 days after sowing. Necessary shading by polythene sheet was provided to the seedbed to protect the young seedlings from scorching sunshine or heavy rainfall. Dithane M-45 was spread in the seedbeds at the rate of 2 Gl-1 to protect the seedlings from damping off and other diseases. Weed control, mulching and irrigation were provided on time.

Treatments of the experiment

The experiment consisted of two factors *viz:* Factor-A: Variety (BR11(Mukta), BRRI dhan33); Factor – B: Solarization: *viz*-Solarized (soil), Non-solarized, the experiment was laid out in a Randomized Complete Block

Design (RCBD) with five replication. Fertilizer was applied at the rate of 80, 60, 40, and 10 kg ha^{-1} of urea, TSP, MP and Gypsum, respectively. Half of the urea, full dose of TSP, MP and Gypsum were applied at the time of puddling. The remaining half of urea was applied in two equal instalments at 15 and 30 days after transplanting (BARC 1997).

Transplanting of seedlings

Twenty-five days old healthy and uniform seedlings were taken from the solarized and non-solarized seedbeds and were transplanted in the experimental field on 25 July 2007, maintaining a spacing of 25 cm x 20 cm between the row and hill, respectively.

Intercultural operations

Weeding, Insect and pest infestation of grasshopper was controlled by applying Basudin 10G at 62 DAT at the rate of 20 kg ha^{-1} (BRRI 1997). The experimental crop of BRRI dhan33 was harvested on 20 October 2007 and BR11 on 4 November 2007. Harvested rice was then threshed, cleaned and processed.

Data collection

The following data were recorded from 5 randomly selected plants from each plot.
Seedling height(cm), root length(cm), shoot weight dry g/10plant, root weight dry g/10, number of galls, total number of gall 1 m x 1 m seedbed was counted, number of tillers hill^{-1}, number of effective tiller hill^{-1}, plant height (cm), panicle length (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, grain yield t ha^{-1}, straw weight, harvest index (HI), harvest index was calculated at the harvest by the following formula, proposed by (Donald and Hamblin, 1976).

Harvest index(%)= Grain yield / Biological yield × 100

Analysis of data

The collected data were analyzed statistically following two factorial experiments in RCBD with the help of MSTAT computer packages (Russell 1986). The mean differences were compared by the Duncans Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

The chapter comprises the presentation and discussion of the result obtained from the study on the effects of soil solarization in the growth and yield of rice. The data are presented in tables the results of each parameter are discussed under the following headings. Significant differences were observed in yield and yield related traits of rice with soil solarization as presented in Tables 3 and 4. There was a significant variation due to solarization treatment on seedling height. It was observed that solarized seedling produced the longest (42.18 cm), whereas non-solarized one produced the shortest seedling length (26.25 cm) (Table 3). The root length of rice seedlings was significantly increased in solarized seedlings compared to non-solarization seedlings. The highest root length was found (8.80 cm) in solarized seedlings, while non-solarized seedlings produced the shortest root length (6.80 cm) (Table 3). This result is in agreement with CYMMIT Bangladesh Published Leaflet 2005, which reported soil solarization as a non-chemical method which means healthy seedlings. The shoot weight of seedlings significantly varied between solarized seedlings and non-solarized seedlings. The highest weight of 10 oven-dry seedling shoots (10.33 g) was found in non-solarized seedling shoot weight (8.13 g) (Table 3). Root weight was significantly varied due to solarization. The highest weight of 10 seedling roots (1.21 g) was found in the solarized seedbed and the lowest weight of 10 seedling roots (0.96 g) was found in the non-solarization seedbed (Table 3). Significant variation was found in the number of galls (1 m x 1 m seedbed) for solarization treatment at 5% level. The highest number of galls was recorded in non-solarized seedlings (1.0) and the lowest number of galls (0.30) in solarized seedbeds (Table 3). The number of tillers significantly varied due to solarization treatment at 5% level. The highest number of tillers (13.0) was found in the solarized treatment and the lowest number of tillers (11.40) in the non-solarized treatment (Table 3). There was a significant variation in effective tiller at 1% level. The highest effective tiller (11.60 hill^{-1}) was received from solarization treatment. The lowest number of effective tillers (8.60 hill^{-1}) was found in non-solarized treatment (Table 3).

Table 3. Soil solarization effect on crop characters and yield contributing characters of rice

Treatment	Seedling length (cm)	Root length (cm)	Shoot weight of 10 seedlings (g)	Root weight of 10 seedlings (g)	Galls/ seedbed (m^2)	Tillers hill^{-1}	Effective tillers hill^{-1}
Solarized	42.19	8.88	10.33	1.21	0.30	13.70	11.60
Non-solarized	26.25	6.88	8.13	0.96	1.00	11.40	8.60
CV (%)	5.88	16.58	8.02	10.02	106.03	15.0	15.50
Level of significance	**	**	**	**	*	*	**

NS= Non-significant,*= Significant at 5% level, **= Significant at 1% level

Plant height was measured at the final harvest. There was significant variation due to solarized treatment at 1% level. The highest plant height (102.82 cm) was received from solarized treatment and the lowest plant height (95.58 cm) was in non-solarized treatment (Table 4). The data on panicle length were found significant at 1% level. In solarized treatment, the highest panicle length was 25.78 cm while the lowest panicle length was (20.79 cm) in the non-solarized plot (Table 4). The effect of soil solarization on filled grain production was found significant at 1% level. The highest number of filled grains (166.00 panicle^{-1}) was found in the solarized plot and the lowest number of filled grains (137.90 panicle^{-1}) was in the non-solarized plot (Table 4). Significant variation was found due to solarization at 1% level. The highest number of unfilled grains (48.10 panicle^{-1}) was found in the non-solarized plot and the lowest number of unfilled grains (48.80 panicle^{-1}) Solarized plot (Table 4).

Table 4. Soil solarization effect on crop characters and yield contributing characters of rice

Treatment	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Solarized	102.82	25.78	166.00	24.80	4.90	6.98	41.35
Non-solarized	95.58	20.79	137.90	48.10	4.19	6.88	37.94
CV (%)	3.54	8.70	10.38	19.75	5.56	10.47	6.33
Level of significance	**	**	**	**	**	NS	*

NS= Non-significant,*= Significant at 5% level, **= Significant at 1% level

Grain yield varied significantly due to solarization at 1% level. The highest grain yield (4.90 t ha^{-1}) was received from a solarized plot and the lowest grain yield (4.19 t ha^{-1}) was from a non-solarized plot. This result agrees with Singh *et al.* (2003), who reported that the highest grain yield of wheat, 5,038 kg ha^{-1} was recorded with solarization with 5 weeks (27%) higher than non-solarized control (Table 4). Straw yield doesn't vary about solarized treatment. There was a significant variation at 5% level for solarization treatment. The highest harvest index (41.35%) was found in solarization treatment and the lowest harvest index (37.94%) was in non-solarized treatment (Table 4). This result agrees with Singh *et al.* 2004, who found the emergence of Jungle rice by 95% and wild jute by 83%, weed population and dry weight by 82% and 90% respectively solarization for 4 and 5 weeks resulted in the greatest leaf area and crop dry matter plant^{-1} solarization with transparent polythene markedly increased the yield attributed.

Marked variation in seedling height was observed due to different varieties. This variation in seedling length was highly significant at 1% level. The highest height was found (36.85 cm) in BR11 and the lowest (31.54 cm) seedling height was found in BRRI dhan33 (Table 5). Malaker *et al.* (2003) reported that soil solarization is a method of heating soil by covering it with a transparent polythene sheet to control soil-borne diseases. It can be successfully used for disinfection of any seedbed to produce healthy seedlings of vegetable as well as rice crops.Root length height variation was not found across cultivers. There was a significant variation between varieties. The highest shoot weight (9.81 g) was recorded in BR11 (Mukta) and the lowest was in BRRI dhan33 (8.65 g) (Table 5). there was a significant variation due to variety. The highest root weight (1.20 g) was found in BR11 and the lowest root weight (0.97 g) in BRRI dhan33 (Table 5). No variation in root gall/m^2 area was found among the cultivers Significant variation was found in varietal treatment at 5% level. The highest number of tillers (13.50) was found in BR11 and the lowest number of tillers (11.60) was recorded in BRRI dhan33 (Table 5). Significant variation was found due to the varietals effect at 5% level. The highest number of effective tillers (10.9 hill^{-1}) was found in BR11 and the lowest number (9.3 hill^{-1}) of effective tillers BRRI dhan33. This result corroborates with the findings of the Bangladesh Wheat and Maize Research Institute about solarization of rice in North West Bangladesh (Bakshi *et al.* 2001) (Table 5).

Table 5. Effect of varieties on growth characters of rice

Treatment	Seedling length (cm)	Root length (cm)	Shoot weight of 10 seedlings(g)	Root weight of 10 seedlings(g)	Gall/ seedbed (m^2)	Tiller hill^{-1}	Effective tiller hill^{-1}
BR11	36.85	8.40	9.81	1.20	0.60	13.50	10.90
BRRI dhan33	31.58	7.36	8.65	0.97	0.70	11.60	9.30
CV (%)	5.88	16.58	8.02	10.02	106.03	15.0	15.50
Level of significance	**	NS	**	**	NS	*	*

NS= Non-significant,* = Significant at 5% level, **= Significant at 1% level

Plant height was significantly influenced by different rice varieties at 1% level. The highest plant height (111.60 cm) was found in BR11 and the lowest plant height (86.80 cm) was in BRRI dhan33 (Table 6). No variation was found among cultivars in panicle length (cm), field grain/panicle, unfield grain/panicle and straw yield t ha^{-1} parameters. The Varietals effect was significant at 1% level. The highest grain yield (4.75 t ha^{-1}) was found in BR11 and the lowest grain yield (4.34 t ha^{-1}) was found in BRRI dhan33 (Table 6) This result supports the findings of (Bakshi *et al.* 2001) who found that there was a significant yield increase (36%) after using solarized seedlings.

On the other hand, significant variation at 1% level was found due to varieties. The highest harvest index (41.55%) was found in BR11 and the lowest (37.74%) was BRRI dhan33 (Table 6).

Table 6. Effect of varieties on yield and yield attributes of rice

Treatment	**Plant height (cm)**	**Panicle length (cm)**	**Filled grains panicle^{-1}**	**Unfilled grains panicle^{-1}**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Harvest index (%)**
BR11	111.60	24.17	153.20	33.60	4.75	6.74	41.55
BRRI dhan33	86.80	22.40	150.70	39.30	4.34	7.12	37.74
CV (%)	3.54	8.70	10.38	19.75	5.56	10.47	6.33
Level of significance	**	NS	NS	NS	**	NS	**

NS= Non-significant,*= Significant at 5% level, **= Significant at 1% level

No interaction effect was observed for seedling length(cm), root length(cm), shoot weight of 10 seedlings(g), root weight of 10 seedlings(g), gall/seedbed(m^2), tillers hill^{-1} and Effective tiller hill^{-1} which is presented in Table 7.

Table 7. Interaction effect of soil solarization and rice varieties on crop characters and yield contributing characters

Treatments	**Seedling length (cm)**	**Root length (cm)**	**Shoot weight of 10 seedlings (g)**	**Root weight of 10 seedlings (g)**	**Gall/ seedbed (m^2)**	**Tillers hill^{-1}**	**Effective tiller hill^{-1}**
S_1V_1	44.10	9.40	11.06	1.38	0.20	14.40	12.20
S_1V_2	40.27	8.36	9.60	1.04	0.40	13.00	11.00
S_1V_1	29.60	7.40	8.56	1.02	1.00	12.60	9.60
S_1V_2	22.90	6.36	7.70	0.90	1.00	10.20	7.60
CV (%)	5.88	16.58	8.02	10.02	106.03	15.0	15.50
Level of significance	NS	NS	NS	NS	NS	NS	NS

S_1= Solarized, S_2= Non-solarized, V_1= BR11, V_2= BRRI dhan33, NS= Non-significant,
*= Significant at 5% level, **= Significant at 1% level

The interaction effect of both soil solarization and cultivar on plant height (cm) was observed. The interaction effect was significant at 1% level. The highest plant height (112.80 cm) was found in solarized BR11 and the lowest plant height (80.76 cm) was in non-solarized BRRI dhan33(Table 8). This result corroborates with Olson (2021) who found Solarization is a non-chemical method for controlling soilborne diseases, insects, nematodes and weeds in soil prior to planting. The interaction effect of grain yield was significantly varied at 1% level. The highest grain yield (4.92 t ha^{-1}) was found in solarized BR11 and the lowest grain yield (3.80 t ha^{-1}) was in non-solarized BRRI dhan33 (Table 8). The interaction effect was significant at 1% level. The highest straw yield (7.62 t ha^{-1}) was found in solarized BRRI dhan33 and the lowest straw yield (6.34 t ha^{-1}) was in non-solarized BRRI dhan33 (Table 8). On the other hand no significant variation of interaction effect on panicle length (cm), no. of filled grains panicle^{-1}, grain yield (t ha^{-1}) and harvest index (%**).**

Table 8. Interaction effect of soil solarization and rice varieties on crop characters and yield contributing characters

Treatment	**Plant height (cm)**	**Panicle length (cm)**	**No. of filled grains panicle^{-1}**	**No. of unfilled grains panicle^{-1}**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Harvest index (%)**
S_1V_1	112.80a	26.88	167.20	23.20	4.92a	6.62ab	43.69
S_1V_2	92.84b	24.69	164.80	26.40	4.84a	7.62a	39.01
S_1V_1	110.40a	21.46	139.20	44.03	4.58a	7.14b	39.42
S_1V_2	80.76c	20.12	136.60	52.20	3.80b	6.34b	36.46
CV (%)	3.54	8.70	10.38	19.75	5.56	10.47	6.33
Level of significance	**	NS	NS	NS	**	**	NS

S_1= Solarized, S_2= Non-solarized, V_1= BR11, V_2= BRRI dhan33, NS= Non-significant,
*= Significant at 5% level, **= Significant at 1% level

CONCLUSION

Comparative performance of two aman rice varieties with solarized and non-solarized conditions was observed in this study. BR11 and BRRI dhan33 produced the highest crop characteristics such as healthy seedlings, number of tillers, number of effective tillers, plant height as well as yield contributing characteristics such as number of filled grain, grain yield, harvest index and lowest number of unfilled grain. From the above study, it may be concluded that this is an eco-friendly technique for raising healthy rice seedlings which has an excellent potential to use an IPM practice for rice cultivation. By practicing this technique, farmers can manage nematode and root disease to grow healthy plants resulting in increased rice yield.

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