Original Research Article

EFFECT OF VARIETY AND PLANTING ARRANGEMENT ON WEED CONTROL AND YIELD PERFORMANCE OF TRANSPLANTED AMAN RICE

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during June to November 2016 in order to find out the effect of variety and planting arrangement on weed control and yield performance of transplanted *Aman* rice. The experiment consisted of four varieties viz., Binadhan-7, Binadhan-12, Binadhan-17 and Binadhan-16 and five planting arrangement viz. 25cm × 20cm, 25cm × 15cm, 20cm × 20cm, 20cm × 15cm and 15cm × 15cm. The experiment was laid out in Split Plot Design with three replications. Results indicated that the highest weed density (90.93 m^{-2}), weed biomass (131.87 gm^{-2}),leaf chlorophyll content (SPAD value)(40.02), sterile spikelets $panicle^{-1}$ (76.86),% sterility $panicle^{-1}$(28.66),grain yield(4.51t ha^{-1}) and straw yield (4.63 t ha^{-1})were obtained from Binadhan-17.Binadhan-17 gave the highest grain yield (4.51 t ha^{-1}). The variety Binadhan-7 showed the best performance in respect of number of total tillers $hill^{-1}$ (11.06), number of effective tillers $hill^{-1}$ (10.12) compared to the other varieties used in the study. The highest non-effective tillers $hill^{-1}$(10.68%) was obtained from Binadhan-16. The highest leaf chlorophyll content (SPAD value) (36.48), plant height (99.72 cm), panicle length (22.03 cm), number of total tillers $hill^{-1}$(10.21) and number of effective tillers $hill^{-1}$(9.45) were found at25 cm × 20 cm planting arrangement. The highest grain yield (4.31 t ha^{-1})was recorded from 20cm × 15cm planting arrangement. The interaction between variety and planting arrangement showed numerically higher grain yield (5.38 t ha^{-1}) from Binadhan-7 at 20cm × 15cm planting arrangement, whereas

the lowest grain yield (2.61 t ha^{-1}) was achieved from the variety Binadhan-12 at 15cm × 15cm planting arrangement. Among the four varieties Binadhan-7 performed the best for grain yield while the grain yield of Binadhan-12 was the worst compared to the others. It can be concluded that Binadhan-7 at 20cm × 15cm planting arrangement may be used for achieving the best yield with less weed interference in *Aman* season.

Key words: planting arrangement, weed management, yield, Aman rice.

INTRODUCTION

Bangladesh is an agricultural country and Rice (*Oryza sativa* L.), as staple food, is the most extensively cultivated crop in Bangladesh. Rice is the vital food for more than two billion people in Asia and four hundred million of people in Africa and Latin America (IRRI, 2010). The climatic condition of our country is suitable for rice production. About 74.85% of cropped area of Bangladesh is used for rice production with annual production of 3,47,10,000 metric tons from 11,386,234.82ha of land (BBS, 2016). *Aman*rice covers 49.12% of total rice area producing 1,34,83,437 metric tons in 2015-16 (BBS, 2016).

The population of Bangladesh is still growing by two million every year and may increase by another 40 million over the next 20 years which will require about 27.26 tons of rice for the year 2020 (BBS,2011). On the other hand, agricultural land is decreasing day by day. About 220 hectares agricultural lands are decreased per year due to urbanization, industrialization, housing and road construction purposes. Twenty lakh ha of agricultural land decreased during last 20 years (BBS, 2012). So it is time to think how to sustain the food production of the country. Since there is a little scope of horizontal expansion of the rice area in the country.

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Among the various factors reducing the rice yield weed is considered as a major constraint. Weed is one of the most important agricultural pests. In Bangladesh, weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for transplanted *Aman*rice (Autumn) and 22-36% for modern *Boro*rice varieties (Winter rice) (BRRI, 2008). There is no doubt that maximum benefit from costly inputs like fertilizers and pesticide in rice can be fully derived when the crop is kept free from weed infestation. Repeated hand weeding is done to keep the crop free from weed as far as practicable but the method is cumbersome, uneconomical and being more difficult day-by-day due to the scarcity of labor. By providing optimum spacing to the plants to grow-aboveground and underground parts-thro' ugh efficient utilization of solar radiation and nutrients, planting arrangement plays a vital role in the growth development and yield of rice (Khan et al. 2005). The inter-plant competition, in a densely populated crop, is very high for nutrients, air and light, which usually results in mutual shading, lodging and thus assists more straw yield than grain yield (Alam et al. 2012). On the flip side,under wider plant spacing,desired hills unit-1 area cannot be obtained- which ultimately reduces yield unit^{-1} area. So, to maximizing the yield of rice, it is important to determine optimum spacing (Baloch et al. 2002).

weeds are one of the major worldwide biotic problem for rice production. Compare to yield of transplanted rice in other countries the yield of transplanted aman rice is much lower. serious weed infestation is one of the major problem of this low yield. A great loss in the rice yield due to weed infestation from different parts of the world was mentioned by many investigators (Nandal and Singh, 1994). yield losses of rice due to weed infestation mainly depends on weed species, time of weed association with crops and the management practices (mechanical and chemical) that are used to control the weeds (Mitra et al. 2005). the amount of yield losses of aman rice due to weed are 30-40% in Bangladesh (BRRI 2008).

The use of Herbicide is gaining popularity in Bangladesh as it lower the weeding cost (Hossain 2006). on the other hand, it was noticed that the phytotoxicity of herbicides lead to lower yield performance of crop (Islam 2001; Rahman 2001; Mondal et al. 1995). so a appropriate weed management practice need to adopt to maximize the rice yield. The present study was, therefore,

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undertaken to evaluate the effect of, variety, planting arrangement and the interaction effect of variety and planting arrangement, if any, on weed control and yield performance of transplanted *Aman* rice.

MATERIALS AND METHODS

Experimental site

The experimental site is located at 24°75' N latitude and 90°50' E longitude at an elevation of 18 m above the mean sea level. The experimental area is characterized by non-calcareous dark grey floodplain soil belonging to the Sonatola Soil Series under the Old Brahmaputra Floodplain, Agro-Ecological Zone 9 (FAO, 1988).The soil of the experimental field was more or less neutral in reaction with pH value 6.8, low in organic matter and fertility level. The land type was medium high with silty loam in texture.

Experimental treatment design and layout

The experiment involved two sets of treatment as 4 Cultivar variety viz. Binadhan-7 (V_1), Binadhan-12(V_2), Binadhan-17(V_3), Binadhan-16(V_4) and 5 Planting arrangement viz. 25cm × 20cm (S_1) ,25cm × 15cm (S_2), 20cm × 20cm (S_3), 20cm × 15cm (S_4),15cm × 15cm (S_5). The experiment was laid out in a Split plot Design with three replications. Variety was randomly assigned to main plot and planting arrangement is the sub plot. Total numbers of unit plots were 4×5×3=60 and each plot size was 4.0 m× 3m. The distance maintained between the plots and the blocks were 0.5m and 1.0m, respectively.

Description of rice cultivars

It is a short duration and high yielding transplanted short duration variety tolerant to sheath blight, leaf blight and stem rot, major insect-pests specially to Brown Plant Hopper (BPH) and hispa, with good quality of rice released in 2007. It produce grain yield 5-5.5 t ha^{-1}. Binadhan-12 is a submergence tolerant rice variety for season, released in 2013. It takes about 140-145 days (under 20-25 days submerged condition with yield of 3.8-4.0 t ha^{-1}) and 125-130 days for non-submerged condition 4.2-4.5 t ha^{-1}. Binadhan-17 is a suitable rice variety for season. The duration of this variety is 112 to 118 days. It is an insect and disease tolerant variety. Binadhan-17 produces 7.0 t ha^{-1} yield in season.Binadhan-16 is a short duration and photo insensitive variety. It takes about 100-108 days which is 8-10 days earlier to Binadhan-7 with average grain yield of 5.5 tha^{-1}.Seeds of Binadhan-7, Binadhan-12, Binadhan-16 and Binadhan-17 were collected from the Bangladesh Institute of Neuclear Agriculture (BINA), Mymensingh.

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Preparation of seedling and experimental land

Then sprouted seeds were sown in the nursery beds on 8 July 2016. Proper care was taken to raise the seedlings in the seedbed. The experimental land was first opened with a power tiller on 15 July 2016. Then the land was prepared by ploughing and cross-ploughing with a country plough and subsequently leveled by laddering

Fertilizer application and seedlings and transplanting

The land was fertilized with triple super phosphate, muriate of potash and gypsum at the rate of 132, 88 and 66 kg ha^{-1}, respectively. The entire amount of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied on 4 August at final land preparation. Nitrogen was applied in the form of urea in three equal splits at 15, 25 and 40 days after transplanting (DAT).Twenty eight days old seedlings were uprooted from the nursery bed carefully and then transplanted in the well puddled plots with 2 seedlings $hill^{-1}$ on 6 August 2016.

Pre-emergence herbicide application and water management

Pre-emergence herbicide Pretilachlor 500 EC was sprayed at the rate of 1 liter ha^{-1} on 10 August 2016 *i.e. at* 4DAT.The experimental plots were irrigated and drained out as and when necessary during the growing period of the crop.

Sampling, harvesting and processing

The crop was harvested at full maturity, when 90% of the grain became golden yellow in color. Five hills (excluding border rows) were selected randomly from each unit plot and uprooted for recording data.

Variety Binadhan-7 and variety Binadhan-16 was harvested on 25 October while Binadhan-12 and Binadhan-17 were harvested on 6 November, 2016. The harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor. The crop was threshed by pedal thresher and the fresh weights of grain and straw were recorded $plot^{-1}$. The grains were cleaned and sun dried to a moisture content of 14%. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

Data collection

Data were collected on Weed parameters Weed density (m^{-2}),Weed biomass (g m^{-2}),Visual scoring on weed control and Crop parameters viz. Leaf chlorophyll content (SPAD value),Plant height (cm),Panicle length (cm),Number of total tillers $hill^{-1}$,Number of effective tillers $hill^{-1}$, % Non-effective tillers $hill^{-1}$,Number of grains $panicle^{-1}$, Number of sterile spikelets $panicle^{-1}$, % Sterility $panicle^{-1}$, Number of effective tillers m^{-2}, Thousand grains weight (g), Grain yield (t ha^{-1}), Straw yield (t ha^{-1}), Crop biomass (gm^{-2}).Data on individual plant parameters were recorded from five randomly selected hills of each plot and those on 1000-grains weight, grain yield and straw yield were recorded at harvest. Data on weed density were collected from each plot at vegetative growth stage of the rice plants by using 0.25m × 0.25m quadrate as per method described by Cruz *et al.* (1986). The collected weeds were dried in an electrical oven for 72 hours at a temperature of 80°C. The dry weight of each species was taken by an electrical balance and expressed in gm^{-2}.Chlorophyll content of plant leaves was measured by spade meter.

Statistical analysis

Data on different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer package Statistix 10. The difference among the treatments was tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Result and Discussion

Effect of variety on Weed density, Weed biomass, Crop biomass and Visual scoring on weed control

Weed density was not significantly affected by variety (Table 1). Numerically the weed density was highest (90.93 m^{-2}) with Binadhan-17 and the lowest (65.73 m^{-2}) with Binadhan-16. Weed biomass, crop biomass and visual scoring on weed control were significantly influenced by variety (Table 1). The highest, weed biomass (131.87 g m^{-2}) was found in Binadhan-17, crop biomass (498.85 g m^{-2}) was found in Binadhan-16,the visual scoring on weed control was the highest (6.53) in Binadhan-12 .

Effect of planting arrangement on Weed density, Weed biomass, Crop biomass and Visual scoring on weed control

Weed density, weed biomass, Visual scoring on weed control were significantly affected planting arrangement (Table 1). The highest ,(107.67 m^{-2}) weed density, (162.18 gm^{-2}) weed biomas were obtained from planting arrangement 20 cm × 20 cm .It was found from the experiment that crop biomass was not affected significantly (Table 1). However, the highest (460.17 g m^{-2}) was obtained from the planting arrangement of 25 cm × 15 cm followed by (153.69 g m^{-2}) by the planting arrangement 25 cm × 20 cm and the lowest (426.42 g m^{-2}) crop biomass was obtained from the 20 cm × 15 cm planting arrangement. The highest (6.33) visual scoring on weed control was found that from 25 cm × 20 cm and 20 cm × 20 cm.

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Interaction effects of variety and planting arrangement on Weed density, Weed biomass, Crop biomass and Visual scoring on weed control

Weed density, weed biomass and crop biomass was significantly influenced by interaction effects of variety and planting arrangement (Table 2). The highest, weed density (150.67 m^{-2}), weed biomass (254.72 g m^{-2}) were obtained from Binadhan-17 with 20 cm × 20 cm planting arrangement. Visual scoring on weed control did not vary significantly due to interaction of varieties and planting arrangement (Table 2). However, the highest (7.33) visual scoring on weed control was obtained from Binadhan-12 with 20 cm × 20 cm and 15 cm × 15 cm planting arrangement. The lowest (3.33) was obtained from Binadhan-7 with 20 cm × 15 cm planting arrangement.

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Effect of variety Leaf chlorophyll content, Plant height and Panicle length, Number of total tillers hill-1, Number of effective tillers hill-1, % Non-effective tillers hill-1, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and % sterility grains panicle^{-1} in transplanted *Aman* rice

The highest leaf chlorophyll content (40.02) was recorded from Binadhan-17 which was statistically identical to variety Binadhan-16 (37.07).The tallest plant height (101.11 cm) was obtained from Binadhan-12. The longest panicle length (22.66 cm) was obtained from Binadhan-7 which was statistically identical to variety Binadhan-12. The probable reason of these results might be due to genetic makeup of these varieties. Number of total tillers hill^{-1}varied significantly by variety (Table 3). Higher (11.06) number of total tillers, number of effective tillers hill^{-1} (10.12) were obtained from variety Binadhan-7. The non-effective tillers hill^{-1} varies from (5.74 to 10.68). the lowest (5.74%) was obtained from Binadhan-17. Varieties significantly affected the number of grains panicle^{-1} (Table 3). Maximum (329.60) number of grains panicle^{-1} was obtained from Binadhan-12. Numerically maximum number of sterile spikelets (76.86) panicle^{-1} was obtained from Binadhan-17 and minimum (44.00) was form Binadhan-16. The sterility panicle^{-1} varies from (12.29 to 28.66%) by variety (Table 3). The highest (28.66%) was obtained from Binadhan-17.

Effect of planting arrangement on Leaf chlorophyll content, Plant height and Panicle length, Number of total tillers hill-1, Number of effective tillers hill-1, % Non-effective tillers hill-1, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and % sterility grains panicle^{-1} in transplanted *Aman* rice

It was observed that leaf chlorophyll content (SPAD) and Panicle length was not significant due to varietal variation (Table 3). However, the highest leaf chlorophyll content (36.48) and the longest panicle length (22.03 cm) was recorded from 25 cm × 20 cm planting arrangement **.** The tallest (99.72 cm) plant height was obtained from 25 cm × 20 cm planting arrangement followed by (99.65 cm) 25 cm × 15 cm planting arrangement. With the planting arrangement total number of tillers hill^{-1} and number of tillers hill^{-1} was significantly affected (Table 3). Total number tillers hill^{-1} was highest (10.21) and number of effective tillers (9.45) with planting arrangement 25 cm × 20 cm The non-effective tillers hill^{-1} varies from (6.72 to 11.00%) by planting arrangement (Table 3). The highest (11.00%) was obtained from 15 cm × 15 cm planting arrangement. Number of grains panicle^{-1} did not significantly affected due to the planting arrangement (Table 3). However, the highest number of grains panicle^{-1} (230.58) was obtained from 25 cm × 15 cm planting arrangement Maximum (60.08) number of sterile spikeletspanicle^{-1} was obtained from planting arrangement 20 cm × 15 cm and minimum (45.66) was found at the planting arrangement 25 cm × 20 cm.The sterility panicle^{-1} varies from (17.00 to 21.80%) by planting arrangement (Table 3).

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Effect of interaction on Leaf chlorophyll content, Plant height and Panicle length, Number of total tillers hill-1, Number of effective tillers hill-1, % Non-effective tillers hill-1, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and % sterility grains panicle^{-1} in transplanted *Aman* rice

Leaf chlorophyll content (SPAD value) was not significantly affected by the interaction between variety and planting arrangement (Table 4). However, the highest leaf chlorophyll content (40.36) was recorded from Binadhan-17 with 25 cm × 20 cm.However, numerically tallest plant height (103.38 cm) was obtained from Binadhan-12 with 25 cm × 20 cm followed by (102.79 cm) at 20 cm × 20 cm.The highest panicle length (23.46 cm) was obtained from Binadhan-7 with 25 cm × 15 cm planting arrangement followed by (22.92 cm) at 25 cm ×20 cm planting arrangement with same variety. The lowest (20.68 cm) was obtained from Binadhan-17 with 15 cm × 15 cm planting arrangement.

The number of total tillers hill^{-1} was not significantly affected by the interaction between variety and planting arrangement (Table 4). However, the highest (12.00) number of total tillers hill^{-1} was obtained from Binadhan-7 with the planting arrangement 25 cm × 15 cm and 20 cm × 20 cm. The results showed that the varieties and planting arrangement were not varied significantly on number of effective tillers hill^{-1} (Table 4). But numerically maximum (11.00) number of effective tillers hill^{-1} were produced at variety Binadhan-7 with 20 cm × 20 cm planting arrangement. The highest (14.86%) was obtained from Binadhan-12 with 15 cm × 15 cm planting arrangement. The lowest (2.59%) was obtained from Binadhan-17 with 25 cm × 15 cm planting arrangement.

For the interaction effect of number of grains panicle^{-1} and Number of sterile spikelets panicle^{-1} was not significantly affected (Table 4). However, the maximum (348.67) number of grains panicle^{-1} was obtained from Binadhan-12 with planting arrangement 20 cm × 15 cm followed by (336.33) 15 cm × 15 cm planting arrangement with same variety and the minimum (146.33) was obtained from Binadhan-16 with 20 cm × 15 cm planting arrangement. However, highest number of sterile spikelets panicle^{-1} (88.00) was obtained from Binadhan-17 with15 cm × 15 cm planting arrangement **.** The sterility panicle^{-1} varies from (9.12 to 32.04%) due to interaction between varieties and planting arrangement (Table 4). The highest (32.04%) was obtained from Binadhan-17 with 15 cm × 15 cm planting arrangement.

Effect of variety Number of effective tillers m^{-2}, thousand grains weight, grain yield and straw yield

Number of effective tillers m^{-2} was significantly affected by variety (Table 5). Higher (294.65) number of bearing tillers m^{-2} was found from variety Binadhan-7 Significant variation was found on 1000 grains weight in varietals performance . It was evident from the results that Binadhan-16 produced the higher (23.72g) and the lower (18.56 g) from Binadhan-12.Grain yield was significantly affected by variety (Table 5). The highest grain yield (4.51 t ha^{-1}) was obtained from Binadhan-17 and which was statistically identical with variety Binadhan-7.The Lowest (3.00 t ha^{-1}) was obtained from Binadhan-12 which was statistically identical with variety Binadhan-16.Significant variation of straw yield was found among the varietal effects(Table 5).The highest straw yield (4.63 t ha^{-1}) was obtained from Binadhan-17 which was statistically identical with variety Binadhan-7.The lowest straw yield(2.89 t ha^{-1}) was obtained from Binadhan-16.

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Effect of planting arrangement Number of effective tillers m^{-2}, thousand grains weight, grain yield and straw yield

Highest number of effective tillers m^{-2} (305.90) was obtained from the 15 cm × 15 cm .The highest 1000 grain weight (19.14) was obtained from 25 cm × 20 cm planting arrangement. Grain yield was significantly varied due to planting arrangement effect (Table 5). The highest (4.31 t ha^{-1}) grain yield was obtained from planting arrangement 20 cm × 15 cm which was statistically identical with planting arrangement 25 cm × 15 cm. The lowest (3.49 t ha^{-1}) was obtained from 25 cm × 20 cm planting arrangement which was statistically identical with 20 cm × 20 cm and 15 cm × 15 cm. Straw yield was significantly affected by planting arrangement (Table 5). The highest (4.38 t ha^{-1}) was obtained from planting arrangement 25 cm × 15 cm followed by (4.08 t ha^{-1}) planting arrangement 20 cm × 15 cm and the lowest (3.68 t ha^{-1}) was obtained from 25 cm × 20 cm planting arrangement.

Effect of interaction on Number of effective tillers m^{-2}, thousand grains weight, grain yield and straw yield

Number of effective tillers m^{-2} was not significant due to interaction effects of variety and planting arrangement (Table 6). The highest number (379.22) of effective tillers m^{-2} was obtained fromBinadhan-7 with 15 cm × 15 cm followed by (313.30) at same variety with 20 cm × 15 cm planting arrangement. The highest (24.0g) was obtained from Binadhan-16 with 20 cm × 15 cm planting

arrangement followed by (23.83g) 20 cm × 20 cm planting arrangement with same variety and the lowest (12.26g) was obtained from Binadhan-12 with 25 cm × 20 cm planting arrangement. Grain yield was significantly affected by the interaction between variety and planting arrangement (Table 6). The highest grain yield (5.38 t ha^{-1}) was obtained from Binadhan-7 with 20 cm × 15 cm planting arrangement followed by (4.95 t ha^{-1}) 15 cm × 15 cm planting arrangement with Binadhan-17. The lowest grain yield (2.61 t ha^{-1}) was obtained from Binadhan-12 with 15 cm × 15 cm planting arrangement. The highest straw yield (5.67 t ha^{-1}) was obtained from Binadhan-17 with 20 cm × 15 cm planting arrangement which was followed by same variety (5.03 t ha^{-1}) with 25 cm × 15 cm planting arrangement. Plant spacing directly affect the normal physiological activities as well as yield (Oad *et al*. 2001). Grain yield was higher in wider spacing and lower in closer spacing. This might be due to limitation of light, nutrient, and water in close spacing plant and vice-versa.

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Conclusion

Results revealed that proper spacing options play an important role in increasing yield of rice. Optimum spacing provides sufficient nutrients and moisture for proper growth and development of crop. On the other hand, good combination of variety and planting arrangement weed infestation and maximum rice yield. Therefore, it may be concluded that variety Binadhan-7 produced highest yield at 20 cm × 15 cm planting arrangement. However further study is required to draw a definite conclusion.

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Table 1.Effect of variety and planting arrangement(s) on weed density, weed biomass, crop biomass and visual scoring on weed control in transplanted *Aman* rice

Variety	Weed density (m^{-2})	Weed biomass (g m^{-2})	Crop biomass (g m^{-2})	Visual scoring on weed control
Binadhan-7 (V_1)	69.73	88.03b	484.00a	5.06
Binadhan-12 (V_2)	88.66	130.65a	398.01b	6.53
Binadhan-17 (V_3)	90.93	131.87a	388.18b	6.00
Binadhan-16 (V_4)	65.73	78.27b	498.85a	5.26
Level of significance	NS	**	**	NS
$LSD_{(0.05)}$	23.27	20.38	54.09	2.59
Planting arrangement(s)				
25 cm × 20 cm (S_1)	98.83a	140.46a	453.69	6.33a
25 cm × 15 cm (S_2)	65.67b	83.41c	460.17	5.75a
20 cm × 20 cm (S_3)	107.67a	162.18a	438.65	6.33a
20 cm × 15 cm (S_4)	62.33b	86.91c	426.42	4.33b
15 cm × 15 cm (S_5)	59.33b	63.08d	432.37	5.83a
Level of significance	***	***	NS	**
CV (%)	26.81	20.09	13.56	27.61
$LSD_{(0.05)}$	17.56	17.91	49.87	1.31

transplanted *Aman* rice

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly.

***=0.1% level of significance,

** = 1% level of significance,

NS = Non-significant.

Table 2: Effect of interaction between variety and planting arrangement on weed density, weed biomass, crop biomass and visual scoring on weed control in transplanted *Aman* rice

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Variety×Planting arrangement (v×s)	Weed density(m^{-2})	Weed biomass(g m^{-2})	Crop biomass (g m^{-2})	Visual scoring on weed control
V_1× S_1	96.00bc	130.23de	626.81a	6.33
V_1× S_2	56.00c	34.07ij	505.81bcd	4.33
V_1× S_3	88.00bc	142.13bcde	388.64efgh	5.00
V_1× S_4	60.67c	90.33fgh	452.16bcdef	3.33
V_1× S_5	48.00c	43.37ij	446.57bcdefg	6.33
V_2× S_1	100.67ab	172.19b	343.57gh	6.66
V_2× S_2	76.00c	110.09efg	347.29gh	6.33
V_2× S_3	133.33a	165.68bcd	500.76bcd	7.33
V_2× S_4	58.67c	70.33hi	351.91fgh	5.00
V_2× S_5	74.67c	134.97cde	446.53bcdefg	7.33
V_3× S_1	112.00ab	168.68bc	376.17efgh	7.00
V_3× S_2	73.33c	127.32ef	439.44cdefgh	6.33
V_3× S_3	150.67a	254.72a	339.87h	6.33
V_3× S_4	54.67c	47.23ij	405.31defgh	5.00
V_3× S_5	64.00c	61.40hi	380.12efgh	5.33
V_4× S_1	86.67bc	90.75fgh	468.21bcde	5.33
V_4× S_2	57.33c	62.15hi	548.13ab	6.00
V_4× S_3	58.67c	86.17gh	525.35abc	6.66
V_4× S_4	75.33c	139.75bcde	496.29bcd	4.00
V_4× S_5	50.67c	12.56j	456.24bcde	4.33
Level of significance	*	***	***	NS
CV (%)	26.81	20.09	13.56	27.61

$LSD_{(0.05)}$	35.12	35.82	104.03	3.48

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly.

***=0.1% level of significance,

** = 1% level of significance,

NS = Non-significant

Table 3.Effect of variety and planting arrangement on Leaf chlorophyll content (SPAD value), Plant height (cm), Number of total tillers hill-1, Number of effective tillers hill-1, % Non-effective tillers hill-1, number of filled grains panicle-1, number of unfilled grains panicle-1 and %

Variety	Leaf chlorophyll content (SPAD value)	Plant height (cm)	Panicle Length (cm)	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	% Non-effective tillers hill^{-1}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	% Sterilitypanicle^{-1}
Binadhan-7 (V_1)	34.9bc	99.47	22.66a	11.06a	10.12a	8.50	197.20b	50.80	20.48
Binadhan-12 (V_2)	32.86c	101.11	22.06a	7.38b	6.77c	8.27	329.60a	46.20	12.29
Binadhan-17 (V_3)	40.02a	98.10	21.19b	8.02b	7.56bc	5.74	191.33b	76.86	28.66
Binadhan-16 (V_4)	37.07a	96.75	21.16b	9.74a	8.70ab	10.68	168.80b	44.00	20.68
Level of significance	**	NS	**	**	*	-	***	NS	-
$LSD_{(0.05)}$	11.07	4.36	3.51	19.0	23.0	-	22.32	77.01	-
Planting arrangement(s)									
25 cm × 20 cm (S_1)	36.48	99.72	22.03	10.21a	9.45a	7.44	223.00	45.66	17.00
25 cm × 15 cm (S_2)	36.27	99.65	21.97	9.15ab	8.40b	8.20	230.58	51.16	18.16
20 cm × 20 cm (S_3)	36.25	98.82	21.86	9.55ab	8.66ab	9.32	219.42	58.91	21.17
20 cm × 15 cm (S_4)	36.26	98.81	21.91	8.63bc	8.05b	6.72	215.50	60.08	21.80
15 cm × 15 cm (S_5)	35.83	97.26	21.07	7.73c	6.88c	11.00	220.17	56.50	20.42
Level of significance	NS	NS	NS	***	***	-	NS	NS	-
CV (%)	7.12	2.62	4.07	19.09	13.72	-	14.07	27.55	-
$LSD_{(0.05)}$	2.14	2.15	0.73	1.08	0.94	-	25.92	12.47	-

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly. *** = 0.1% level of significance, * = 5% level of significance, NS = Non-significant.

Table 4.Effect of interaction between variety and planting arrangement on leaf chlorophyll content (SPAD value), plant height, panicle length number of total tillers hill-1, number of effective tillers hill-1

Variety×Planting arrangement (v×s)	Leaf chlorophyll content (SPAD value)	Plant height (cm)	Panicle length(cm)	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	% Non-effective tillers hill^{-1}
V_1× S_1	35.03	99.04	22.92	11.46	10.80	5.76
V_1× S_2	34.00	102.42	23.46	12.00	10.86	9.50
V_1× S_3	37.00	97.63	22.83	12.00	11.00	8.303
V_1× S_4	34.76	100.96	22.92	10.00	9.40	6.00
V_1× S_5	33.86	97.29	21.18	9.86	8.53	13.49
V_2× S_1	32.53	103.38	22.15	9.13	8.46	7.34
V_2× S_2	33.90	99.29	22.21	6.40	6.00	6.25
V_2× S_3	32.13	102.79	22.00	7.80	6.86	12.05
V_2× S_4	32.83	100.33	22.73	7.33	7.00	4.50
V_2× S_5	32.90	99.75	21.23	6.26	5.33	14.86
V_3× S_1	40.36	99.63	21.93	9.53	8.80	7.66
V_3× S_2	39.60	100.33	20.99	7.73	7.53	2.59
V_3× S_3	40.06	96.42	21.28	7.93	7.40	6.68
V_3× S_4	39.80	97.37	21.09	8.13	7.80	4.06
V_3× S_5	40.26	96.75	20.68	6.80	6.26	7.94
V_4× S_1	38.00	96.88	21.13	10.73	9.73	9.32
V_4× S_2	37.60	96.58	21.23	10.46	9.20	12.05
V_4× S_3	35.80	98.46	21.35	10.46	9.40	10.13
V_4× S_4	37.66	96.58	20.89	9.06	8.00	11.70
V_4× S_5	36.30	95.25	21.21	8.00	7.20	10.00

Level of significance	NS	NS	NS	NS	NS	-
CV (%)	7.12	2.62	4.07	14.43	13.72	-
$LSD_{(0.05)}$	5.22	5.42	1.48	2.17	2.39	-

and % non-effective tillers hill^{-1} in transplanted

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly. *** = 0.1% level of significance, * = 5% level of significance, NS = Non-significant.

V1 = Binadhan-7, V2 = Binadhan-12, V3 = Binadhan-17, V4 = Binadhan-16,S1 = 25 cm × 20 cm, S2 = 25 cm × 15 cm, S3 = 20 cm × 20 cm, S4 = 20 cm × 15 cm, S5 = 15 cm × 15cm

Table 5.Effect of Variety and planting arrangement on number of effective tillersm^{-2}, thousand grains weight, grain yield and straw yield in transplanted *Aman* rice in 2016

Variety	Number of effective tillers m-2	Thousand grains weight (g)	Grain yield	Number of effective tillers m-2
Binadhan-7 (V_1)	294.65a	20.04b	4.38a	4.55a
Binadhan-12 (V_2)	196.03c	12.56d	3.00b	3.73b
Binadhan-17 (V_3)	220.06bc	18.96c	4.51a	4.63a
Binadhan-16 (V_4)	252.31ab	23.72a	3.42b	2.89c
Level of significance	**	***	***	***
$LSD_{(0.05)}$	21.95	2.03	13.15	15.99
Planting arrangement(s)				
25 cm × 20 cm (S_1)	189.00d	19.14a	3.49b	3.68c
25 cm × 15 cm (S_2)	223.94c	18.76b	4.10a	4.38a
20 cm × 20 cm (S_3)	216.67c	18.79b	3.66b	3.75bc
20 cm × 15 cm (S_4)	268.31b	18.79b	4.31a	4.08ab
15 cm × 15 cm (S_5)	305.90a	18.63b	3.55b	3.87bc
Level of significance	***	***	***	**
CV (%)	12.32	1.22	11.58	11.65
$LSD_{(0.05)}$	24.67	0.19	0.37	0.38

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly. *** = 0.1% level of significance, * = 5% level of significance, NS = Non-significant.

Table 6.Effect of interaction between variety and planting arrangement on number of grains panicle^{-1}, number of sterile spikelets panicle^{-1} and % sterility panicle^{-1}, number of effective tillers m^{-2}, thousand grains weight, grain yield and straw yield in transplanted *Aman* rice.

Variety×Planting arrangement (v×s)	Number of grains panicle^{-1}	Number of sterile spikelets panicle-1	% Sterility panicle^{-1}	Number of effective tillers m^{-2}	Thousand grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
V_1× S_1	213.33	59.00	21.66	216.00	20.88c	4.00cdef	4.14cdefg
V_1× S_2	187.33	51.66	21.62	289.71	19.72de	4.90ab	5.03ab
V_1× S_3	185.00	48.00	20.60	275.00	19.36e	4.24bcde	4.31bcdef
V_1× S_4	190.33	44.33	18.89	313.30	19.44de	5.38a	5.67a
V_1× S_5	210.00	51.00	19.54	379.22	20.84c	3.38fghij	3.60fghij
V_2× S_1	314.33	34.00	9.76	169.33	12.26j	2.91hij	3.72efghi
V_2× S_2	325.33	32.66	9.12	159.96	12.32j	3.16ghij	4.00defg
V_2× S_3	323.33	55.66	14.69	171.67	12.72i	2.82ij	3.34ghij
V_2× S_4	348.67	61.66	15.03	233.31	13.16h	3.50efghi	3.70efghi
V_2× S_5	336.33	47.00	12.26	245.90	12.36ij	2.61j	3.88efgh
V_3× S_1	173.33	49.00	22.04	176.00	19.88d	3.80defg	3.94efgh
V_3× S_2	223.00	83.33	27.20	200.84	19.28e	4.75abc	5.01abc
V_3× S_3	197.00	81.00	29.14	185.00	19.28e	4.37bcd	4.57bcde
V_3× S_4	176.67	83.00	31.96	259.97	18.54f	4.70abc	4.77bcd
V_3× S_5	186.67	88.00	32.04	278.49	17.84g	4.95ab	4.88abcd
V_4× S_1	191.00	40.66	17.55	194.67	23.56b	3.28fghij	2.91ijk
V_4× S_2	186.67	37.00	16.54	245.27	23.72ab	3.60defghi	3.49fghij
V_4× S_3	172.33	51.00	22.84	235.00	23.83ab	3.24fghij	2.76jk
V_4× S_4	146.33	51.33	25.97	266.64	24.03a	3.69defgh	2.16k
V_4× S_5	147.67	40.00	21.31	319.97	23.48b	3.29fghij	3.11hij
Level of significance	NS	NS	-	NS	***	*	**
CV (%)	14.07	27.55	-	12.32	1.22	11.58	11.65

$LSD_{(0.05)}$	51.90	43.46	-	24.67	0.48	0.74	0.88

In a column, figures having same letter (s) do not differ significantly and dissimilar letter (s) differ significantly. *** = 0.1% level of significance, * = 5% level of significance, NS = Non-significant.

V1 = Binadhan-7, V2 = Binadhan-12, V3 = Binadhan-17, V4 = Binadhan-16,S1 = 25 cm × 20 cm, S2 = 25 cm × 15 cm, S3 = 20 cm × 20 cm, S4 = 20 cm × 15 cm, S5 = 15 cm × 15cm