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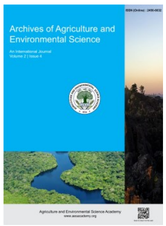

ORIGINAL RESEARCH ARTICLE

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Response of integrated fertilizer and weed management on weed occurrence and growth traits of aromatic *Boro* rice

Purnendu Roy[1], Md. Abdur Rahman Sarkar[1], Newton Chandra Paul[2], Kallyan Kanty Saha[1] and Swapan Kumar Paul[1*]

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, BANGLADESH
[2]Department of Agronomy, Khulna Agricultural University, Khulna, BANGLADESH
[*]Corresponding author's Email: skpaul@bau.edu.bd

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to study the effect of integrated fertilizer and weed management on the growth performance of aromatic *Boro* rice (cv. BRRI dhan50). The experiment comprised six fertilizer managements *viz.*, control (no manures and no fertilizers), recommended dose of inorganic fertilizers (*i.e.* Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, and 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} and four weed managements *viz.*, control (no weeding), pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + one hand weeding at 35 DAT, post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1} + one hand weeding at 35 DAT, pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}. The experiment was laid out in a factorial randomized complete block design with three replications. Growth traits of aromatic *Boro* rice (cv. BRRI dhan50) were significantly influenced by integrated fertilizer and weed management. Plant height, number of tillers hill^{-1}, total dry matter, leaf area index (LAI) and crop growth rate (CGR) gave their highest values in 75% of recommended dose of inorganic fertilizers and poultry manure @ 2.5 t ha^{-1} along with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1} while their corresponding lowest values were found in control. So it can be concluded that, the interaction of 75% of recommended dose of inorganic fertilizers and poultry manure @ 2.5 t ha^{-1} along with pre-emergence herbicide (Panida 33 EC @ 2.5 l ha^{-1}) + post-emergence herbicide (Granite 240 SC @ 93.70 ml ha^{-1}) appears as the promising combination in respect of growth performance of aromatic *Boro* rice (cv. BRRI dhan50).

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INTRODUCTION

Rice (*Oryza sativa* L.) is consumed as the staple food in Bangladesh and has been given the highest priority in meeting the demands of its ever-increasing population. It is the most important food crop and a primary food source for more than one-third of world's population (Singh and Singh, 2008; Aljumaili *et al*., 2018). Rice is the second most widely consumed cereal in the world next to wheat. About 74.85% of cropped area of Bangladesh is used for rice production, with annual production of 34.72 million ton from 11.52 million ha of land (BBS, 2019). *Boro* rice covers 4.79 million ha (41.94% of total rice area) of land with production of 19.56 million ton (BBS, 2019). Aromatic rice contributes a small but special group of rice which covers 2% of the national rice acreage of Bangladesh (Roy *et al*., 2018). Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive type and grown during *Aman* season (Kabir *et al*., 2004) while BRRI dhan50 (*Banglamati*) recommended for only *Boro* season (Paul *et al*., 2020). Proper growth is prerequisite for higher yield of rice. Integrated fertilizer and weed management are directly influence the growth, yield and quality of aromatic rice. Continuous use of chemical fertilizers without organic sources will lead to gradual decline of organic matter content and change of native N status in the soils, which results in lower productivity (Amanullah and Hidayatullah, 2016). Judicious use of chemical and organic fertilizers can improve rice plant growth, and increase rice yield and quality (Sarkar *et al*., 2016; Jahan *et al*., 2017; Paul *et al*., 2020). Integrated use of chemical fertilizers along with organic manure has been widely recommended for sustaining agricultural production (Amanullah and Khalid, 2016). Weeds are major causes of yield loss in upland rice and its control is labour intensive. The climate as well as the edaphic condition of Bangladesh is favourable for the growth of weeds. So, the rice crops usually infested heavily with weeds resulting in the reduction in grain yield by 70–80%, 30–40% and 22–36% in *Aus, Aman* and *Boro* season, respectively in Bangladesh (Sarkar *et al*., 2017). Due to weed infestation aromatic rice lost its grain yield by 59.82% for BRRI dhan50 in *Boro* season (Sinha *et al*., 2018) and 28.16% for Binadhan-9 in *Aman* season (Zannat *et al*., 2014). There is no doubt that maximum benefit for costly inputs like fertilizers and pesticides in rice can be fully derived when the crop is kept free from weed infestation. The traditional method of weed control is hand weeding which is very much laborious and time consuming. Mechanical weeding and herbicides are the alternative to hand weeding. Japanese rice weeders are in use in some areas of the country. But due to some disadvantages to its use, it has not gained wide spread popularity. Herbicides are effective in controlling weeds alone or in combination with hand weeding. Weed competition at early growth stage can be eliminated through pre-emergence and post-emergence herbicides like Panida, Ronstar 25 EC, Rifit 50 EC, Granait 240 SC and 2, 4-D amine which are good selective, pre-emergence and post-emergence herbicides (Ahmed *et al*., 2005). The efficient fertilizer management increases the vegetative growth of crop and at the same time reduces fertilization cost. Therefore, the present study was undertaken to evaluate the effects of integrated fertilizer and weed management on the growth performance of aromatic Boro rice (cv. BRRI dhan50).

MATERIALS AND METHODS

Experimental site and experimentation

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (24° 75' N latitude and 90° 50' E longitude and at an altitude of 18 meter above the sea level), Mymensingh during the period from December 2014 to May 2015 to study the effect of integrated fertilizer and weed management on the growth performance of aromatic *Boro* rice (cv. BRRI dhan50). The experimental site belongs to the Sonatola series of the dark grey floodplain soil type under Old Brahmaputra Floodplain Agro-Ecological Zone (AEZ-9). The field was a medium high land with well drained silty -loam texture having pH 6.5 and 1.29% organic matter content. The experiment comprised six fertilizer managements *viz*., control (no manures and no fertilizers), recommended dose of inorganic fertilizers (*i.e.* Urea, TSP, MoP, Gypsum, $ZnSO_4$@ 250, 120, 120, 100, 10 kg ha^{-1},respectively), 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, and 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} and four weed managements *viz*., control (no weeding), pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, pre-emergence herbicide, Panida 33 EC + post-emergence herbicide, Granite 240 SC. The experiment was laid out in a factorial randomized complete block design with three replications.

Crop husbandry

Healthy seeds of BRRI dhan50 rice were collected from the Bangladesh Rice Research Institute, Joydebpur, Gazipur. The nursery beds were puddled with country plough, cleaned and leveled with ladder. Then the sprouted seeds were sown in the nursery beds on 07 December 2014. At the time of final land preparation, respective unit plots were amended with organic and inorganic fertilizers according to treatment specification. Urea was top dressed in three equal splits at 15, 35 and 55 DAT (panicle initiation stage). Full dose of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation. Thirty five-day old seedlings were transplanted on 10 January 2015 in the well puddled plot with a spacing of 25 cm × 15 cm and two-seedling $hill^{-1}$.

Data collection on growth traits

Five hills were marked by bamboo stick excluding boarder rows to collect data on plant height and tiller number. Five hills were destructed every sampling dates for leaf area index. Data on crop growth parameters *viz*., plant height, number of tillers $hill^{-1}$ and leaf area index were taken at intervals of 15 days at 20, 35, 50, 65 and 80 DAT. The leaf area was measured by an automatic leaf area meter (Type AAN-7, Hayashi Dam Ko Co., Japan). Leaf area index was calculated as the ratio of total leaf area and total ground area of the sample as described by Hunt (1978).

$$LAI = LA/P$$

Where,

LAI = Leaf area index

LA = Total leaf area of the leaves of all the sampled plants (cm^2)

P = Area of the ground surface covered by the plant (cm^2)

In order to collect samples, five sample plants were uprooted from each plot at 15 day intervals up to 80 DAT and were cleaned, de-rooted and leaves were separated from the culms. Collected samples were dried in an electric oven for 72 hours maintaining a constant temperature of 70°C. After drying, weight of each sample was recorded. Crop growth rate refers to increase of plant dry matter production per unit of time per unit of ground area. It was calculated with the following formula.

$$CGR = \frac{1}{A} \times \frac{W_2 - W_1}{T_2 - T_1} \text{ g m}^{-2} \text{ day}^{-1}$$

Where,
W_1 = dry matter production at T_1 time
W_2 = dry matter production at T_2 time
A= ground area (m^2)

The weed density and dry weight of infesting weed species were recorded at 60 DAT in all weeding treatments with the help of a plant quadrate measuring 1.0 m × 1.0 m as per method described by Cruz *et al.* (1986) from each plot. To determine the plant total dry weight and weed dry weight, the plant and the weed samples were collected. The collected weeds were dried in an electric oven for 72 hours at a temperature of 85 ± 5° C. After drying, the dry weight of each plot was recorded by an electrical balance.

Statistical analysis of data

The recorded data were statistically analyzed using the "Analysis of Variance" technique and the differences among treatment means were adjudged by Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weed parameters

Weed flora: Weeds found in aromatic *Boro* rice (cv. BRRI dhan50) field are aquatic, semi aquatic, broad leaved and grasses which can withstand water logging usually enough to depress crop yield very significantly if not controlled (Sinha *et al*., 2018 and Paul *et al*., 2019). Conditions favourable for growing aromatic *Boro* rice (cv. BRRI dhan50) are also favourable for the exuberant growth of a number of weed species that compete with crop plants. The experimental plots were infested with thirteen weed species belonging to six families (Table 1). Five weed species were of the family Gramineae, three of the family Cyperraceae, one of the family Oxalidaceae and Araceae and Verbenaceae and two of the family Potenderiaceae. Among the total weed vegetation most of them were annual.

Weed dry weight: The interaction between integrated fertilizer and weed management had significant effect on total weed dry weight m^{-2} at 60 DAT (Figure 1). The highest weed dry weight 22.7 g was found in $F_5 \times W_0$ (75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} with control (unweeded) and the lowest weed dry weight (1.76g) was found in $F_0 \times W_3$ (no fertilizer and no manure with pre-emergence herbicide, Panida 33 EC + post-emergence herbicide, Granite 240 SC) which was statistically identical with $F_0 \times W_1$ (no fertilizer and no manure with pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT), $F_0 \times W_2$ (no fertilizer and no manure with post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT) (Figure 1). Similar results were reported elsewhere (Gnanavel and Anbhazhagan, 2010; Sinha *et al*., 2018 and Paul *et al*., 2019) who reported that maximum weed dry weight was observed in the weedy check plots compared to other weed control treatments.

Growth traits of plant

Plant height: The interaction effect of integrated fertilizer and weed management exhibited significant influence on plant height at all sampling dates (Table 2). The tallest plant stature (78.53 cm) was at 80 DAT in $F_5 \times W_3$ (75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide Granite 240 SC @ 93.70 ml ha^{-1}) and the shortest plant stature (68.40 cm) was in $F_0 \times W_0$ (no fertilizers and no manure under unweeded condition) which was statistically identical to the treatment $F_0 \times W_1$ (no fertilizers and no manure with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + one hand weeding at 35 DAT) and $F_0 \times W_3$ (no fertilizers and no manure with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}) (Table 2). Similar trend in plant height was reported by Sarkar *et al.* (2016) and Jahan *et al.* (2017) who documented that integrated manure inorganic fertilizers and also weed management are the important ones in boosting the vegetative growth of rice. Islam *et al.* (2014) reported that three weeding at 15, 30 and 45 DAT along with with 50% BRRI recommended chemical fertilizers + poultry manure @ 2.5 t ha^{-1}produced tallest plants compared to control.

Number of tillers hill^{-1}: Tiller production ability in rice is an important agronomic trait for panicle number per unit land area as well as grain production (Badshah *et al*., 2014). Tiller number varied significantly among the treatment interactions at all crop growth stages (Table 3). The highest number of tillers (23.47) was obtained was at 80 DAT from $F_5 \times W_3$(75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}) which was statistically identical to the treatment $F_5 \times W_1$ (75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + one hand weeding at 35 DAT) while the lowest values (9.53) was obtained from $F_0 \times W_0$ (no fertilizers and no manure under unweeded condition) (Table 3). Inadequacy of nutrients in control plots hampered tiller production in rice compared to

Table 1. Infesting species of weeds in the experimental field of aromatic *Boro* rice (cv. BRRI dhan50).

Common name	English name	Scientific name	Family name	Life cycle
Shama	Barnyard grass	*Echinochloa crus-galli* L. Beauv.	Gramineae	Annual
Angta	Joint grass	*Panicum repens* L.	Gramineae	Perennial
Panikachu	Pickerel weed	*Monochoria vaginalis* (Burm. f.) Presl.	Pontederiaceae	Perennial
Halood mutha	Yellow nutsedge	*Cyperus esculentus* L.	Cyperraceae	Annual
Chesra	Bulrush	*Scirpus juncoides* Roxb.	Cyperraceae	Annual
Anguli ghash	Crab grass	*Digitaria sanguinalis* L.	Gramineae	Annual
Arail	Southern cutgrass	*Leersia hexandra* Sw.	Gramineae	Annual
Joina	Grass like fimbristylis	*Fimbristylis milliaceae* L.	Cyperraceae	Annual
Motka	Bushy matgrass	*Lippia germinata* H.B.K.	Verbenaceae	Annual
Topapana	Water lettuce	*Pistia stratiotes* Var.	Araceae	Perennial
Chela ghash	Curved sicklegrass	*Parapholis incurva* (L.) C. E. Hubb	Gramineae	Perennial
Kachuripana	Water hyacinth	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	Perennial
Amrul	Yellow wood sorrel	*Oxalis europaea* Jord.	Oxalidaceae	Annual

Table 2. Effect of interaction between integrated fertilizer and weed management on plant height at different days after transplanting of aromatic *Boro* rice (cv. BRRI dhan50).

Integrated fertilizer × weed management	Plant height (cm)				
	Days after transplanting (DAT)				
	20 DAT	35 DAT	50 DAT	65 DAT	80 DAT
$F_0 \times W_0$	21.27c	33.67i	47.80ghi	61.33efgh	68.40g
$F_0 \times W_1$	18.40d	32.53i	46.53i	58.20gh	70.53fg
$F_0 \times W_2$	21.23c	34.00i	47.53hi	59.20gh	69.13fg
$F_0 \times W_3$	22.19bc	34.27i	47.59ghi	58.80gh	69.80efg
$F_1 \times W_0$	23.60ab	38.67fgh	52.02bcdef	65.27bcd	72.13cdefg
$F_1 \times W_1$	23.10abc	39.67efg	51.33defg	60.53fgh	74.40abcde
$F_1 \times W_2$	22.20bc	40.33ef	50.73efgh	59.93gh	71.00defg
$F_1 \times W_3$	22.37abc	38.73fgh	50.37efgh	60.67fgh	72.00cdefg
$F_2 \times W_0$	22.47abc	37.60gh	47.73ghi	57.40h	69.40fg
$F_2 \times W_1$	22.53abc	41.50cde	53.67bcde	65.13bcde	74.87abcd
$F_2 \times W_2$	22.87abc	40.53def	54.73abcd	66.27abc	74.67abcd
$F_2 \times W_3$	23.13abc	36.93h	53.47bcde	64.47bcdef	74.17abcde
$F_3 \times W_0$	22.60abc	40.13ef	49.57fghi	59.07gh	70.97defg
$F_3 \times W_1$	23.40ab	40.47def	49.60fghi	64.13cdef	73.47bcdef
$F_3 \times W_2$	24.13ab	41.60cde	50.43efgh	58.57gh	73.13bcdef
$F_3 \times W_3$	23.33ab	40.20ef	50.47efgh	59.80gh	71.47cdefg
$F_4 \times W_0$	24.30a	45.60a	55.50ab	66.13abc	76.00abc
$F_4 \times W_1$	23.57ab	40.20ef	51.25defgh	61.80defg	71.87cdefg
$F_4 \times W_2$	22.39abc	43.40abc	57.77a	68.47ab	76.80ab
$F_4 \times W_3$	24.30a	43.50abc	58.27a	69.80a	77.47ab
$F_5 \times W_0$	23.63ab	42.67cd	51.63cdef	60.90fgh	71.33defg
$F_5 \times W_1$	23.93ab	45.40ab	53.40bcde	66.63abc	78.20a
$F_5 \times W_2$	23.87ab	43.53abc	55.53ab	65.50bcd	77.20ab
$F_5 \times W_3$	23.83ab	43.27bc	55.17abc	65.57bcd	78.53a
$S\bar{x}$	0.594	0.721	1.12	1.21	1.37
Level of significance	*	**	**	**	**
CV (%)	4.51	3.14	3.76	3.35	3.23

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; * = Significant at 5% level of probability.

F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

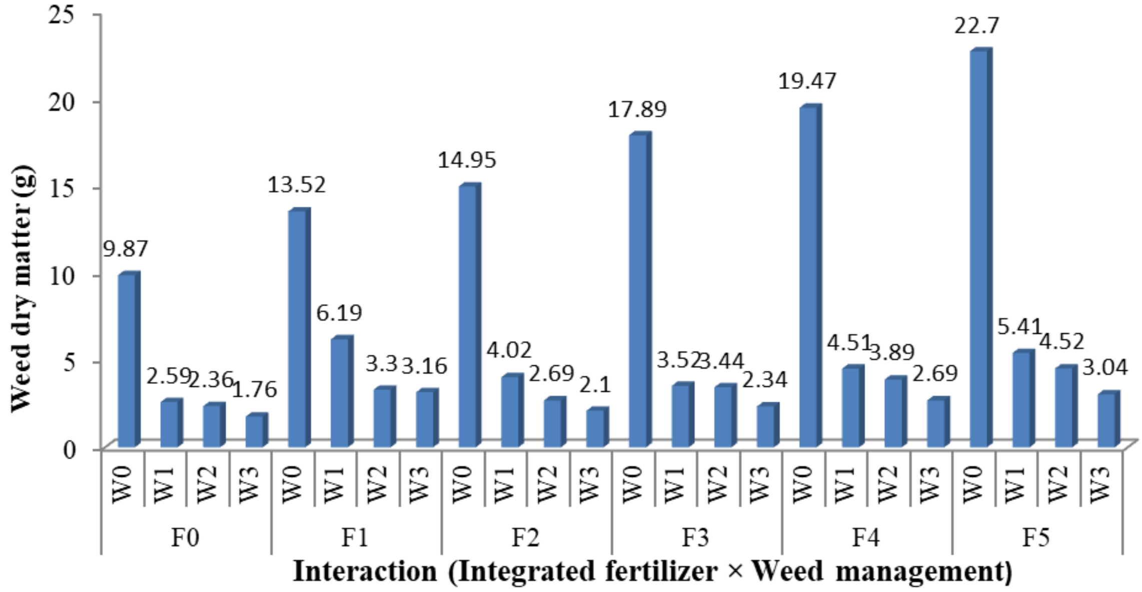

Figure 1. *Effect of interaction between integrated fertilizer and weed management on weed dry weight at 60 DAT of aromatic Boro rice (cv. BRRI dhan50).*

F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post -emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

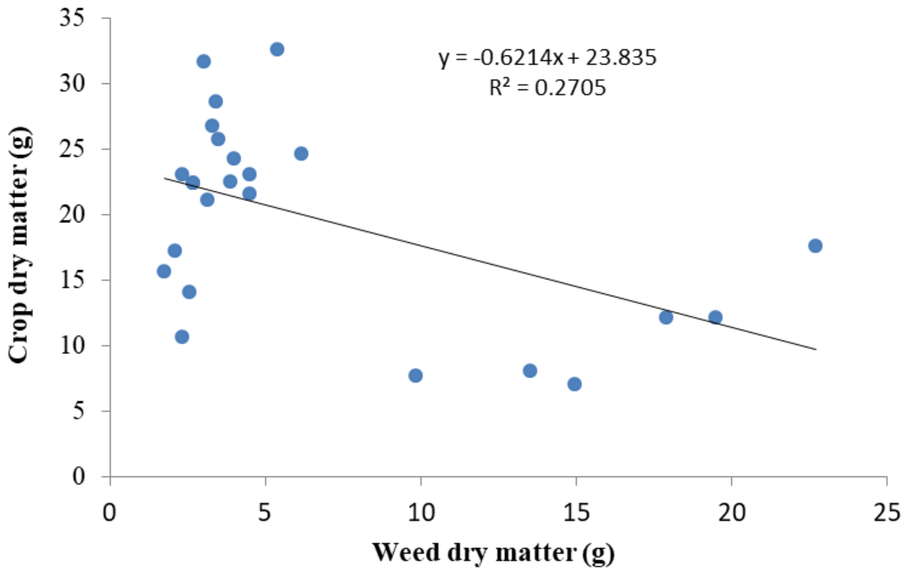

Figure 2. *Functional relationship between weed and crop dry matter at 60 DAT of fine aromatic Boro rice (cv. BRRI dhan50).*

other treatments with nutrient. On the other hand, weeding kept the land with lowest weed population density which reduced the competitive ability of weeds for nutrients and other growth factors with crop facilitate to absorb greater amount of plant nutrients, moisture and greater reception of solar radiation for growth resulted in higher number of tillers $hill^{-1}$. On the other hand, in weedy check plots weeds were allowed to grow without restriction, which competed with crop throughout its life cycle, consequently, it reduced crop growth and yield. These results corroborate with the findings of Choudhury *et al*. (1995) and Sinha *et al.* (2018) who reported that tiller production $hill^{-1}$ significantly differed with weeding treatments due to weed crop competition.

Leaf area index (LAI): The interaction between integrated fertilizer and weed management had significant effect on leaf area index at all sampling dates (Table 4). Irrespective of treatment combinations the leaf area index was increased in course of time up to 65 DAT and thereafter declined. Similar trend was depicted by Paul *et al.* (2013) and Paul *et al.* (2014). The results indicate that the interaction of $F_5 \times W_3$ (75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}) produced the highest the leaf area index (6.26) at 65 DAT. The second highest leaf area index was produced from interaction of $F_5 \times W_2$ (75% of recommended dose of inorganic fertilizer + poultry

Table 3. Effect of interaction between integrated fertilizer and weed management on number of total tillers hill^{-1} at different days after transplanting of aromatic *Boro* rice (cv. BRRI dhan50).

Integrated fertilizer x weed management	Number of tillers hill^{-1}				
	Days after transplanting (DAT)				
	20 DAT	35 DAT	50 DAT	65 DAT	80 DAT
$F_0 \times W_0$	2.40g	4.20j	5.54h	7.94h	9.53j
$F_0 \times W_1$	2.80fg	4.34j	7.60g	9.93g	13.07hi
$F_0 \times W_2$	2.87ef	6.14hi	8.267fg	11.40fg	13.33hi
$F_0 \times W_3$	3.20cdef	6.14hi	9.167efg	15.37de	17.27def
$F_1 \times W_0$	3.467abc	5.67i	9.067fg	11.40fg	15.58fgh
$F_1 \times W_1$	3.333abcde	8.74bcde	12.53bc	16.40cd	20.60abc
$F_1 \times W_2$	3.733ab	8.87abcd	13.07bc	18.03bc	22.47a
$F_1 \times W_3$	3.200cdef	7.20fgh	11.40cd	15.73de	19.07bcd
$F_2 \times W_0$	3.533abc	7.60efg	9.87def	10.73fg	12.13i
$F_2 \times W_1$	3.467abc	9.07abc	15.67a	19.07ab	22.47a
$F_2 \times W_2$	3.533abc	10.00ab	16.07a	18.83ab	21.67ab
$F_2 \times W_3$	3.400abcd	7.67defg	15.67a	18.53ab	20.97abc
$F_3 \times W_0$	3.20cdef	8.27cdef	11.13cde	12.20f	14.70fghi
$F_3 \times W_1$	3.40abcd	9.00abc	12.80bc	14.27e	16.33efg
$F_3 \times W_2$	3.34abcde	9.94ab	16.13a	19.67ab	23.00a
$F_3 \times W_3$	3.20cdef	8.20cdef	14.20ab	18.13bc	21.47abc
$F_4 \times W_0$	2.93def	6.94gh	9.930def	12.00f	13.80ghi
$F_4 \times W_1$	3.40abcd	9.33abc	15.87a	19.07ab	22.53a
$F_4 \times W_2$	3.27bcdef	8.600cde	13.20bc	16.00de	18.67cde
$F_4 \times W_3$	3.67abc	10.13a	15.73a	18.13bc	21.27abc
$F_5 \times W_0$	3.40abcd	8.800bcde	12.40bc	14.37e	16.27efg
$F_5 \times W_1$	3.47abc	10.13a	15.87a	19.07ab	22.20a
$F_5 \times W_2$	3.80a	10.00ab	15.27a	18.07bc	20.73abc
$F_5 \times W_3$	3.80a	10.00ab	16.20a	20.27a	23.47a
$S\bar{x}$	0.146	0.381	0.648	0.627	0.862
Level of significance	*	**	**	**	**
CV (%)	7.59	8.14	8.91	6.96	8.11

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; * = Significant at 5% level of probability.
F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post -emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

manure @ 2.5 t ha^{-1} with post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT) which was statistically identical to the interaction of $F_1 \times W_3$ (Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}). The lowest leaf area index was recorded (0.85) in the interaction of $F_0 \times W_0$ (no fertilizers and no manure under unweeded condition) at the 65 DAT (Table 4). Weed free condition favoured congenial environment for crop growth. The crop population was maximum in weed free plots than weedy check which facilitated the crop for absorption of greater amount of nutrients, moisture and greater reception of solar radiation for growth resulted in higher number of tillers hill^{-1} and leaves tiller^{-1}. The increase in LAI may be due to production of higher number of tillers plant^{-1} and leaves tiller^{-1} was reported by Sarath and Thailak (2004).

Dry matter production: Interaction effects of integrated fertilizer and weed management exhibited significant influence on total dry matter production at all sampling dates except 20 DAT (Table 5). The total dry matter production hill^{-1} increased in course of time and reached maximum at final sampling date at 80 DAT. Similar result was reported by Kant *et al.* (2018). Total dry matter production of $F_5 \times W_1$ (75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + one hand weeding at 35 DAT) gave the maximum dry matter (32.59g hill^{-1} at 80 DAT). While the lowest values (7.01g) was obtained from $F_2 \times W_0$ (50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1} with weedy check (unweeded) which was statistically identical to $F_0 \times W_0$ (under application of no fertilizer and no manure with weedy check (unweeded) at 80 DAT (Table 5). Integrated nutrient management influenced plant growth resulting higher dry matter accumulation than sole application of chemical fertilizer or manures. Fertilizer applied in conjunction with organic manure produced equivalent or even highest dry matter and N uptake than inorganic sources (Saravanan *et al.*, 1987 and Katsura *et al.*, 2007) reported that higher grain yield was obtained due to large biomass accumulation before heading which resulted from its leaf area duration (LAD) than its radiation use efficiency (RUE). Under weed free condition the crop plants treated with 50% recommended dose of chemical fertilizers + poultry manure @ 2.5 t ha^{-1} gave the maximum dry matter was reported by Islam *et al.* (2014).

Table 4. Effect of interaction between integrated fertilizer and weed management on leaf area index at days after transplanting of aromatic *Boro* rice (cv. BRRI dhan50).

Integrated fertilizer x weed management	Leaf area index (LAI)				
	Days after transplanting (DAT)				
	20 DAT	35 DAT	50 DAT	65 DAT	80 DAT
$F_0 \times W_0$	0.073l	0.2567j	0.557j	0.854f	0.747h
$F_0 \times W_1$	0.083l	0.3098j	1.18i	2.05e	1.89g
$F_0 \times W_2$	0.093kl	0.3431j	1.24hi	2.16e	2.02g
$F_0 \times W_3$	0.083l	0.2868j	1.27hi	2.13e	1.93g
$F_1 \times W_0$	0.096kl	0.4436i	1.30hi	2.20e	2.04g
$F_1 \times W_1$	0.113jk	0.8328f	2.04f	3.39d	3.04f
$F_1 \times W_2$	0.123hij	0.8508f	2.12f	3.40d	3.02f
$F_1 \times W_3$	0.146defgh	1.335ab	3.15bc	4.85b	4.48c
$F_2 \times W_0$	0.156cdef	0.4520i	1.28hi	2.15e	2.01g
$F_2 \times W_1$	0.150defg	0.7008h	2.74e	3.83cd	3.49de
$F_2 \times W_2$	0.130ghij	0.6665h	2.66e	4.23c	3.59d
$F_2 \times W_3$	0.146defgh	0.6729h	2.60e	3.84cd	3.20ef
$F_3 \times W_0$	0.120ij	0.4521i	1.37gh	2.28e	2.05g
$F_3 \times W_1$	0.140efghi	0.8257f	2.96d	3.96c	3.67d
$F_3 \times W_2$	0.136fghij	0.8107fg	2.93d	4.23c	3.63d
$F_3 \times W_3$	0.136fghij	0.7264gh	2.61e	4.01c	3.67d
$F_4 \times W_0$	0.153defg	0.8308f	1.49g	2.33e	2.12g
$F_4 \times W_1$	0.146defgh	1.077e	3.03cd	4.12c	3.74d
$F_4 \times W_2$	0.156cdef	1.110e	3.08bcd	4.15c	3.74d
$F_4 \times W_3$	0.163cde	1.152de	3.02cd	4.28c	3.72d
$F_5 \times W_0$	0.170bcd	0.8480f	1.50g	2.42e	2.09g
$F_5 \times W_1$	0.190ab	1.249bc	3.23b	4.25c	3.81d
$F_5 \times W_2$	0.180bc	1.220cd	3.26b	4.98b	5.07b
$F_5 \times W_3$	0.206a	1.416a	3.67a	6.26a	5.73a
$S\bar{x}$	0.00750	0.031	0.058	0.153	0.106
Level of significance	**	**	**	**	**
CV (%)	9.49	6.79	4.41	7.76	5.90

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; * = Significant at 5% level of probability.
F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post -emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

Crop growth rate: The interaction effect of integrated fertilizer and weed management on crop growth rate was significant at all sampling dates (Table 6). The highest crop growth rate (42.23 g m^2 day^{-1}) was observed in $F_5 \times W_3$(75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} with pre-emergence herbicide, Panida 33 EC + post-emergence herbicide, Granite 240 SC) at 65-80 DAT. The lowest crop growth rate (3.66 g m^2 day^{-1}) was observed in $F_0 \times W_0$(no fertilizers and no manure under unweeded condition) (Table 6). Weeding kept the land clean and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth resulted in higher CGR. This result is in line with findings of Kamal *et al.* (2007) and Kant *et al.* (2018). Paul *et al.* (2014) also reported that three weedings with 50% recommended chemical fertilizers along with poultry manure showed the highest values of CGR.

Functional relationship between weed and crop dry matter of aromatic *Boro* rice (cv. BRRI dhan50)

A negative linear relationship between weed dry matter and crop dry matter of fine aromatic *Boro* rice, which indicated that higher the weed dry matter the lower the crop dry matter. The relationship of weed dry matter and crop dry matter of fine aromatic *Boro* rice was determined by using the respective interaction data between integrated fertilizer and weed management. The response of weed dry matter to the crop dry matter of fine aromatic *Boro* rice followed a linear negative relationship which could be adequately described by regression equation. In Figure 2, the regression equation indicates that an increase in weed dry matter would lead to a decrease in the crop dry matter of fine aromatic *Boro* rice. The functional relationship was significant at $p \leq 0.01$. The functional relationship can be determined by the regression equation Y = -0.6214x + 23.835 (R^2 = 0.2705). The functional relationship revealed that 27% of the variation in crop dry matter could be explained from the variation in weed dry matter. Dry matter production of crop and weed are directly related to grain yield of rice was documented by Paul *et al.* (2019).

Table 5. Effect of interaction between integrated fertilizer and weed management on total dry matter at days after transplanting of aromatic *Boro* rice (cv. BRRI dhan50).

Integrated fertilizer x weed management	Total dry matter (g hill^{-1})				
	Days after transplanting (DAT)				
	20 DAT	35 DAT	50 DAT	65 DAT	80 DAT
$F_0 \times W_0$	0.21	0.520j	2.167o	3.707l	7.713m
$F_0 \times W_1$	0.24	0.843i	2.273o	4.100l	14.06j
$F_0 \times W_2$	0.22	1.207h	2.803n	6.507jk	10.64l
$F_0 \times W_3$	0.26	1.097h	3.687m	6.560j	15.69i
$F_1 \times W_0$	0.32	1.103h	3.393m	6.037k	8.093m
$F_1 \times W_1$	0.26	1.643g	6.860fgh	12.95b	24.62d
$F_1 \times W_2$	0.25	1.973f	6.243ijk	12.10d	26.74c
$F_1 \times W_3$	0.29	2.087def	7.427abc	12.12d	21.09g
$F_2 \times W_0$	0.32	1.083h	2.250o	3.187m	7.013m
$F_2 \times W_1$	0.25	1.500g	7.103cdef	12.31cd	24.30d
$F_2 \times W_2$	0.26	1.573g	7.517abc	15.15a	22.38ef
$F_2 \times W_3$	0.26	1.597g	6.563ghi	9.230gh	17.21h
$F_3 \times W_0$	0.34	2.850b	6.093k	8.100i	12.17k
$F_3 \times W_1$	0.33	2.203cdef	7.670ab	12.36cd	25.75c
$F_3 \times W_2$	0.35	2.260cde	7.753a	12.39cd	28.66b
$F_3 \times W_3$	0.33	2.293cd	7.440abc	12.84bc	23.05e
$F_4 \times W_0$	0.33	2.277cd	6.913defgh	9.287gh	12.14k
$F_4 \times W_1$	0.35	2.160cdef	5.480l	9.680g	21.59fg
$F_4 \times W_2$	0.34	2.143cdef	7.310bcde	11.49e	22.51ef
$F_4 \times W_3$	0.34	2.183cdef	6.957defg	12.42cd	22.37ef
$F_5 \times W_0$	0.34	2.017ef	6.913efgh	10.60f	17.59h
$F_5 \times W_1$	0.35	3.167a	6.513hij	8.837h	32.59a
$F_5 \times W_2$	0.36	2.390c	6.123jk	8.217i	23.07e
$F_5 \times W_3$	0.39	2.393c	7.347abcd	10.38f	31.64a
$S\bar{x}$	0.0182	0.075	0.135	0.174	0.364
Level of significance	NS	**	**	**	**
CV (%)	11.13	7.05	4.00	3.14	3.21

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability, NS = Not significant; * = Significant at 5% level of probability.
F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post -emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

Table 6. Effect of interaction between integrated fertilizer and weed management on crop growth rate at different days after transplanting of aromatic *Boro* rice (cv. BRRI dhan50).

Integrated fertilizer x weed management	Crop growth rate (CGR) ($g\ m^{-2}\ day^{-1}$)			
	Days after transplanting (DAT)			
	20-35 DAT	35-50 DAT	50-65 DAT	65-80 DAT
$F_0 \times W_0$	0.553i	2.930l	2.737l	3.657l
$F_0 \times W_1$	1.060h	2.547lm	3.247kl	17.71gh
$F_0 \times W_2$	1.753g	2.837l	6.583g	7.347k
$F_0 \times W_3$	1.490g	4.603k	5.110hi	16.23hi
$F_1 \times W_0$	1.397gh	4.070k	4.700hij	5.080kl
$F_1 \times W_1$	2.453f	9.273bcde	10.83b	20.75f
$F_1 \times W_2$	3.067de	7.590h	10.42bc	26.02de
$F_1 \times W_3$	3.190cde	9.497bcd	8.347ef	15.94hi
$F_2 \times W_0$	1.353gh	2.073m	1.667m	7.12k
$F_2 \times W_1$	2.220f	9.967ab	9.263de	21.32f
$F_2 \times W_2$	2.330f	8.57b	11.57a	12.85j
$F_2 \times W_3$	2.367f	8.833defg	4.740hij	14.19ij
$F_3 \times W_0$	4.457b	5.767j	3.570jkl	7.233k
$F_3 \times W_1$	3.333cde	9.720bc	8.337ef	23.81e
$F_3 \times W_2$	3.390cde	9.767bc	8.250ef	28.93c
$F_3 \times W_3$	3.497cd	9.153cdef	9.593cd	18.16gh
$F_4 \times W_0$	3.467cd	8.243gh	4.220ijk	6.807kl
$F_4 \times W_1$	3.220cde	5.907j	7.467fg	21.18f
$F_4 \times W_2$	3.213cde	9.183cdef	7.427fg	19.59fg
$F_4 \times W_3$	3.273cde	8.487fg	9.720cd	17.69gh
$F_5 \times W_0$	2.987e	8.707efg	6.560g	12.42j
$F_5 \times W_1$	5.007a	5.953j	4.130ijk	37.43b
$F_5 \times W_2$	3.617c	6.637i	3.723jkl	26.40d
$F_5 \times W_3$	3.557c	6.82hji	10.61a	42.23a
$S\bar{x}$	0.132	0.235	0.365	0.810
Level of significance	**	**	**	**
CV (%)	8.35	5.73	9.52	7.84

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; * = Significant at 5% level of probability.
F_0 = Control (no fertilizer and no manure), F_1 = Recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), F_2 = 50% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizer + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}, W_0 = control (unweeded), W_1 = pre-emergence herbicide, Panida 33 EC + one hand weeding at 35 DAT, W_2 = post-emergence herbicide, Granite 240 SC + one hand weeding at 35 DAT, W_3 = pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post -emergence herbicide, Granite 240 SC @ 93.70 ml ha^{-1}.

Conclusion

From the present study it can be concluded that application of 75% of recommended dose of inorganic fertilizers and poultry manure @ 2.5 t ha^{-1} along with pre-emergence herbicide, (Panida 33 EC @ 2.5 l ha^{-1}) + post-emergence herbicide (Granite 240 SC @ 93.70 ml ha^{-1}) may be used to boosting the growth performance of aromatic *Boro* rice (cv. BRRI dhan50).

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