EFFECT OF GREEN GROWTH REGULATOR AND HERBICIDES ON THE DRY MATTER PARTITIONING AND YIELD OF BARO RICE IN DIRECT SEEDING METHOD

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ABSTRACT

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An experiment was carried out at the experimental field of Bangladesh Institute of Nuclear Agriculture, Mymensingh, during the period from February to May 2005 to investigate the effect of green growth regulator (GGR-6) and herbicides on the dry matter partitioning and yield contributing characters of *Boro* rice (cv. Iratom-24) in direct seeding method. The concentration of GGR-6 was 0 (control) and 30ppm of aqueous solution. The herbicides were Machete 5G and Ronstar25 EC at the rate of 25 kg ha^{-1} and 2 litre ha^{-1} respectively. The green growth regulator and herbicides had positive effect on dry matter partitioning and yield contributing characters. GGR-6 at 30ppm and Machete 5G under direct seeding with plant spacing 25cm x 20cm was the best for ,dry weight of leaves hill^{-1}, dry weight of stem hill^{-1}, total dry matter, number of filled grains panicle^{-1} while 1000-grain weight were non-significant.. The highest grain growth rate was found from direct seeding with plant spacing 25cm x 20cm and GGR-6 at 30ppm. Interaction effect on direct seeding method, herbicides and GGR-6 on grain growth was non-significant. GGR-6 at 30ppm and Machete 5 G under direct seeding method with plant spacing 20cm x 20cm possessed better yield contributing characters resulted in the highest grain yield (5.87 t ha^{-1}). GGR-6 at 30ppm and Machete 5G under direct seeding with plant spacing 25cm x 20cm possessed the 2nd highest grain yield (5.41 t ha^{-1}). The broadcasting of seeds produced the least yield (2.30 t ha^{-1}) in all treatments. From the present study, it may be concluded that for enhancing yield of direct seeding method with plant spacing 20cm x 20cm, GGR-6 at 30ppm and Machete 5G at the rate of 25kg ha^{-1} would be recommended in rice cultivation.

Key Words: Growth regulator, herbicide, dry matter partitioning, direct seeding methods

INTRODUCTION

Rice is one of the major food crops of the world. The world has long been facing with an accelerating demand for food. The obvious cause is the continuing higher growth rate in the world's population (Toenniessen, 1984). Bangladesh has been running in shortage of grain food. Moreover, population is increasing at 1.43% per year (BBS, 2002) and cultivable land is decreasing. To meet the consequent increasing demand, production of cereal must be increased. Country like Bangladesh where the availability of land is limited, the horizontal expansion of cultivation for food production is not possible. For higher crop production modern agronomic packages along with HYV and quality seedling could obviously play an important role (Sekh, 2002). Breeders have been developing modern varieties of almost all crops and are being used by the famers. it seems that the genetic potentiality of the varieties to increase their production has already been full exceeded. And there is hardly scope for the breeder to make break through in further improvement for yield increment through conventional methods. In this connection use of plant growth regulators (PGR_s) and other modern technologies might be a useful tool to increase rice production. Recently, there has been global realization of the increasingly important role of PGR_s in crop production especially in better growth of crops and in enhancing yield of different crops (Prasad and Paudel, 1994). Following these reports, the present work was designed to study the effect of herbicides and green growth regulators on the growth and yield contributing characters of *Boro* rice in direct-seeding methods in Bangladesh. Yields of rice raised in direct seeding method may be as good as or even higher than transplanting method (Talukdar, 1996). The average yield loss due to weeds is less for direct seeded rice than that for transplanted rice. Therefore, yield and economic advantage of direct seeded rice should be higher than those of transplanted rice when herbicide is used. So, the experiment was undertaken to investigate the effect of green growth regulator (GGR-6) and herbicides on the dry matter partitioning and yield contributing characters of *Boro* rice (cv. Iratom-24) in direct seeding method.

MATERIALS AND METHODS

The experiment was carried out at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during February to May 2005. The experiment included direct seeding methods with plant spacing 15cm x 20cm, 20cm x 20cm, 25cm x 20cm, broadcasting with a seed rate of 80 kg ha^{-1} and transplanting with plant spacing 15cm x 20cm. Two different herbicides were Machete 5G and Ronstar25 EC at the rate of 25 kg ha^{-1} and 2 litre ha^{-1} respectively. The concentration of GGR-6 was 0ppm (control) and 30ppm. The experimental design was split-split plot with three replications. The sprouted seeds were dibbling by hand and broadcasted on February 14, 2005. On the other hand seedlings were transplanted on March 5, 2005. The following recommended production technology for cultivation of rice (Iratom-24). The treatments of Machete 5 G and Ronstar25 EC

were applied, four days after sowing as per treatment. The PGR were applied as foliar spray at two times at 35 DAS and 42 DAS. The experimental field was a medium low land, fairly leveled with silty loam texture having a soil P^H value about 6.32 (BARC, 1997). The size of the main plot was 17m x 4m. The sub plot size was 3m x 4m. Distance among the sub plot 0.5m. the sub-sub size 3m x 1.75m and the distance between sub-sub plots 0.5m The fertilizers urea, TSP, MP and gypsum were applied @ 150, 100, 70 and 60 kg ha^{-1} respectively. At the time of the final land preparation full doses of TSP, MP and gypsum were applied. Urea was applied in three equal splits at 10, 30, 45 days after planting respectively (BARC, 1997). No weeding or stirring of soil was done after the application of herbicides. Irrigation was done from time to time in order to provide condition for proper growth and development of the crop. Three seedlings $hill^{-1}$ were used with a spacing of 15cm x 20cm. The experimental crop was harvested plot wise at maturity. The grains were cleaned and dried to moisture content of 14%. Three samplings were done at 50, 60 and 70 days after planting. At each sampling, five random hills from each sub-sub plot were up rooted avoiding border hills and washed them in running tap water. Dry matter of leaves, stem and root were counted then the plant parts were dried in an electric oven at 80^0 C for 72 hours. Data on leaf dry matter, stem dry matter, root dry matter, total dry matter (TDM) , Number of filled grains $panicle^{-1,}$ 1000-grain weight (g), Straw yield t ha^{-1}), and Grain yield t ha^{-1} were recorded and statistically analyzed to compared by Duncan's Multiple Rang Test(DMRT).

RESULTS AND DISCUSSION

Effect of direct seeding methods, herbicides and plant growth regulator on the dry matter partitioning

Stem dry matter $hill^{-1}$

Effect of direct seeding methods

Stem dry matter was significantly affected by the direct seeding methods at all dates of observation (Table 1). The maximum stem dry matter $hill^{-1}$ was found from direct seeding method with plant spacing 25 cm x 20 cm as 7.74 g at 50, 21.82 g at 60 and 32.11 g $hill^{-1}$ at 70 DAS and the minimum stem dry matter production $hill^{-1}$ was found from broadcasting with a seed rate 80 kg ha^{-1} as 2.01 g at 50, 6.29 g at 60 and 8.84 g $hill^{-1}$ at 70 DAS. Dense populated plants could not produce more tillers due to competition of plant nutrient and other growth factors like space, moisture, air and photoperiod as a result stem dry matter was produced minimum by closest plant spacing.

Effect of herbicides

Stem dry matter $hill^{-1}$ was significantly influenced by different kinds of herbicides except 70 DAS (Table 2). The highest stem dry mater $hill^{-1}$was found from Machete 5 G herbicide at 50 (5.72 g), 60 (16.37 g) and 70 (23.71 g) DAS. Such result obtained might be due to lower weed infestation and lower weed-crop completion for nutrients, water, space and light etc. The lowest stem dry matter $hill^{-1}$ was obtained by Roaster 25 EC as 5.11 g at 50, 14.41 g at 60 and 22.67 g at 70 DAS. Such result was obtained due to higher weed infestation and higher weed-crop competition.

Effect of plant growth regulator (GGR-6)

Stem dry weight was estimated at 50, 60 and 70 DAS. The concentration effect of plant growth regulator (GGR-6) on stem dry matter was highly significant (Table 3). The highest stem dry matter $hill^{-1}$ was produced with 30 ppm concentration at 50 (6.46 g), 60 (17.48 g) and 70 DAS (24.58 g) and the lowest stem dry matter $hill^{-1}$ was found in control condition. The present result fully agrees with the report of Rao and Shiying (1992) reported that the above ground parts of the plants treated with 25ppm of ABT grew more vigorously in terms of increased stem dry weight and leaves.

Interaction effect of direct seeding methods, herbicides and plant growth regulator (GGR-6)

The interaction effect of direct seeding methods, herbicides and different concentration of GGR-6 on stem dry matter $hill^{-1}$ was showed statistically significant (Table 4). Direct seeding with plant spacing 25 cm x 20 cm produced the highest stem dry matter $hill^{-1}$ under Machete 5 G herbicide and 30ppm GGR-6 at 70 (34.71 g) DAS. The lowest stem dry matter was found from broadcasting with a seed rate 80 kg ha^{-1} under Ronstar25 EC and no GGR-6 as (7.98g) at 70 DAS.

Leaf dry matter $hill^{-1}$

Effect of direct seeding methods

Leaves dry matter $hill^{-1}$ was significantly influenced by direct seeding methods at all the date of observation (Table 1). The maximum leaves dry matter $hill^{-1}$ was found in direct seeding methods with plant spacing 25 cm x 20 cm as 6.18 g at 50, as 10.60 at 60 and as 12.0 g at 70 DAS. Minimum leaves dry matter $hill^{-1}$ was obtained as 1.70 g at 50, as 3.02 g at 60, as 3.51 g at 70 DAS from broadcasting with a seed rate at 80 kg ha^{-1}. Direct seeding methods with plant spacing 20 cm x 20 cm, which was statistically similar to transplanting at 50 DAS. The

production of more leaves in widely spaced plants was probably due to absorption of more nutrients and moisture and also availability of more sunlight in comparison to more derides of broadcasting as a result leaf dry matter was produced maximum by wider plant spacing.

Effect of herbicides

The effect of herbicides on leaves dry matter hill^{-1} was found significant at different days after sowing except 60 DAS (Table 2). The highest leave dry matter hill^{-1} was found from Machete 5G herbicides as 4.62 g at 50, as 8.05 g at 60 and 8.86 g at 70 days. The lowest leaves dry matter was found from Ronstar25 EC herbicide as 4.09 g, 7.40 g and 8.14 g at 50, 60 and 70 DAS. Leaf dry weight was found higher in the pre-emergence application of Machete 5G than Ronstar25EC. It might be due to the cause of higher infestation of weed at the rate of 2 l ha^{-1} of Ronstar25EC. It was also observed that Machete 5G herbicide produced higher leaf dry weight. As a result lower weed-crop competition was occurred and higher dry matter produced in leaf. Leaf dry weight hill^{-1} increased with the increase of age up to flowering stage.

Effect of GGR-6

Effect of plant growth regulator (GGR-6) on leaf dry matter hill^{-1} was found significant (Table 3). At 30ppm produced the highest leaf dry matter hill^{-1} as 9.19 g at 70 DAS than the control condition.

Interaction effect between direct seeding methods, Herbicides and plant growth regulator (GGR-6)

Interaction effect between direct seeding methods, herbicides and different concentration of GGR-6 was found statistically significant (Table 4). The highest leaf dry matter was produced as 7.0 g at 50, as 12.85 g at 60 and 13.87 at 70 DAS from Machete 5 G, at 30ppm and direct seeding with plant spacing 25cm x 20cm. The 2nd highest root dry mass as 5.81 g at 50 11.49 g at 70 from Machete 5 G and direct seeding with plant spacing 25 cm x 20 cm. Another 2nd highest leaves dry mass as 10.97 g at 60 DAS from Machete 5 G, GGR-6 at 30ppm. and direct seeding with plant spacing 20 cm x 20 cm which was statistically similar to Ronstar25 EC, GGR-6 at 30 ppm and direct seeding with plant spacing 25 cm x 20 cm at 50 and 70 DAS. The lowest leaves dry mass as 1.38g at 50 DAS from Machete 5G, no GGR-6 and broadcasting method which was statistically similar to Ronstar25 EC without GGR-6 and broadcasting @ 80 kg ha^{-1}. It was clear that broadcasting with a seed rate 80 kg ha^{-1} and Ronstar25EC at the rate of 2 l ha^{-1} gave the lowest leaf dry weight might be due to closer plant density and some phytotoxic effect of Ronstar25EC on leaf.

Root dry matter hill^{-1}

Effect of direct seeding methods

Root dry matter hill^{-1} was significantly influence by direct seeding methods with different plant spacing (Table 5). Direct seeding with plant spacing 25 cm x 20 cm produced the highest root dry matter hill^{-1} as 3.96 g at 50, 7.97 g at 60 and 10.86 at 70 DAS. The lowest root dry matter hill^{-1} was found from broadcasting with a seed rate 80 kg as 1.01 g at 50, as 1.97 g at 60 and 2.80 g at 70 DAS.

Effect of herbicides

Root dry matter hill^{-1} was significantly influence by different kinds of herbicide at all the dates of observation (Table 6). The highest root dry mass hill^{-1} was found from Machete 5G at 50 (2.90 g), 60 (5.76 g) and 70 (8.21 g) DAS. The lowest root dry mass hill^{-1} was found from Ronstar25 EC at 50 (2.50 g), 60(4.83 g) and 70 (6.64 g) DAS.

Effect of plant growth regular (GGR-6)

Effect of PGR (GGR-6) on root dry mass was observed highly significant (Table 7). The 30ppm concentration could produced the highest root dry mass as 8.39 g hill^{-1} at 70 DAS. The root dry mass gradually increased over control. These results indicate that GGR-6 applied in rice was effective in enhancing growth. This study was fully agreed with that report. Sekh (2002) observed that GABA produced the highest root dry weight than TNZ-3003 and CI-IAA.

Interaction effect of direct seeding methods, herbicides and GGR-6

The interaction between direct seeding methods, herbicides and plant growth regulator on root dry matter hill^{-1} was significant in all dates of observation (Table 8). The highest root dry matter hill^{-1} was recorded from Machete 5 G herbicide, GGR-6 at 30ppm and direct seeding with wider spacing 25 cm x 20 cm as 13.88 hill^{-1} at 70 DAS. The lowest root dry matter was obtained from Ronstar25 EC, GGR-6 and broadcasting with a seed rate 80 kg ha^{-1} as 0.81 g at 50, 1.52 g at 60 and 2.03 g at 70 DAS which was statistically identical to Machete 5G, No GGR-6 and broadcasting method. The second highest root dry mass was obtained from Machete 5 G herbicide, GGR-6 at 30ppm and plant spacing 20 cm x 20 cm at 50 (4.64 g), 60(8.25 g) and 70 (12.37 g) DAS. It was statistically similar to Ronstar25 EC, GGR-6 at 30ppm and wider plant spacing 25 cm x 20 cm at 60 (8.67 g) and 70 (11.61 g) DAS.

Total dry matter hill^{-1}

Effect of direct seeding methods

Total dry matter hill^{-1} was significantly influenced by direct seeding methods at all sampling dates (Table 5). The highest total dry matter hill^{-1} was recorded from direct seeding with plant spacing 25 cm x 20 cm as 17.89 at 50, 41.16g at 60 and 54.989 at 70 DAS. The lowest total dry matter hill^{-1} was found broadcasting with a seed rate 80 kg ha^{-1} at 50 (4.75 g), 60 (11.90 g) and 70 (15.15 g). Total dry matter was higher in direct seeding with spacing 25 cm x 20 cm than broadcasting due to absorption of more nutrients and moisture and also more space and sunlight.

Effect of herbicides

Total dry matter hill^{-1} was significantly affected by herbicides (Table 6). The highest total dry matter hill^{-1} was obtained from Machete5G herbicide as 13.23g at 50, 30.09g at 60 and 40.85 g at 70 DAS and produced by Ronstar25EC as 11.72 g at 50, 28.44 g at 60 and 37.53 g at 70 DAS. Machete5G herbicide suppressed the weeds growth at the period of growth stage and low toxic effect on rice plant than Ronstar25EC, which was helpful for the crop growth. So, dry matter accumulation and distribution in the plant was higher in Machete 5G than Ronstar25EC.

Effect of plant growth regulator (GGR-6)

Total dry matter hill^{-1} was found significant in different concentration (Table 7). The concentration of 30ppm produced the highest TDM at 50 (14.249 g), 60 (33.07 g) and 70 (42.16 g) and the lowest TDM was produced at 50 (10.70 g), 60 (25.47 g) and 70 (36.22 g) DAS in control condition. The application of 30ppm GGR-6 resulted might enhance auxin content of plants. The higher plant hormone influenced the leaf growth lead by higher leaf area and higher anabolic activity which could contribute higher assimilation and having the maximum total dry matter.

Interaction effect of direct seeding methods, herbicides and GGR-6

Total dry matter hill^{-1} differed significantly due to interaction between the direct seeding methods, herbicides and GGR-6 at all sampling dates (Table 8). The data revealed that 50, 60 and 70 days direct seeding with plant spacing 25 cm x 20 cm Machete 5G and GGR-6 at 30ppm produced the maximum total dry matter hill^{-1}. The lowest total dry mass hill^{-1} was produced from broadcasting with a seed rate 80 kg ha^{-1} and Ronstar25EC which was statistically similar to broadcasting with same seed rate and Machete 5G. It was evident that, interaction between 25 cm x 20 cm spacing, Machete 5G at the rate of 25 kg ha^{-1} and GGR-6 at 30ppm were produced the highest total dry matter might be due to presence of favourable condition for plant growth.

The effect of direct seeding methods, herbicides and plant growth regular and their interaction on yield and yield contributing characters

Number of total filled grains panicle^{-1}

Effect of direct seeding methods

The result showed that direct seeding methods had significant effect on number of total filled grains panicle^{-1} (Table 9). The maximum number of total filled grains panicle^{-1} (96.64) was found from direct seeding with plant spacing 25 cm x 20 cm and the minimum number of total filled grains panicle^{-1} was obtained (74.73) from broadcasting method with a seed rate 80 kg ha^{-1}. The direct seeding method with plant spacing 15 cm x 20 cm and transplanting was statistically identical. Evidently direct seeding with wider spacing induced greater number of filled grains panicle^{-1} than broadcasting method. Development of grains depends on environmental factors such as nutrients, moisture and light. Wider spacing possible facilitated to supply more food materials, moisture and light for the plant and ultimately for development of grains.

Effect of herbicides

The effect of different kinds of herbicide was obtained to be significant (Table 10). The highest number of total filled grains panicle^{-1} (91.58) was observed from Machete 5 G herbicide applied in the rice field and the lowest number of total filled grains panicle^{-1} (86.86) was observed from Ronstar25 EC herbicide applied in the rice field.

Effect of different concentration of GGR-6

The number of total filled grains panicle^{-1} was found highly significant at 30ppm in comparison to control (Table 11). It was observed that 30ppm produced the highest number of total filled grains panicle^{-1} (91.60) and the lowest number of total filled grains panicle^{-1} (88.83) was found in control. Guoping (1992) explained the cause of increase of grain due to the improvement of the root by ABT first, than the absorption and transportation were enhanced and than exuberant growth of the above ground part appeared. Furthermore, at each crucial stage of the differentiation period of the panicles, adequate nutrient is supplied to the plant to meet the need

to maintain the vigorous physiological and biochemical metabolism and finally the process of normal differentiation become smoothly. Besides the huge root system absorbs sufficient nutrients and waster to be supplied for conversion and hence the number of grains per panicle is increased.

Interaction effect of direct seeding methods, herbicides and GGR-6

The interaction effects between direct seeding methods, herbicides and GGR-6 were significant on the number of total filled grains panicle^{-1} (Table 12). The highest number of total filled grains panicle^{-1} was obtained from direct seeding with plant spacing 25 cm x 20 cm, Machete 5 G and GGR-6 at 30ppm. The lowest number of total filled grains panicle^{-1} was obtained from broadcasting with a seed rate 80 kg ha^{-1}, Ronstar25 EC and no GGR-6 which was statistically similar to broadcasting with a seed rate 80 kg ha^{-1}, Machete 5 G and no GGR-6. It was evident that, interaction between 25 cm x 20 cm spacing, Machete 5G at rate of 25 kg ha^{-1} and GGR-6 at 30ppm were produced the highest number of filled grains panicle^{-1} might be due to presence of favourable condition for plant growth.

1000-grain weight

Effect of direct seeding methods

The direct seeding methods had significant effect on 1000-grain weight (Table 9). The highest 1000-grain weight (30.94 g) was found from direct seeding with plant spacing 25 cm x 20 cm. The lowest 1000-grain weight (28.26 g) was obtained from broadcasting with a seed rate 80 kg ha^{-1}. From the direct seeding with plant spacing 15 cm x 20 cm and transplanting with plant spacing 15 cm x 20 cm, was statistically similar. Such variation might be due to the variation of supply of food material, moisture and light for proper development of grain.

Effect of herbicides

It was observed that Machete 5G and Ronstar25 EC herbicides had no significant on 1000-grain weight (Table 10).

Effect of plant growth regulator (GGR-6)

Concentration effect of plant growth regulator (GGR-6) was found significant (Table 11). The result showed that as the concentration increased the weight of grains was also increased. The concentration 30ppm produced the highest 1000-grain weight (29.87 g) and the lowest 1000-grain weight (28.82) in the control condition. Seeds weight is a genetically controlled character which was not influenced by PGRs.

Interaction effect of direct seeding methods, herbicides and GGR-6

The result showed that interaction effect of direct seeding methods, different kinds of herbicide and different concentration (control, 30ppm) of GGR-6 had no significant effect on 1000-grain weight (Table 12).

Straw yield (t ha^{-1})

Effect of direct seeding methods

The effect of direct seeding methods was significant in respect of straw yield (Table 9). The highest straw yield (7.04t ha^{-1}) was recorded from direct seeding with plant spacing 20 cm x 20 cm and which was statistically identical with direct seeding with plant spacing 25 cm x 20 cm. The lowest straw yield (3.45 t ha^{-1}) was found from broadcasting with a seed rate 80 kg ha^{-1}. The spacing 20 cm x 20 cm produced the highest straw yield. It might be attributed to a greater number of plants in closely spaced plots. Straw yield was the lowest in broadcasting. A gradual reduction in straw yield was noticed with the decrease in plant population which was due to lower number of total tillers per unit area.

Effect of herbicides

Straw yield was significantly influenced by herbicides (Table 10). The highest straw yield (6.08 t ha^{-1}) was found from Machete5G herbicide and the lowest straw yield (5.96 t ha^{-1}) was recorded from Ronstar25 EC. The Ronstar25 EC treatment produced the lowest straw yield due to higher weed infestation that reduced the crop growth and finally reduced the straw yield.

Effect of GGR-6

The concentration effect of plant growth regulator (GGR-6) was found highly significant on straw yield (Table 11). The highest straw yield (6.11 t ha^{-1}) was found in GGR-6 at 30ppm and the lowest straw yield (5.93 t ha^{-1}) produced in the control (no GGR-6) condition.

Interaction effect on direct seeding methods, herbicides and GGR-6

The interaction between direct seeding methods, herbicides and GGR-6 was significant on straw yield (Table 12). The result showed that the direct seeding with plant spacing 20 cm x 20 cm, Machete 5 G herbicide and GGR-6 at 30ppm produced the highest straw yield (7.23 t ha^{-1}). The lowest straw yield (3.23 t ha^{-1}) was

produced from broadcasting with a seed rate 80 kg ha^{-1}, Ronstar25 EC and without GGR-6 which was statically identical to broadcasting with a seed rate 80 kg ha^{-1}, both herbicides (Machete 5 G and Ronstar25 EC) and GGR-6 (at 30ppm, control)

Grain yield (t ha^{-1})

Effect of direct seeding methods

Grain yield was remarkable influenced due to direct seeding methods (Table 9). The highest grain yield (5.28 t ha^{-1}) was found from direct seeding with plant spacing 20 cm x 20 cm. The lowest grain yield (2.68 t ha^{-1}) was obtained from broadcasting with a seed rate 80 kg ha^{-1}. Apparently, for direct seeding with plant spacing 25 cm x 20 cm, the growth and yield components was higher than that for direct seeding with planting spacing 20 cm x 20 cm, but actually there was an increased yield for later spacing as there was a high number of total hill ha^{-1}. Due to proper plant spacing, plants got proper light and no competition for nutrients than broadcasting method and also it might be due to the fact that the number of effective tiller $hill^{-1}$ and number of grains $panicle^{-1}$ were increased significantly in direct seeding (line sowing) method than broadcasting method. BRRI (1999) observed that line sowing method with 20 cm x 20 cm spacing gave comparatively better grain yield than broadcasting.

Effect of herbicides

Grain yield was significantly influenced by herbicides (Table 10). The highest yield (4.65 t ha^{-1}) was found by using Machete 5 G herbicide and the lowest grain yield (4.29 t ha^{-1}) was found by Ronstar25 EC. Machete 5G herbicide killed many weeds and less weeds were grown through the crop growing period in the Machete 5G herbicide treated plot than Ronstar25 EC treated plot, which favoured the significant growth development and also in yield.

Effect of plant growth regulator (GGR-6)

The concentration of plant growth regulator (GGR-6) showed highly significant 30ppm produced the highest grain yield (4.77 t ha^{-1}) and the lowest grain yield (4.17 t ha^{-1}) in control (Table 11). Salam and Islam (1995) reported that ABT application showed significant increase in grain yield. The application of plant growth regulator produced the highest grain yield at 30ppm concentration in Iratom-24. The increase in the effective tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$ due to the effect of plant growth regulator (GGR-6) resulted in cumulative effect to produce higher grain yield in all plants treated with hormone.

Interaction effect of direct seeding methods, herbicides and GGR- 6

The interaction between direct seeding methods, herbicides and plant growth regulator (GGR-6) had remarkable effect on grain yield (Table 12). The highest grain yield (5.87 t ha^{-1}) was found from direct seeding with plant spacing 20 cm x 20 cm, Machete 5G and GGR-6 at 30ppm. The lowest grain yield was (2.30 t ha^{-1}) found from broadcasting with a seed rate 80 kg ha^{-1}, Ronstar25 EC and no GGR-6 (control) which was statistically similar to broadcasting with a seed rate 80 kg ha^{-1}, Machete 5 G and without hormone (GGR-6).

It may be concluded that Iratom-24 may be planted in direct seeding with plant spacing 20cm x 20cm along with Machete 5G at the rate of 25kg ha^{-1} along with 30ppm concentration of GGR-6 to optimize grain yield of Iratom-24 in *Boro* season.

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Table1. Effect of direct seeding methods in different spacing on stem dry matter hill^{-1} and leaf dry matter hill^{-1}

Treatment	Stem dry matter (g) hil^{-1}			Leaf dry matter (g) hill^{-1}		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
T_1	5.03c	13.04d	22.69d	4.06c	7.29d	8.01d
T_2	6.26b	18.83b	27.83b	4.91b	9.59b	10.13b
T_3	7.74a	21.82a	32.11a	6.18a	10.60a	12.00a
T_4	2.01d	6.29e	8.84e	1.70d	3.02e	3.51e
T_5	6.03b	16.97c	24.66c	4.93b	8.12c	8.85c
LSD at 5%	0.253	0.552	1.435	0.350	0.439	0.238
CV (%)	4.47	4.96	3.04	5.45	7.18	3.76

Figure (s) in column having common letter (s) do not differ significantly at 5% level as per DMRT
DAS = Days after sowing
Where,
T_1 = Direct seeding with 15cm x 20cm spacing, T_2 = Direct seeding with 20cm x 20cm spacing, T_3 = Direct seeding with 25cm x 20cm spacing, T_4 = Broadcasting with a seed rate 80kg ha^{-1}, T_5 = Transplanting with 15cm x 20cm spacing.

Table 2. Effect of herbicides on stem dry matter hill^{-1} and leaf dry matter hill^{-1}

Herbicides	Stem dry matter (g) hill^{-1}			Leaf dry matter (g) hill^{-1}		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
Machete –5G	5.72a	16.37a	23.71	4.62a	8.05	8.86a
Ronstar-25 EC	5.11b	14.41b	22.67	4.09b	7.40	8.14b
LSD at 5%	0.245	1.043		0.304		0.452
CV (%)	4.47	4.96	3.04	5.45	7.18	3.76

Table 3. Effect of plant growth regulator (GGR-6) on stem dry matter hill^{-1} and leaf dry matter hill^{-1}

Concentration of GGR-6	Stem dry matter (g) hill^{-1}			Leaf dry matter (g) hill^{-1}		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
Control	4.36b	13.30b	21.87b	3.92b	6.85b	7.81b
30 ppm	6.46a	17.48a	24.58a	4.79a	8.60a	9.19a
LSD at 5%	0.269	0.847	0.785	0.361	0.616	0.354
CV (%)	4.47	4.96	3.04	5.45	7.12	3.76

Figure (s) in a column having common letter (s) do not differ significantly at 5% level as per DMRT, DAS = Days after sowing

Table 4. Interaction effect of direct seeding methods in different spacing, herbicides and plant growth regulators (GGR-6) on stem dry matter hill^{-1} and leaf dry matter hill^{-1}

Herbicides	Treatment	GGR-6	Stem dry matter (g) hill^{-1}			Leaf dry matter (g) hill^{-1}		
			50 DAS	60 DAS	70 DAS	50 DAS	60 DAS	70 DAS
Machete-5 G	T_1	Control	4.96hij	12.40h	22.15i	3.98f	6.63gh	7.87h
		30ppm	6.03f	15.81e	24.70fg	4.87e	8.93de	9.00f
	T_2	Control	5.32gh	16.43e	26.68e	4.79e	8.75de	9.72de
		30ppm	7.87c	23.87ab	30.52c	5.67bcd	10.97b	11.24bc
	T_3	Control	6.45ef	20.83c	30.69c	5.81b	9.74cd	11.49b
		30ppm	9.56a	25.05a	34.71a	7.00a	12.95a	13.87a
	T_4	Control	1.50m	6.14k	8.60kl	1.38i	2.91i	3.21k
		30ppm	2.75l	7.80j	9.19kl	2.21h	3.44i	3.99j
	T_5	Control	5.09hi	15.16ef	23.90gh	4.88e	7.35fg	8.29gh
		30ppm	7.67c	20.26c	26.67e	5.62bcd	8.96de	9.94d
Ronstar-25 EC	T_1	Control	3.56k	10.86i	20.67j	3.28g	6.21h	7.01i
		30ppm	5.60g	13.10gh	23.24hi	4.11f	7.42fg	8.19h
	T_2	Control	4.83ij	14.23fg	25.62ef	4.01f	8.10ef	8.78fg
		30ppm	7.02d	20.79c	28.53d	5.19cde	10.54bc	10.78c
	T_3	Control	6.06f	18.33d	29.89c	5.75bc	9.13de	10.91c
		3ppm	8.90b	23.29b	33.18b	6.18b	10.68b	11.76b
	T_4	Control	1.33m	5.31k	7.98l	1.21i	2.59i	2.97k
		30ppm	2.47l	6.04k	9.59k	2.01h	3.16i	3.88j
	T_5	Control	4.57j	13.62gh	22.60i	4.13f	7.11fgh	7.89h
		30ppm	6.81de	18.84d	26.49ef	5.11de	9.08de	9.28ef
LSD at 5%			0.140	1.299	1.204	0.554	0.945	0.544
CV (%)			4.47	4.96	3.04	5.45	7.18	3.76

Figure(s) in a column having common letter(s) do not differ significantly at 5% level of probability as per DMRT

Table 5. Effect of direct seeding methods in different spacing on root dry matter hill^{-1} and Total dry matter

Treatment	Root dry matter (g) hil^{-1}			Total dry matter (g)		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
T_1	2.30d	4.34d	6.63d	11.40d	25.96d	37.34d
T_2	3.51b	6.83b	9.32b	14.66b	36.21b	47.46b
T_3	3.96a	7.97a	10.86a	17.89a	41.16a	54.98a
T_4	1.01e	1.97e	2.80e	4.73e	11.90e	15.15e
T_5	2.73c	5.37c	7.51c	13.70c	31.12c	41.02c
LSD at 5%	0.213	0.313	0.270	0.711	1.060	0.865
CV (%)	8.35	5.53	6.55	4.01	4.04	3.85

Figure (s) in a column having common letter (s) do not differ significantly at 5% level as per DMRT, DAS = Days after sowing

Where,

T_1 = Direct seeding with 15cm x 20cm spacing, T_2 = Direct seeding with 20cm x 20cm spacing, T_3 = Direct seeding with 25cm x 20cm spacing

T_4 = Broadcasting with a seed rate 80kg ha^{-1}, T_5 = Transplanting with 15cm x 20cm spacing.

Table 6. Effect of herbicides on root dry matter hill^{-1} and total dry matter

Herbicides	Root dry matter (g) hill^{-1}			Total dry matter (g)		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
Machete –5G	2.90a	5.67a	8.21a	13.23a	30.09a	40.85a
Ronstar-25 EC	2.50b	4.83b	6.64b	11.72b	28.44b	37.53b
LSD at 5%	0149	0.447	0.473	0.430	0.993	2.521
CV (%)	8.35	5.53	6.55	4.01	4.04	3.85

Table 7. Effect of plant growth regulator (GGR-6) on Root dry matter hill^{-1} and Total dry matter

Concentration of GGR-6	Root dry matter (g) hil^{-1}			Total dry matter (g)		
	50 DAS	60DAS	70 DAS	50 DAS	60DAS	70 DAS
Control	2.41b	4.55b	6.46b	10.70b	25.47b	36.22b
30ppm	2.99a	6.04a	8.39a	14.24a	33.07a	42.16a
LSD at 5%	0.250	0.325	0.540	0.555	1.314	1.242
CV (%)	8.23	5.53	6.55	4.01	4.04	3.54

Figure (s) in column having common letter (s) do not differ significantly at 5% level as per DMRT, DAS = Days after sowing

Table 8. Interaction effect of direct seeding methods in different spacing, herbicides and plant growth regulator (GGR-6) on root dry matter (g) hill^{-1} total dry matter

Herbicides	Treatment	GGR-6	Root dry matter (g) hill^{-1}			Total dry matter (g)		
			50 DAS	60 DAS	70 DAS	50 DAS	60 DAS	70 DAS
Machete-5 G	T_1	Control	2.39ij	4.49j	6.73hi	11.34i	23.52i	36.75i
		30ppm	2.47hij	5.31gh	7.96efg	13.37g	29.25fg	41.66gh
	T_2	Control	3.12def	6.86c	8.79de	13.23g	31.04f	45.19f
		30ppm	4.64b	8.25b	12.37b	18.08c	42.35bc	54.12c
	T_3	Control	3.49d	6.56cd	9.87c	15.75de	37.12d	52.02d
		30ppm	5.11a	10.73a	13.88a	21.61a	49.63a	62.46a
	T_4	Control	0.97k	1.82mn	2.70l	3.85l	10.87k	14.51lm
		30ppm	1.21k	2.42l	3.60k	6.17k	13.66j	16.78k
	T_5	Control	2.39ghi	5.05hi	7.62fgh	12.66gh	28.16gh	39.81h
		30ppm	2.94efg	6.17de	8.62de	16.23d	35.39de	45.32f
Ronstar-25 EC	T_1	Control	2.07j	3.04k	5.51j	8.94j	22.01i	33.19j
		30ppm	2.27ij	4.54ij	6.35ij	11.98hi	29.06fg	37.78i
	T_2	Control	2.98efg	5.60fg	7.08ghi	11.82hi	30.65f	42.18g
		30ppm	3.31de	6.62cd	9.06cd	15.52def	40.83c	48.37e
	T_3	Control	3.17def	5.95ef	8.09ef	14.98ef	34.25e	48.89e
		30ppm	4.08c	8.67b	11.61b	19.16b	43.64b	56.56b
	T_4	Control	0.81k	1.52n	2.03l	3.35l	10.73k	12.98m
		30ppm	1.07k	2.14lm	2.88kl	5.55k	12.34jk	16.35kl
	T_5	Control	2.47hij	4.64ij	6.21ij	11.17i	26.37h	36.70i
		30ppm	2.82fgh	5.64fg	7.59fgh	14.74f	34.56e	42.36g
LSD at 5%			0.384	0.499	0.829	0.851	2.015	1.904
CV (%)			8.35	5.53	6.55	4.01	4.04	3.85

Figure(s) in a column having common letter(s) do not differ significantly at 5% level of probability as per DMRT

Where,

T_1 = Direct seeding with 15cm x 20cm spacing, T_2 = Direct seeding with 20cm x 20cm spacing, T_3 = Direct seeding with 25cm x 20cm spacing, T_4 = Broadcasting with a seed rate 80kg ha^{-1}, T_5 = Transplanting with 15cm x 20cm spacing.

Table9. Effect of direct seeding methods in different spacing on yield attributes and yield

Treatment	Filled grains panicle^{-1}	1000-grain weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_1	90.78c	28.98c	6.45b	4.69c
T_2	92.97b	29.62b	7.04a	5.28a
T_3	96.64a	30.94a	6.72ab	4.92b
T_4	74.73d	28.26d	3.45c	2.68d
T_5	90.96c	28.93c	6.44b	4.78c
LSD at 5%	1.570	0.580	0.367	0.112
CV (%)	4.38	2.75	5.33	4.68

Figure (s) in column having common letter (s) do not differ significantly at 5% level as per DMRT

Where,

T_1 = Direct seeding with 15cm x 20cm spacing, T_2 = Direct seeding with 20cm x 20cm spacing, T_3 = Direct seeding with 25cm x 20cm spacing T_4 = Broadcasting with a seed rate 80kg ha^{-1}, T_5 = Transplanting with 15cm x 20cm spacing

Table10. Effect of herbicides on yield attributes and yield

Herbicides	Filled grains panicle^{-1}	1000- grain weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Machete-5G	91.58a	29.52	6.08a	4.65a
Ronstar25 EC	86.86b	29.17	5.96b	4.29b
LSD at 5%	1.654		0.099	0.175
CV (%)	4.38	2.75	5.33	4.68

Table 11. Effect of Plant growth regulator (GGR-6) on yield attributes and yield

Concentration of GGR-6	Filled grains panicle^{-1}	1000- grain weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Control	86.83b	28.82b	5.93b	4.17b
30ppm	91.60a	29.87a	6.11a	4.77a
LSD at 5%	2.361	0.895	0.356	0.131
CV (%)	4.38	2.75	5.33	4.68

Figure (s) in a column having common letter (s) do not differ significantly at 5% level as per DMRT

Table12. Interaction effect of direct seeding methods in different spacing, herbicides and GGR- 6 on yield and yield components

Herbicides	Treatment	GGR-6	Filled grains panicle^{-1}	1000- grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
Machete-5 G	T_1	Control	90.77ef	28.69	6.49bcde	4.63gh
		30 ppm	95.33bc	29.92	6.68abcde	5.24bcd
	T_2	Control	9053ef	29.13	6.97abc	5.09cde
		30 ppm	98.68b	30.20	7.23a	5.87a
	T_3	Control	96.89bc	30.29	6.71abcde	4.77fg
		30 ppm	101.25a	32.04	7.03ab	5.41b
	T4	Control	74.50i	28.07	3.40f	2.61l
		30ppm	79.00h	28.87	3.72f	3.09k
	T_5	Control	9089ef	28.77	6.38cde	4.60gh
		30 ppm	96.07bc	29.24	6.23e	5.29bc
Ronstar-25 EC	T_1	Control	86.25g	27.97	6.39cde	4.21j
		30 ppm	90.89ef	29.35	5.25e	4.70gh
	T_2	Control	89.67efg	29.03	6.89abcd	4.76fg
		30 ppm	93.02cde	30.13	7.09ab	5.39b
	T_3	Control	91.33de	30.07	6.33de	4.49hi
		30 ppm	95.11bcd	31.37	6.84abcde	5.07de
	T4	Control	70.82i	27.69	3.23f	2.30m
		30ppm	74.60i	28.44	3.46f	2.77l
	T_5	Control	86.78fg	28.53	6.51bcde	4.30 ij
		30 ppm	90.22ef	29.18	6.66abcde	4.94ef
LSD at 5%			3.620		0.546	0.201
CV (%)			4.38	2.75	5.33	4.68

Figure(s) in a column having common letter(s) do not differ significantly at 5% level of probability as per DMRT
Where,

T_1 = Direct seeding with 15cm x 20cm spacing, T_2 = Direct seeding with 20cm x 20cm spacing, T_3 = Direct seeding with 25cm x 20cm spacing
T_4 = Broadcasting with a seed rate 80kg ha^{-1}, T_5 = Transplanting with 15cm x 20cm spacing.