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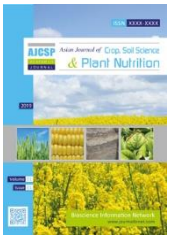

The efficacy of herbicides on yield of late *boro* rice (cv. Binadhan-14)

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ABSTRACT

The investigation was conducted at the Agronomy Field Laboratory, Bangladesh Institute of Nuclear Agriculture, Mymensingh, from February to June 2019 to study the efficacy of herbicides on yield of late boro rice (cv. Binadhan-14). The experiment was consisted of 20 treatments such as Control (T_1), Hand weeding (T_2), Bensulfuran methyl 8% +Acetachlor 14% (T_3), 2-4, D Amine 72SCL (T_4), Pretilachlor 500EC (T_5), Bispyriback sodium 300WP (T_6), Pyrazosulfuran ethyl 10WP (T_7), Trisulfuron 40WP (T_8), Pendimethyline 33EC (T_9), Metsulfuran methyl 20WDG (T_{10}), Butachlor 5G (T_{11}), Ethoxysulfuron 150WG (T_{12}), Carfentrazol ethyl 24EC (T_{13}), Fenoxpro-p-ethyl 9EC (T_{14}), Glyphosate 480SL (T_{15}), Paraquate dichloride 27.6% (T_{16}), Bensulfuran methyl 120 gm+ Bispyriback sodium 180, 300WP (T_{17}), Triafemon 240SC (T_{18}), Penoxsulum 240SC (T_{19}), Pyrazosulfuran ethyl 100gm+ Pretilachlor 100gm 20WP (T_{20}). Establishing the experiment involved using a randomized full block design with three replications. The highest plant height (92.5 cm), number of total tillers per hill (12.30), number of effective tillers per hill (10.70), panicle length (17.66 cm), number of filled grains per panicle (107.50), weight of thousand seeds (23.2 g), grain yield (5.49 t/ha), straw yield (6.73 t/ha), biological yield (12.03 t/ha) and harvest index (45.63%) was obtained when Ethoxysulfuron 150WG was applied in the field. The findings conclude that herbicide Ethoxysulfuron 150WG followed by Bispyriback-sodium 300WP, Hand weeding and Pyrazosulfuran ethyl 10WP would be the most effective weed management practice for late transplanting boro rice (cv. Binadhan-14).

Key Words: *Efficacy, Herbicides, Yield, Late Boro Rice, Cultivar and Binadhan-14.*

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I. Introduction

Over half of the world's population lives off rice (*Oryza sativa* L.), making it a major food source. This staple meal holds the top position in terms of production. Bangladesh's agronomic and topographical factors make rice farming advantageous (Saha et al., 2021). In Bangladesh, 95% of the grains consumed are rice. In the average person's daily diet, rice provides around 75% of the necessary calories and 55% of the protein. The cereal crop that is grown most widely in Bangladesh is rice. Bangladesh produces 36.28 million metric tons of rice annually from an area of 11.45 million hectares, or about 75% of the country's cropped land (BBS, 2020). Rice has three separate growing seasons, i.e., *Aus*, *Aman* and *Boro*. These seasons contribute approximately 7%, 38%, and 55% of the total rice produced annually, respectively (Farhat et al., 2023). Boro covers around 41.94% of the total rice land and has the highest average yield of every crop (3.96 t/ha) (BBS, 2018).

In Bangladesh, transplanted rice produced 18.60 million metric tons of grain from 4.68 million hectares of agricultural area (USDA Foreign Agricultural Service, 2015). Weeds not only drastically lower agricultural yields but also increase the expense of cultivation, decrease the effectiveness of input utilization, lower grain quality, act as alternative habitats for pests, decrease the aesthetic value of the ecosystem, reduce biodiversity and harm the health of humans and animals. Herbicide resistance in weeds, weed shift, weed spreading, and environmental contamination are all consequences of continuous use of the same class of herbicides over an extended time on the same plot of land, according to studies by Gnanavel and Natarajan (2014) and Sharma (2014). Compared to manual weeding, which takes more time and labor-intensive, herbicides are more efficient and cost-effective for controlling weeds in rice fields. Herbicide use by rice farmers is encouraged by Bangladesh's growing labor issue and high labor wages. Rice cultivation is changing significantly because labor prices are rising, as there are fewer workers available in rural areas and less water available for agriculture. Farmers are using new methods to produce rice, like alternate wetting and drying (AWD), direct seeding, transplanting and dabbling, and using less water to suppress weeds early on (Bista, 2018).

Moreover, synthetic herbicides have been applied extensively to manage weeds in critical crops (Bo et al., 2017). Herbicides are a promising substitute for weed management in such an environment. Many studies have noted the influence of herbicides on weed management; however, very little is known about the efficacy of the mentioned herbicides in controlling weeds in rice, particularly in Bangladesh with the late *boro* cultivar rice Binadhan-14. This study aims to determine how effective various herbicides are at enhancing the yield performance of late transplanted *boro* rice (Binadhan-14).

II. Materials and Methods

Experimental site and design

The research field was a medium-high area of the Old Brahmaputra Floodplain Agro-ecological Zone-9 made from non-calcareous dark grey floodplain soil. The location of the experiment is situated at an elevation of 18 meters above mean sea level at latitude $24^{0}75$N and longitude $90^{0}50$E. A completely randomized block design was used to establish the experiment. Three replications of each treatment were conducted. There was a total of 60-unit plots (20 × 3). Every plot measured 4.0 m by 2.5 m. The replications and the main plot were separated by 0.5 and 1.0 meters, respectively.

Experimental treatments

The treatment consisted of 20 herbicides as follows: T_1 = Control, T_2 = Hand weeding, T_3 = Bensulfuran methyl 8% +Acetachlor 14%, T_4 = 2-4, D amine 72SCL, T_5 = Pretilachlor 500ec, T_6 = Bispyriback-sodium 300WP, T_7 = Pyrazosulfuran ethyl 10 WP, T_8 = Trisulfuron 40WP, T_9 = Pendimethyline 33EC, T_{10} = Metsulfuran methyl 20WDG, T_{11} =Butachlor 5G, T_{12} = Ethoxysulfuron 150WG, T_{13} = Carfentrazol ethyl 24EC, T_{14} = Fenoxpro-p-ethyl 9EC, T_{15} = Glyphosate 480SL, T_{16} =Paraquate dichloride 27.6%, T_{17} = Bensulfuran methyl 120 gm+ Bispyriback sodium 180 gm,300WP, T_{18} = Triafemon 240SC, T_{19} = Penoxsulum 240SC, T_{20} = Pyrazosulfuran ethyl 100 gm+ Pretilachlor 100 gm 20WP.

Preparation of seedling nursery bed and seed sowing

A specific region of land was chosen to cultivate seedlings. The field was first leveled with a ladder and then thoroughly puddled with a country plough. On February 12, 2019, the sprouting seeds were

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planted in the nursery bed. The healthy seeds in the nursery bed were raised with the necessary treatment. Weeds were cleared from the nursery bed and irrigation was added as needed.

Main land preparation

A power tiller was used to break up the field, and then a country plough was used four times before laddering. Following the last land preparation stage, the field's layout was created. Each plot was cleared of weeds and stubble and cleaned.

Transplanting of seedlings

Healthy seedlings of comparable size were chosen for transplantation after being uprooted. On March 12, 2019, seedlings were transplanted into the prepared puddle field at a rate of two to three seedlings $hill^{-1}$, with a row and hill distance of 25 cm and 15 cm, respectively.

Fertilizer application

The BINA suggestion for Binadhan-14 was followed when fertilizing the soil with urea, triple superphosphate, muriate of potash, and gypsum. When final land preparation was done, all of the required amounts of triple superphosphate, muriate of potash, and gypsum were applied. After transplantation, urea was given in three stages at 15, 30, and 45 days (DAT).

Sampling, harvesting and processing

Crops were harvested when they reached full maturity. Crop maturity was defined as the point at which 90% of the grains turned a golden yellow color. June 22, 2019, was the harvest date of the crops. Subsequently, all harvested crops aside from 5 hills $plot^{-1}$ were tied individually, appropriately labeled, and transported to the threshing floor. Following the threshing of the crops, the fresh weights of grain and straw were plot-wise recorded. After cleaning the grains, the weight was changed to a 14% moisture content. The grain and straw $plot^{-1}$ yields were recorded and converted to t ha^{-1} after the straw was sun-dried.

Crop characters at harvest

Plant height (cm), Number of total tillers per hill, Number of effective tillers per hill, Panicle Length (cm), Number of grains per panicle, Weight of 1000 grains (g), Grain yield (t/ha), Straw yield (t/ha), Biological yield (t/ha), Harvest index (%).

Harvest index (%)

Harvest index of each plot was calculated by using the following formula:

$$\text{Harvest index (\%)} = \frac{Grain\ yield}{Biological\ yields} x100$$

Statistical analysis

The recorded data for each parameter was tabulated correctly. We performed a statistical analysis on the acquired data on different plant characteristics. The computer program MSTAT was used to calculate the mean of all treatments and analyse variance (ANOVA) for each of the parameters under investigation. The Duncan's New Multiple Range Test was used to compare the variations in treatment means (Gomez and Gomez, 1984).

III. Results and Discussion

Plant height

Effects of herbicide on plant height were not statistically significant at harvest. At harvest, the tallest plant (90.25 cm) was observed when Ethoxysulfuron 150WG was applied in the field, followed by Pretilachlor 500EC (90.63 cm) and Pyrazosulfuran Ethyl 10WP (90.43 cm), whereas the control treatment contained the shortest plant, measuring 85.66 cm (Table 01). Similar results about significant variations in plant height were reported by Kanaujiya et al. (2021).

Number of total tillers per hill

Effect of herbicide was found significant on number of total tillers $plant^{-1}$. The highest number of total tillers per plant (12.30) was observed in the Binadhan-14 when Ethoxysulfuron 150WG was applied in

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the field. The second higher number of total tillers per plant (11.90) was found in the Binadhan-14 when Pyrazosulfuran ethyl 10 WP and Bensulfuran methyl + Bispyriback sodium 300WP were applied in the field. While lowest number of total tillers per plant (9.60) was found in the control condition, followed by Penoxsulum 240SC (10.90) (Table 01). Kundu et al. (2020) identified a considerable difference in the number of total tillers per hill, which is compatible with their findings.

Number of effective tillers per hill

Effects of herbicide were found significant on number of effective tiller plant^{-1} at harvest. A higher number of effective tillers per plant (10.70) was found in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field. The second higher number of effective tillers per plant (10.20) was found in the Binadhan-14 when Carfentrazol ethyl 24EC was applied. While lower number of effective tillers per plant (8.16) was observed in the control condition, followed by Fenoxpro-p-ethyl 9EC (8.70) (Table 01). A similar phenomenon was previously reported by Rahman (2014).

Number of non-effective tillers per hill

Effects of herbicide were found significant on number of non-effective tillers per plant at harvest. At harvest, a higher number of non-effective tillers per plant (3.00) was found in the Binadhan-14 when Triafemon 240SC and Pyrazosulfuran ethyl 100gm + Pretilachlor 100gm 20WP were applied in the field. The second higher number of non-effective tillers per plant (2.90) was observed in the Binadhan-14 when Paraquate dichloride 27.6% was applied in the field. While lower number of non-effective tillers per plant (1.00) was seen in the rice field when Ethoxysulfuron 150WG was applied as herbicide (Table 01). These results conform with those obtained by Chowdhury Begum et al. (2003).

Table 01. Effect of herbicide on yield and yield contributing characters of Binadhan-14

Treatment	Plant height (cm)	Total tillers per hill	Effective tillers per hill	Non-effective tillers per hill	Panicle length (cm)	Grains per panicle
T_1	85.66	9.60d	8.16f	1.43fg	20.3	64.70k
T_2	89.8	11.20bc	9.30cde	1.90def	20.2	76.30i
T_3	90.3	11.70abc	10.20ab	1.33fg	20.4	106.50a
T_4	89.6	11.30bc	9.60bc	1.70ef	21.2	87.20cde
T_5	90.63	11.10bc	8.90de	2.20bcde	20.6	80.10h
T_6	90.3	11.80abc	9.20cde	2.60abc	21.1	89.37bc
T_7	90.43	11.90ab	9.10cde	2.80ab	21	85.70ef
T_8	90	11.13bc	9.53cd	1.60efg	21	73.20j
T_9	89.3	11.53abc	9.50cd	2.80ab	21.3	91.30b
T_{10}	89.3	11.40abc	9.50cd	1.90def	20.9	76.70i
T_{11}	89.73	11.40abc	8.80ef	2.60abc	21.1	82.60g
T_{12}	92.5	12.30a	10.70a	1.00g	17.66	107.50a
T_{13}	90.3	11.30bc	8.76ef	2.53abcd	21.1	79.60h
T_{14}	89.9	11.50abc	8.70ef	2.80ab	21.2	82.90g
T_{15}	89.1	11.70abc	8.90de	2.80ab	21.2	84.60fg
T_{16}	88.6	11.60abc	8.70ef	2.90a	21.3	86.30def
T_{17}	89.7	11.90ab	9.10cde	2.80ab	21.4	77.00i
T_{18}	89.8	11.80abc	8.80ef	3.00a	21.5	88.20cd
T_{19}	89.83	10.90c	8.80ef	2.10cde	22	90.90b
T_{20}	90.3	11.90ab	8.90de	3.00a	21.9	91.30b
LSD $_{(0.05)}$	2.39	0.96	0.65	0.67	2.78	2.26
Level of sig.	NS	**	**	**	NS	**
CV (%)	2.61	5.08	4.33	17.43	8.06	3.61

** = Significant at 1% level of probability, NS= Not significant

T_1=Control, T_2=Hand weeding, T_3=Bensulfuran methyl 8% +Acetachlor 14%, T_4=2-4, D amine 72SCL, T_5=Pretilachlor 500EC, T_6=Bispyriback-sodium 300WP, T_7=Pyrazosulfuran ethyl 10WP, T_8=Trisulfuron 40WP, T_9=Pendimethyline 33EC, T_{10}=Metsulfuran methyl 20WDG, T_{11}=Butachlor 5G, T_{12}=Ethoxysulfuron 150WG, T_{13}=Carfentrazol ethyl 24EC, T_{14}=Fenoxpro-p-ethyl 9EC, T_{15}=Glyphosate 480SL, T_{16}=Paraquate dichloride 27.6%, T_{17}=Bensulfuran methyl 120 gm+ Bispyriback sodium 180 gm, 300WP, T_{18}=Triafemon 240SC, T_{19}=Penoxsulum 240SC, T_{20}=Pyrazosulfuran ethyl 100 gm+ Pretilachlor 100 gm 20WP

Panicle length (cm)
Effects of herbicide were found non-significant on panicle length (cm) of Binadhan-14 at harvest.

Number of grains per panicle
Efficacy of herbicide was found to be significant in number of grains per panicle at harvest. At harvest a higher number of grains per panicle (107.50) was found in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field. The second higher number of grains per panicle (106.50) was found in the Binadhan-14 when Bensulfuran methyl 8% +Acetachlor 14% was applied in the field. At the same time, lower number of grains per panicle (64.70) was seen in the control condition, followed by Trisulfuron 40WP (73.20) (Table 01). Similar outcomes have been reported by Hossain and Rahman (2011) as well.

Number of sterile spikelets per panicle
Effects of herbicide were found significant on number of sterile spikelets per panicle at harvest. At harvest, a higher number of sterile spikeletes panicle^{-1} (30.90) was observed in the Binadhan-14 when no herbicide was applied. A lower number of sterile spikelets per panicle (10.90) was seen in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field (Table 02). Karir et al. (2008) reported similar results, observing significant variance in sterile spikelets per panicle.

Weight of thousand seeds (g)
Effects of herbicide were found non-significant on weight of thousand seeds of Binadhan-14 at harvest (Table 02).

Grain yield
Effects of herbicide were found to be significant on grain yield of Binadhan-14. The highest grain yield (5.49 t/ha) was recorded in Binadhan-14 when Ethoxysulfuron 150WG was applied. The second highest grain yield (5.38 t/ha) was observed in the Binadhan-14 when Pyrazosulfuran ethyl + Pretilachlor 20WP was applied in the field, while the lowest grain yield (3.62 t/ha) was observed in the control condition followed by Pyrazosulfuran ethyl 10 WP (4.58 t/ha) (Table 02). Similar results regarding significant variation in grain yield were reported by Hasanuzzaman et al. (2008).

Straw yield
Effects of herbicide were found significant on straw yield of Binadhan-14. The highest straw yield (6.73 t/ha) was observed in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field. The second highest grain yield (6.72 t/ha) was found in the Binadhan-14 when Pyrazosulfuran ethyl 100gm+ Pretilachlor 100gm, 20WP was applied in the field. While the lowest straw yield (5.65 t/ha) was seen in the control condition, followed by hand weeding (5.86 t/ha) (Table 02). The results agree with the study by Pramanik et al (2020).

Biological yield
Efficacy of herbicide was found to be significant in biological yield of Binadhan-14. The highest biological yield (12.03 t/ha) was observed in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field. The second highest grain yield (5.38 t/ha) was found in the Binadhan-14 when Pyrazosulfuran ethyl + Pretilachlor 20 WP was applied in the field. While the lowest biological yield (9.27 t/ha) was seen in the control condition, followed by hand weeding (10.47 t/ha) (Table 02). The results support the conclusions stated by Islam et al. (2023).

Harvest index
Efficacy of herbicide was found significant on harvest index of Binadhan-14. The highest harvest index (45.63%) was observed in the Binadhan-14 when Ethoxysulfuron 150WG was applied in the field. The second highest harvest index (45.50%) was found in the Binadhan-14 when Bensulfuran methyl 8% +Acetachlor 14% was applied in the field. While the lowest harvest index (39.11%) was seen in the control condition, followed by Penoxsulum 240SC (41.74%) (Table 02).

V. Conclusion
The study found that the variety Binadhan-14 with Ethoxysulfuron 150WG exhibited superior performance among the traits most prevalent. So, it could be concluded that the herbicide

Ethoxysulfuron 150WG would be most effective in promoting higher growth and production of Binadhan-14 within AEZ–9. More research could be required to ensure the current performance in Bangladesh's various AEZs.

Table 02. Effect of herbicide on yield and yield contributing characters of Binadhan-14

Treatment	Sterile spikelets per panicle	1000-seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
T_1	30.90a	21.9	3.62g	5.65j	9.27h	39.11k
T_2	19.20cd	22.1	4.61def	5.86ij	10.47g	44.02ef
T_3	12.50h	23.1	5.36a	6.42bcde	11.78ab	45.50ab
T_4	16.80g	22.6	4.84bcde	5.96hi	10.80fg	44.81bcd
T_5	18.00defg	22.8	4.94bc	6.06fghi	11.00def	44.83bc
T_6	17.50efg	22.8	4.88bc	6.01ghi	10.89efg	44.84bc
T_7	22.30b	23	4.58f	6.34bcdef	10.92efg	41.94ij
T_8	21.96b	22.4	5.05b	5.93i	10.98def	45.99a
T_9	18.23cdef	23	4.93bc	6.50abcd	11.43bcd	43.13gh
T_{10}	19.50c	22.7	4.85bcd	5.97hi	10.82fg	44.83bcd
T_{11}	17.20fg	22.6	4.82bcdef	6.22efgh	11.04def	43.66fg
T_{12}	10.90i	23.2	5.49a	6.73a	12.03a	45.63a
T_{13}	23.10b	23.1	4.99b	6.54abc	11.72abc	42.58hi
T_{14}	18.70cde	21.6	4.91bc	6.38bcde	11.29bcdef	43.49fg
T_{15}	17.80defg	22.1	4.82bcdef	6.26defg	11.08def	43.50fg
T_{16}	19.20cd	22.5	4.97bc	6.30cdef	11.27cdef	44.09def
T_{17}	21.70b	23.0	4.59ef	6.33bcdef	10.92efg	42.03ij
T_{18}	18.80cde	22.7	5.01b	6.42bcde	11.43bcd	43.82efg
T_{19}	17.10fg	22.7	4.73cdef	6.60ab	11.33bcde	41.74j
T_{20}	16.60g	22.9	5.38a	6.72a	12.10a	44.46cde
LSD $_{(0.05)}$	1.43	1.06	0.25	0.27	0.51	0.74
Level of sig.	**	NS	**	**	**	**
CV (%)	4.58	2.85	3.19	2.68	2.77	3.02

** = Significant at 1% level of probability, NS= Not significant

T_1=Control, T_2=Hand weeding, T_3=Bensulfuran methyl 8% +Acetachlor 14%, T_4=2-4, D amine 72SCL, T_5=Pretilachlor 500EC, T_6=Bispyriback-sodium 300WP, T_7=Pyrazosulfuran ethyl 10WP, T_8=Trisulfuron 40WP, T_9=Pendimethyline 33EC, T_{10}=Metsulfuran methyl 20WDG, T_{11}=Butachlor 5G, T_{12}=Ethoxysulfuron 150WG, T_{13}=Carfentrazol ethyl 24EC, T_{14}=Fenoxpro-p-ethyl 9EC, T_{15}=Glyphosate 480SL, T_{16}=Paraquate dichloride 27.6%, T_{17}=Bensulfuran methyl 120 gm+ Bispyriback sodium 180 gm, 300WP, T_{18}=Triafemon 240SC, T_{19}=Penoxsulum 240SC, T_{20}=Pyrazosulfuran ethyl 100 gm+ Pretilachlor 100 gm 20WP

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