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DETERMINATION OF EFFICIENT HERBICIDE IN SUPPRESSING WEED SPECIES, FAMILY FOR BETTER CROP GROWTH AND YIELD OF BORO RICE CULTIVATION IN BANGLADESH

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ABSTRACT

A field experiment was conducted Agronomy Divisions field Laboratory of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during January to May 2019 to determine the efficiency of different classes of herbicide. There is scarcely works on determination of efficiency of available 15 classes of herbicide in Bangladesh. The objectives was to know the efficiency of herbicide in suppressing the flora of weeds species and family, analysis of crop growth parameters and yield of boro rice. The experiments were laid out in a randomized complete block design (RCBD) with three replications and 20 treatments. In this experiment highest weed control efficiency was found at penoxsulam 86.55% which is followed by (bensulfuron methyl + acetachlor), 84.25% and lowest glyphosate 54.62% treated plot. The chemical classes (bensulfuron methyl + acetachlor, pretilachlor, pyrazosulfuron ethyl, ethoxysulfuron, bispyriback sodium, bensulfuron methyl + bispyriback sodium, penoxsulam, pyrazosulfuron ethyl + pretilachlor) WCE % more than 80. Seventeen weed species belongs to six families namely Gramineae, Pontederiaceae, Cyperaceae, Asteraceae, Marsileaceae and Sphenocleaceae were found to grow in weedy check plots. The highest summed dominance ration of weed was 10.5for Cyperus difformis. The infestation of different categories weed maximum relative weed density was observed for *Echinochloa colona, Cyperus difformis, Leersia hexandra L.* The highest grain yield (6.83 t ha-1) was found with penoxsulam treatment which was followed by (6.82 t ha-1) at Bensulfuran methyl+ Bispyriback sodium treatment and lowest (4.61 t ha-1) at control. This results indicates that boro rice could be grown with uses of efficient herbicides classes (bensulfuron methyl + acetachlor, pretilachlor, pyrazosulfuron ethyl, ethoxysulfuron, bispyriback sodium, bensulfuron methyl + bispyriback sodium, penoxsulam, pyrazosulfuron ethyl + pretilachlor) to maximize yield of boro rice.

Keywords: Herbicide, bensulfuron methyl, acetachlor 14%, 2-4, D-amine, pretilachlor, triafemon, pyrazosulfuron ethyl, trisulfuron, pendimethalin, metsulfuron methyl, butachlor, ethoxysulfuron, carfentrazol ethyl, fenoxpro-p-ethyl, bensulfuron methyl, bispyriback sodium, penoxulam, bispyriback sodium, paraquate dichloride, glyphosate, weed density, weed species.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the oldest cultivated cereal crops in the history of mankind (Chauhan, 2013). It is considered a staple food, providing the daily caloric requirements for many people in Latin America, North Africa, Asia, the Caribbean, and sub-Saharan countries (Siwar et al., 2014). Approximately half of the world's population staple food rice (Jabran and Chauhan 2015). Rice producing countries central Africa, Japan, Indonesia, central and South America, Malaysia, the Philippines, India, China, Australia, and Italy (Kaloumenos et al., 2013). Bangladesh is a densely populated country. She has to feed nearly 170 million mouths from an area of 8 million ha of cultivable land. Rising of labor costs in the transplanted seedling approach represent approximately 79% of the total cost of rice production per hectare (Najim et al., 2007). In Bangladesh increasing labor crisis in the periods of peak demand and high wage of labor encourages farmers to use herbicides for weed control in rice field (Krishna, V. et al., 2012). To keep in good terms of food security, it is quite important productivity levels increasing of rice in adverse impacts of climate change. Weeds management is major yield limiting factors in rice cultivation. It creates negative impact on crop production and responsible for 45-55% reduction of rice yield (Ghosh et al., 2013) in case of severe infestation. Previous studied revealed that application of herbicides reported to increase 30 to 40 per cent yield over control in transplanted rice (Bari, 2010). There have been tremendous developments in herbicide technology a wide spectrum range of pre-emergence and post-emergence herbicides now available to rice growing farmers. Application increases due to Improvement selectivity and formulations allow safer, easier, cheap and more flexible application for rice crops. The new way of growing rice, weed control relies heavily on herbicides. Selective herbicides kill specific targets, while leaving the non-targeted planted crops. Herbicides are commonly used due to quick, effective and low cost involvement in rice production system throughout the world (Hossain, M. M.et al., 2015). Nowadays use of herbicides is gaining popularity in rice culture due to their rapid effects and less cost involvement. The efficacy of herbicide in controlling weeds is important. After a field survey from dealers and chemical supplying companies (ACI Crop Care, Auto Crop Care, Macdonald Bangladesh, Intefa, Syngenta Bangladesh, Petrochem Bangladesh, Bayer crop science, National Agricare Import and export, SAM, SEMCO, Agriplus) on availability of common categories of chemical herbicides are used by the farmers are bensulfuron methyl, acetachlor, 2-4 d amine, pretilachlor, bispyriback-sodium, pyrazosulfuron ethyl, sulfonanilide, pendimethyline, metsulfuron methyl, butachlor, penoxsulam, pyrazosulfuron ethyl, pretilachlor, ethoxisulfuron, trisulfuron, machete, carfentrazon ethyl, cyalopbutyl, fenoxpro-pre-ethyl, orthosulfomuron, anilphos, cinmethyl, cinosulfuran, butachlor, glyphosate, paraquate, mefnaset, metsulfuron+chloromuron, MCPA remarkably used in our country. Selectivity unnecessarily dependent upon the compounds, but also on the rates, timing and methods of application as important to follow the manufacturers labelled recommendations. Indiscriminate uses and subsequent dispersion of herbicide compounds and their degradation products in rice fields may hampers the ecosystems. Herbicides can be toxic to humans at higher and lower doses (Zeliger et al., 2011). Soil composition also affects herbicide phytotoxicity and persistence through adsorption, leaching, and volatilization. Soils high in clay, organic matter, or both have a greater potential for herbicide carryover because there is increased adsorption to soil colloids, with a corresponding decrease in leaching and volatilization losses. The efficiency, persistence and mobility of herbicides are influenced by agro-climatic conditions. The information on efficiency of chemical compounds, dose, time and precaution for uses and predict the behavior of herbicides to suppress particular weed species and families for particular topography and soil types. Rice production systems rely on herbicides and the evolution of new weed problems and herbicide resistant ecotypes. It is time to emphasis on the judicious use of herbicides. From consideration of those facts the experiment was conducted.

2. MATERIALS AND METHODS

2.1 Experimental site

The experiment was carried out at the Field Laboratory of Agronomy Division, Bangladesh Institute of Nuclear Agriculture, head quarter farm Mymensingh, boro season during January to May 2019. The experimental field was located at 24.75^0 N latitude and 90.50^0 E longitudes having an elevation of 18 m above from sea level. Initial soil sample was randomly taken and analysis of composite sample to determine the soil morphological, physical and chemical characteristics of the experimental field.

Table 1. Soil morphological, physical and chemical characteristics of the experimental field

Morphological characteristics	
Agro-ecological zone (AEZ)	Old Brahmaputra Floodplain (AEZ 9)
General Soil Type	Non-calcareous Dark Grey Floodplain Soils Parent material, Brahmaputra river borne deposits
Topography	Medium high land and moderate drainage capacity
Order	Inceptisol
Physical Characteristics	
% Sand	22.7
% Silt	64.2
% Clay	13.1
Textural Class	Silt loam
Chemical characteristics	
Interpretation pH	(soil : water=1:2.5) 6.6
Organic matter (%)	2.69
Low Total N	(%) 0.175
Low Available K	(c mol kg^{-1} 0.09)

Low Available P	(mg kg^{-1} 3.00)
Very low Available S	(mg kg^{-1} 14.32)
Low Available Zn	(mg kg^{-1} 0.69)
Low Available B	(mg kg^{-1} 0.24)
Low Available Cu	(mg kg^{-1} 4.17)
High Available Mn	(mg kg^{-1} 68.6)
High Available Fe	(mg kg^{-1} 39.4)

2.2 Treatments and Experimental Design

The experiment was laid out in a factorial Randomized Complete Block Design with three replications. Among 20 treatment i,e; T_0 =control, T_1=two hand weeding (30 days after transplanting and 45 days after transplanting),T_2=bensulfuron methyl 8%+acetachlor 14%, T_3=2-4, D-amine72SCL,T_4= pretilachlor 500EC, T_5=triafemon20SC, T_6=pyrazosulfuron ethyl, T_7=trisulfuron40WP, T_8=pendimethalin 33EC, T_9=metsulfuron methyl20WDG, T_{10}= butachlor3G, T_{11}=ethoxysulfuron150WG, T_{12} =carfentrazol ethyl 24EC,T_{13}=fenoxpro-p-ethyl, T_{14}=bensulfuron methyl20gm+bispyriback sodium180gm, T_{15} =penoxulam240SC, T_{16} =pyrazosulfuron ethyl 100g + pretilachlor100g, T_{17}=bispyriback sodium300WP, T_{18}=paraquate dichloride, T_{19}= glyphosate. The unit plot size was 3mx4m, row and hill spacing was (20×15) cm and test crop was Binadhan-5 HYV (duration 155 days, potential yield 9 t. ha-1. The treatments were randomly distributed to the plots within a block. The bunds around individual plots were sufficiently strong to control water movement between the plots. A drain of one meter wide provided for watering around the whole experimental plot and between the blocks.

2.3 Weather Parameters

Table 2. Weather parameters during experimental periods January to May 2019 in Mymensingh, Bangladesh.

Month	Temperature^{0}C			Rainfall (mm)	RH (%)	Sunshine hours
	Min.	Max.	Average			
January	19	29	24	2.4	49	371
February	19	29	25	16.8	49	333
March	21	32	28	52.5	48	372
April	25	35	31	252.3	61	352
May	26	36	32	413.4	73	332

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2.4 Equation

Summed dominance ration (SDR): Summed dominance ration of weed species was computed using the following equation

$$SDR = \frac{\text{Relative density (RD)} + \text{Relative dry weight (RDW)}}{2}$$

$$\text{Relative density (RD)} = \frac{\text{Density of a given species}}{\text{Total density}} \times 100$$

$$\text{Relative dry weight (RDW)} = \frac{\text{Dry weight of a given species}}{\text{Total dry weight}} \times 100$$

$$\text{Weed control efficiency (WCE)} = \frac{WC-WT}{WC} \times 100$$

WC= Average weed dry weight per unit area in weedy check

WC= Average weed dry weight per unit area in treated plot

Higher value of WCE indicates greater effectiveness of herbicide

Crop growth rate: Crop growth rate (CGR) expresses the increase in dry matter of a plant community on a unite area of land per unite time. The crop growth rate was calculated by the following formula

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \ (gm^{-2}\ day^{-1})$$

Where, W_1 = dry weight at time T_1

W_2 = dry weight at time T_2

GA = ground area or land area (m^2)

Relative growth rate: Relative growth rate (RGR) expresses the total plant dry weight increase in a time interval in relation to the initial weight.

$$RGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \ (g\ g^{-1} day^{-1})$$

Where, W_1 = dry weight of plant at time T_1

W_2 = dry weight of plant at time T_2

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Net assimilation rate: The net assimilation rate (NAR) was calculated by following formula

$$NAR = \frac{1}{LA} \times \frac{dw}{dt} \text{ g m}^{-2} \text{ day}^{-1}$$

Where,

dw = dry weight increased in t days in g.

dt = Number of days.

LA = Leaf area (m^2)

Leaf area: The area of green leaves of sampled plants was measured from 30 DAT at 15 days interval upto 75 DAT by using automatic leaf area meter. Later leaf area index was calculated by using the following formula

$$LAI = \frac{\text{Surface area of green leaves } (m^2)}{\text{Land area from where the leaves were collected } (m^2)}$$

2.5 Fertilizer application

The plots of Boro rice were fertilized with urea 200 kg ha^{-1}, TSP 100 kg ha^{-1}, MoP 140 kg ha^{-1}, gypsum 60 kg ha^{-1}, $ZnSO_4$ H_2O, 6 kg ha^{-1}. The whole amount at triple super phosphate, muriate of potash, gypsum and zinc sulphate (separately) were applied to the soil at the time of final land preparation. Urea was applied in three equal splits. Thirty days old seedlings were transplanting in the experimental plots.

2.6 Herbicide application

Treatment of different herbicide was assigned according to pre-plant, pre-emergence and post-emergence basis and water level was maintained during treatment assigned. After application of pre-plant herbicide (paraquate dichloride, glyphosate) 15 days was considered to transplanting of rice seedling in timely. Treatments of herbicide application time, dose and water level maintained by according to recommendation of commercial grade pack labelled information.

2.7 Harvesting and data collection

The data of weed species and family were collected at 40 DAT. Dry wet of weeds for calculation of RWD, RWB and HE%. The yield and yield contributing characters from10 random hills, the following data were recorded, plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, number of grain $panicle^{-1}$, number of unfilled grains $panicle^{-1}$,1000 grain weight, grain yield (t ha^{-1}), straw yield (t ha^{-1}).

2.8 Data processing and analysis

The data were analysed subjected to analysis of variance (ANOVA) technique and treatment mean differences were adjusted by the Multiple Comparison test and the treatment means were compared using the least significant different test (Gomez, K. A. and A. A. Gomez, 1984).

3. RESULTS

3.1 Weed control efficiency (%)

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To calculate the weed control efficiency the weed species, weed density, weed dry weigh was recorded. The highest weed control efficiency was found at penoxsulam treated plot 86.55 % lowest weed control efficiency (64.14%) was found at 2-4, D amine72SCL (T3) treatment.

Table 3. Effect of herbicide treatment on weed species, weed density, weed dry matter and weed control efficiency

Treatment	Rate of application	Weed Species (no. m^{-2})	Weed Density (no. m^{-2})	Weed Fresh wt. (g m^{-2})	Weed dry wt. (g m^{-2})	WCE (%)
Control (T_0)	No weeding	17	37	124.9	35.7	-
Two hand weeding(T_1)	Two 30DAT, 45DAT	4	14	56.4	8.52	76.13
Bensulfuran methyl 8%+ Acetachlor 14%(T_2)	180g/ha	3	12	49.0	5.62	84.25
2-4, D amine72SCL(T_3)	1.25 L/ha	4	13	71.4	12.8	64.14
Pretilachlor500EC(T_4)	1L/ha	4	12	56.4	7.1	80.11
Triafemon20SC(T_5)	200g/ha	2	17	69.1	7.5	78.99
Pyrazosulfuron ethyl(T_6)	125 g/ha	4	11	50.2	6.7	81.23
Trisulfuron40WP(T_7)	400 g a. i/ha	2	8	54.0	7.8	78.15
Pendimethalin33EC(T_8)	1000ml/ha	4	13	71.2	13.3	62.74
Metsulfuron methyl20WDG(T_9)	50g/ha	4	13	35.4	8.3	76.75
Butachlor3G(T_{10})	25kg/ha	3	17	47.8	8.7	75.63
Ethoxysulfuron150WG (T_{11})	100g/ha	1	11	38.9	6.7	81.23
Carfentrazol ethyl 24EC(T_{12})	(1.8L/ha)	1	15	53.3	8.2	77.03

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Fenoxpro-p-ethyl(T_{13})	275ml/ha	3	13	67.18	10.5	70.58
Bensulfuron methyl20gm + Bispyriback sodium180gm(T_{14})	160g/ha	3	11	56.38	6.8	80.95
Penoxsulam240SC(T_{15})	87.5ml/ha	4	15	56.84	4.8	86.55
Pyrazosulfuran ethyl100g + Pretilachlor100g(T_{16})	200g/ha	4	12	48.17	6.21	82.60
Bispyriback sodium300WP(T_{17})	200g/ha	6	11	41.7	6.9	80.67
Paraquate dichloride (T_{18})	2.8L/ha	7	17	67.8	15.34	57.03
Glyphosate(T_{19})	3.7L/ha	4	15	63.17	16.12	54.62

3.2 Particulars of weed species in the weedy check plots

From keen observation Out of total 17 weed species annual weeds 12 species were mostly dominating and 5 weed species perennials were less dominating. Out of total 17 weed species 6 belongs to Gramineae, 1 weed species belongs to Pontederiaceae, 6 weed species belongs to Cyperaceae and 1 weed species belongs to Asteraceae, 1 weed species belongs to Marsileaceae, 1 species belongs to Sphenocleaceae family found to grow in the weedy check plots (Table 4). Morphological types were recorded that two weed species were broad-leaved, 6 were grasses and 7 weed species were sedges.

Table 4. Particulars of weed species in the weedy check plots of the experiment

Sl. no.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Shama	*Echinochloa colomum*	Gramineae	Grass	Annual
2	Gaicha	*Paspalum distichum*	Gramineae	Grass	Perennial
3	Panikachu	*Monochoria vaginalis*	Pontederiaceae	Broad-leaved	Perennial
4	Arail	*Leersia hexandra L.*	Gramineae	Grass	Annual
5	Chechra	*Scirpus mucronatus L.*	Cyperaceae	Sedge	Perennial
6	Zhilmorich	*Sphenoclea zeylanica*	Sphenocleaceae	Broad-leaved	Annual
7	Shushnishak	*Marsilea quadrifolia*	Marsileaceae	Sedge	Annual

8	Holdemutha	*Cyperus difformis.*	Cyperaceae	Sedge	Annual
9	KhudeShama	*Echinochloa colona*	Gramineae	Grass	Annual
10	Keshuti	*Eclipta alba*	Asteraceae	Sedge	Annual
11	Barochucha	*Cyperus iria*	Cyperaceae	Sedge	Perennial
12	Chechra	*Scirpus maritimus*	Cyperaceae	Sedge	Annual
13	Durba	*Cynodon dactylon*	Gramineae	Grass	Perennial
14	Nunia	*Portulaca oleracea*	Portulaceae	Broad-leaved	Annual
15	Fulkaghash	*Leptochloa chinensis*	Gramineae	Grass	Annual
16	Chotaceich	*Cyperus difformis*	Cyperaceae	Sedge	Annual
17	Zaina	*Fimbristylis miliacea*	Cyperaceae	Sedge	Annual

3.3 Weed ranking

The summed dominance ratio an important pointer of showing ranking of weeds in a particular location. From close observation the dominant weed species was (*Leersia hexandra. Cyperus difformis, Cyperus iria*) in experiment plots.

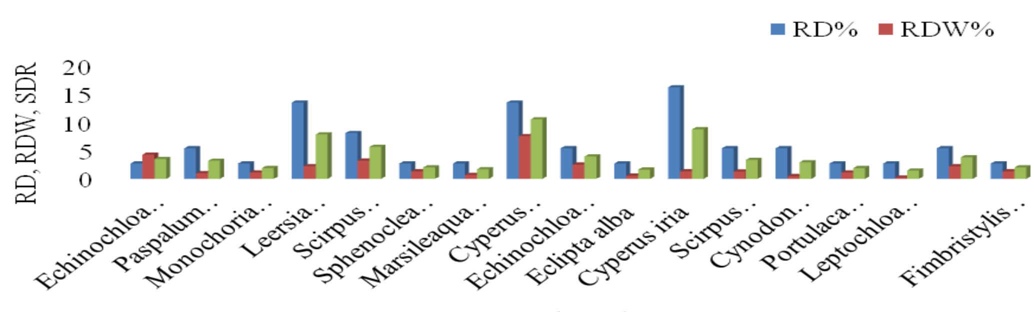

Figure 2: Weed ranking

3.4 Weed species composition

The maximum weed species 17 was found at control plot. Hand weeding is widely used weed control method, availability of labour in season the main limitation to its effectiveness. In Bangladesh, hand weeding rice at 30 and 45 DAT only 4 weed species was found. Minimum weed species was found in ethoxysulfuron150WG (T_{11}) and carfentrazol ethyl 24EC (T_{12}) it suppress other 16 weed species compared to treated plot (Table 5). Bensulfuran methyl 8%+

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acetachlor 14% (T_2), butachlor 3G (T_{10}), fenoxpro-p-ethyl (T_{13}), bensulfuron methyl + bispyriback sodium (T_{14}) 3 weed species and (T_3, T_4, T_6, T_8, T_9, T_{15}, T_{16}, T_{19}) treatment 4 weed species was found (Table 5). Among the infested, different species of weeds; maximum relative weed density was observed for *Echinochloa colona*, *Cyperus difformis*, *Leersia hexandra L.* It was observed that broad leaf weeds were less dominating species. Due to application of pre-emergence or early post emergence, the herbicide gives good control over a wide range of grass, broad leaf weeds and sedges species. Single application of Pyrazosulfuron ethyl (T6) provided full control on *C. rotundus* and *F. miliacea* controlled *C. difformis* but less effective to suppress *Ecliptaalba, Marsilea quadrifolia*, *Cyperus difformis*, *Cyperus iria*.

Table 5. Weed species composition and effect of herbicide on weed infestation and relative weed density

Treatment	Local name	Scientific name	Weed infestation (no. m^{-2})	Relative density (%)
T_0	Shama	*Echinochloa colomum*	1	2.70
	Gaicha	*Paspalum distichum*	2	5.40
	Panikachu	*Monochoria vaginalis*	1	2.70
	Arail	*Leersia hexandra L.*	5	13.5
	Chechra	*Scirpus mucronatusL.*	3	8.10
	Zhilmorich	*Sphenoclea zeylanica*	1	2.70
	Shushnishak	*Marsilea quadrifolia*	1	2.70
	Holdemutha	*Cyperus difformis*	5	13.5
	Khudeshama	*Echinochloa colona*	2	5.40
	Keshuti	*Eclipta alba*	1	2.70
	Barochucha	*Cyperus iria*	6	16.2
	Chechra	*Scirpus maritimus*	2	5.40
	Durba	*Cynodon dactylon*	2	5.40
	Nunia	*Portulaca oleracea*	1	2.70
	Fulkaghash	*Leptochloa chinensis*	1	2.70

	Chotaceich	*Cyperus difformis*	2	5.40
	Zaina	*Fimbristylis miliacea*	1	2.70
	Total		37	100
T_1	Khudeshama	*Echinochloa colona*	4	28.57
	Arail	*Leersia hexandra L.*	2	14.28
	Holdemutha	*Cyperus difformis.*	4	28.57
	Chechra	*Scirpus mucronatus L.*	4	28.57
	Total		14	100
T_2	Shama	*Echinochloa colomum*	2	16.66
	Panikachu	*Monochoria vaginalis*	6	50.00
	Holdemutha	*Cyperus difformis.*	4	33.34
	Total		12	100
T_3	Shama	*Echinochloa colomum*	4	25
	Gaicha	*Paspalum distichum*	3	12.5
	Khudeshama	*Echinochloa colona*	3	37.5
	Arail	*Leersia hexandra L.*	3	25
	Total		13	100
T_4	Holdemutha	*Cyperus difformis.*	4	30.76
	Chechra	*Scirpus mucronatus L.*	2	15.38
	Shushnishak	*Marsilea quadrifolia*	3	25.00
	Arail	*Leersia hexandra L.*	3	25.00
	Total		12	100
T_5	Barochucha	*Cyperus iria*	4	23.53
	Gaicha	*Paspalum distichum*	13	76.47
	Total		17	100

T_6	Keshuti	*Eclipta alba*	2	18.18
	Shushnishak	*Marsilea quadrifolia*	5	45.45
	Holdemutha	*Cyperus difformis.*	3	27.27
	Barochucha	*Cyperus iria*	1	9.09
	Total		11	100
T_7	Panikachu	*Monochoria vaginalis*	5	50
	Zhilmorich	*Sphenoclea zeylanica*	5	50
	Total		10	100
T_8	Panikachu	*Monochoria vaginalis*	1	7.69
	Arail	*Leersia hexandra L.*	3	23.07
	Holdemutha	*Cyperus difformis.*	5	38.46
	Chechra	*Scirpus mucronatus L.*	4	30.76
	Total		13	100
T_9	Khudeshama	*Echinochloa colona*	4	30.76
	Arail	*Leersia hexandra L.*	3	23.07
	Panikachu	*Monochoria vaginalis*	2	15.38
	Holdemutha	*Cyperus difformis.*	4	30.76
	Total		13	100
T_{10}	Panikachu	*Monochoria vaginalis*	4	23.52
	Zhilmorich	*Sphenoclea zeylanica*	6	35.29
	Barochucha	*Cyperus iria*	7	41.17
	Total		17	100
T_{11}	Arail	*Leersia hexandra L.*	11	100
	Total		11	100
T_{12}	Khudeshama	*Echinochloa colona*	14	100

	Total		14	100
T_{13}	Panikachu	*Monochoria vaginalis*	4	26.67
	Zhilmorich	*Sphenoclea zeylanica*	5	33.33
	Barochucha	*Cyperus iria*	6	40
	Total		15	100
T_{14}	Khudeshama	*Echinochloa colona*	4	30.76
	Arail	*Leersia hexandra L.*	2	15.38
	Chechra	*Scirpus mucronatusL*	7	43.84
	Total		13	100
T_{15}	Shama	*Echinochloa colomum*	1	12.5
	Keshuti	*Eclipta alba*	3	37.5
	Panikachu	*Monochoria vaginalis*	3	37.5
	Holdemutha	*Cyperus difformis.*	1	12.5
	Total		8	100
T_{16}	Shama	*Echinochloa colomum*	2	13.33
	Gaicha	*Paspalum distichum*	8	53.33
	KhudeShama	*Echinochloa colona*	3	20
	Arail	*Leersia hexandra L.*	2	13.34
	Total		15	100
T_{17}	Barochucha	*Cyperus iria*	1	8.33
	Keshuti	*Eclipta alba*	2	16.67
	Panikachu	*Monochoria vaginalis*	2	16.67
	Zhilmorich	*Sphenoclea zeylanica*	4	33.33
	Shama	*Echinochloa colomum*	2	16.67
	Gaicha	*Paspalum distichum*	1	8.33

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	Total		12	100
T_{18}	Khudeshama	*Echinochloa colona*	1	5.88
	Arail	*Leersia hexandra L.*	3	17.64
	Chechra	*Scirpus mucronatus L.*	2	11.76
	Shushnishak	*Marsilea quadrifolia*	4	23.52
	Holdemutha	*Cyperus difformis.*	1	5.88
	Barochucha	*Cyperus iria*	3	17.64
	Keshuti	*Eclipta alba*	3	17.64
	Total		17	100
T_{19}	Gaicha	*Paspalum distichum*	3	20
	Khudeshama	*Echinochloa colona*	1	6.67
	Arail	*Leersia hexandra L.*	7	46.67
	Gaicha	*Paspalum distichum*	4	26.66
	Total		15	100

3.5 Effect of herbicide on crop growth rate

Crop growth rate expresses the increase in dry matter of a community of plants on a unit area of land in a unit time. The data revealed that treatment effect of herbicide significantly influenced the crop growth rate of rice.

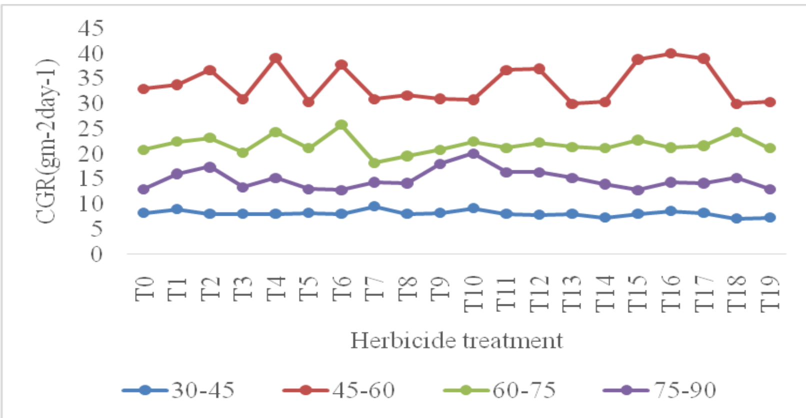

Figure 4. Effect of herbicide on net assimilation rate

3.6 Effect of herbicide on relative growth rate

Relative growth rate expresses the dry matter increase in a time interval in relation to the initial weight. The data reveals that the RGR remains same up to 30-60 DAT and thereafter, fluctuation gradually up to 60-90 DAT.

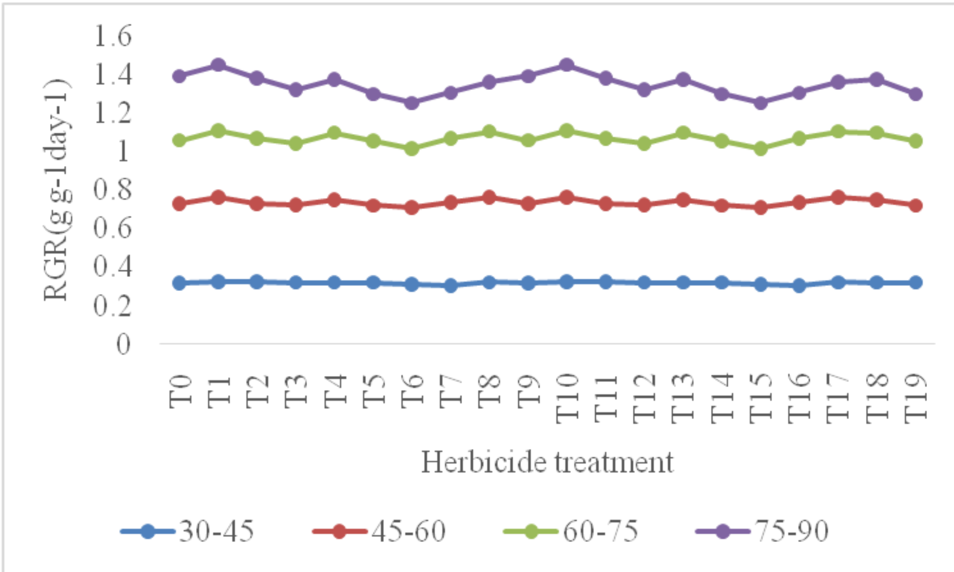

Figure 3. Effect of herbicide on net assimilation rate

3.8 Effect of herbicide on net assimilation rate

Net assimilation rate (NAR) is the net gain in total dry weight per unit of leaf area per unit time. The NAR is the most important index of photosynthetic efficiency of a plant. Highest net assimilation rate was found at 30 DAT and gradually it decreases significantly. Lowest NAR was found at T_3, T_7, T_9, T_{18} and T_{19} treatment 45 DAT.

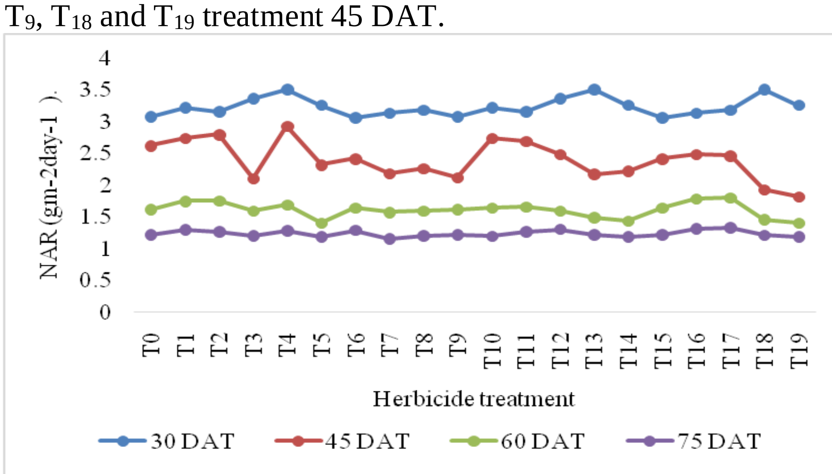

Figure 4. Effect of herbicide on net assimilation rate

3.9 Effect of herbicide on yield and yield contributing characters of rice

There is a statistically significant different in plant height and total tiller hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, grain yield. Maximum plant height (129.3cm) was noted for penoxulam treatment and minimum of that (117.3cm) control plot. The maximum number of tillers hill^{-1} (10.9) was noted for penoxulam, pyrazosulfuron treatment and minimum number of tillers hill^{-1} (8.2) control treatment (Table 6). The maximum number of effective tillers hill^{-1} (8.9) was noted for penoxulam treatment and minimum number of effective tillers hill^{-1} (6.3) at control treatment. The maximum filled grains panicle^{-1} (127.3) had obtained with application of penoxulam treatment, and minimum filled grains (104.3) was observed with control treatment.

Table 6. Effect of herbicide and weed management on yield and yield contributing characters of boro rice (Binadhan-5)

Treatment	Plant height (cm.)	Total tiller hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t.ha^{-1})	Straw yield (t.ha^{-1})
T_0	117.3	8.2	6.3	20.6	104.3	11.4	23.9	4.61	6.32
T_1	124.9	10.0	7.1	20.7	114.5	10.7	24.4	5.63	7.21
T_2	120.3	10.1	8.7	20.4	121.3	7.9	23.3	6.76	7.42
T_3	121.9	9.2	8.1	21.1	116.3	19.3	25.0	5.82	7.84
T_4	124.7	10.5	8.6	20.5	121.1	11.7	24.1	6.67	7.49
T_5	123.1	9.5	8.3	21.1	113.7	10.7	24.7	5.71	7.65
T_6	124.5	10.9	8.2	20.7	127.0	12.5	24.5	6.79	7.41
T_7	120.7	9.1	7.6	21.0	113.2	11.8	22.4	5.85	7.93
T_8	125.3	9.3	7.5	21.3	111.3	10.3	23.0	5.93	8.10
T_9	124.3	10.4	7.4	20.9	116.7	10.5	22.7	5.85	7.97
T_{10}	124.7	10.1	7.7	20.3	114.4	13.6	24.4	5.81	7.89

T_{11}	122.7	10.1	8.1	21.4	127.1	11.7	23.0	6.59	7.33
T_{12}	122.3	10.3	8.6	21.1	122.6	11.1	23.1	6.82	7.73
T_{13}	123.3	10.3	7.1	21.0	111.6	11.6	23.0	5.87	7.52
T_{14}	121.3	10.5	8.2	21.0	113.5	11.5	22.6	5.79	7.54
T_{15}	129.3	10.9	8.9	21.0	127.3	17.1	22.6	6.83	7.60
T_{16}	122.5	10.1	8.3	20.7	124.7	14.3	24.4	6.54	7.18
T_{17}	125.3	10.3	8.1	20.5	123.9	10.7	24.0	6.61	7.41
T_{18}	123.5	9.3	7.4	20.4	114.7	11.3	24.4	5.51	7.19
T_{19}	126.3	10.1	7.8	20.5	112.9	11.7	24.0	5.61	7.42
$LSD_{0.05}$	4.1	2.2	2.1	NS	6.7	NS	NS	0.89	1.13
CV (%)	5.5	7.6	6.9	3.3	8.4	7.8	2.4	7.9	7.2

4. DISCUSSIONS

This chapters covers the discussion of results of following parameters; weed control efficiency

4.1 Weed control efficiency (%)

From recorded data it was found that bensulfuron methyl + acetachlor, pretilachlor, pyrazosulfuron ethyl, ethoxysulfuron, bispyriback sodium, bensulfuron methyl + bispyriback sodium, penoxsulum, pyrazosulfuron ethyl + pretilachlor efficiency more than 80% (Table 3). Whereas pendimethalin 62.74 pretilachlor and pendimethalin recorded almost similar (61.59 and 61.93%, respectively) value of weed control efficiency (Ghansham Payman and Surjit Singh. 2008). Al-Kothayri et al., 1990 reported that all herbicidal treatments reduced weed population significantly when compared with weedy check. It was supported by (Hasanuzzaman et al., 2008). Transplanted boro rice biomass negatively correlated with rice yield (R=--0.76918) (Table 3 and 6) showing high degree of association was affected due to presence of weeds which was supported by (Suresh Kumar et al., 2008).

4.2 Weed species composition

Hand weeding expensive task in short supply of labor in peak season and weed control found imperfect and delayed. Herbicide treatment including post-emergence herbicide was effective for broadleaf weed control which is supported by (Chauhan, B. S et al., 2015). On the contrary pre-emergence herbicide treatments having butachlor results less effective to suppress of sedge weeds *Monochoria vaginalis, Sphenoclea zeylanica* supported to the studies that butachlor was less effective on sedges in case of dry direct seeded rice (Mahajan, G. et al., 2008). Applied late post-emergence herbicide gave full control on *Cyperus rotundus, Fimbristylis miliacea* and *C. difformis* which is supported by (Taslima Zahan et al., 2018). Bispyriback sodium (T_{17}) treated plot only 6 weed species found when compare with control 17 weed species, it is a selective herbicide and effective for the control of grasses, sedges and broadleaf weeds in rice which is supported by (Schmidt L A. et al., 1999). In case of trisulfuron (T_7) treated plot only two broad leaf weed species was found *Monochoria vaginalis, Sphenoclea zeylanica* it might be more effective to suppress grass less effective for broadleaf weed (Table 4).

4.3 Effect of herbicide on crop growth rate (CGR)

Among 20, the highest CGR was recorded at trisulfuron (T_7) treatment 30-45 DAT, pyrazosulfuran ethyl + pretilachlor (T_{16}) 45-60 DAT, pretilachlor (T_4) and Paraquate dichloride (T_{18}), 60-75 DAT, trisulfuron (T_7), 75-90 DAT (Figure 1). It might be due to herbicide treatment initially less utilize the available nutrients in case of less microbial activity due to herbicide toxicity. After 30-45 DAT plant maximum utilize the available nutrients gradually increased leaf area, and higher photosynthesis and dry matter accumulation which enhanced crop growth rate. Herbicides have toxic effects on microorganisms, reducing their abundance, activity and consequently, the diversity of their communities. The toxic effects of herbicides are normally most severe immediately after application (Mondal et al., 2019). Afterwards microorganisms take part in a degradation process and its toxic effect gradually decline up to half-life. Then the degraded organic herbicide provides the substrate with carbon, which leads to an increase of the soil microflora.

4.4 Effect of herbicide on relative growth rate (RGR)

Irrespective of herbicide treatments due to leaf senescence or destruction of chlorophyll pigment and less photosynthetic activity. The highest RGR was found in the treatment with bensulfuron methyl + acetachlor (T_2), butachlor (T_{10}) & fenoxpro-p-ethyl (T_{13}) (Figure 2).

4.5 Effect of herbicide on net assimilation rate (NAR)

Irrespective of herbicide treatment, NAR was higher at the early growth stages and declined very sharply from 45 DAT till maturity. The highest NAR was recorded in the treatment with Pretilachlor (T_4) and Butachlor (T_{10}) treatment. From recorded data at later growth 75-90 DAT stages of growth with steady increase in LAI, and the lowest NAR was found (Figure 3).

4.6 Effect of herbicide on yield and yield contributing characters of rice

All weed control treatments significant difference on plant height, total tillers hill^{-1}, effective tillers hill^{-1}, more number of grains panicle^{-1} grain yield and straw yield and there was no significant difference on panicle length, unfilled grains panicle^{-1}, 1000-grain weight as compared to weedy check (Ghansham Payman and Surjit Singh. 2008). The highest grain yield (6.83tha^{-1}) was found with penoxsulam treatment which was followed by (6.82 t ha^{-1}) at (Bensulfuran methyl + Bispyriback sodium) treatment and lowest (4.61 t ha^{-1}) at control. It was happened due to better weed control that leads to reduced crop-weed competition and facilitates the uptake of more nutrients, proper spacing for maximum solar radiation harvest and assimilates more photosynthates that results in healthier rice plants with more tillers, panicles and biomass production to increase yield (Awan, T. H. et al., 2015 and Ahmed, S., et al., 2014). It was found that average yield varies (6.59 to 6.83) t ha^{-1} of these chemical class bensulfuron methyl + acetachlor, pretilachlor, pyrazosulfuron ethyl, ethoxysulfuron, bispyriback sodium, bensulfuron methyl + bispyriback sodium, penoxsulam, pyrazosulfuron ethyl + pretilachlor treated plots and their weed control efficiencies more than eighty (Table 6).

5. CONCLUSION

It may be concluded that grain yield maximum grain yield found with penoxsulam treatment which was followed by Bensulfuran methyl+ Bispyriback sodium treatment. From recorded data the highest weed control efficiency was found at penoxsulam which is followed by bensulfuron methyl + acetachlor and lowest glyphosate treated plot. The results suggest that for Old Brahmaputra Floodplain (AEZ-9), as like as non-calcareous dark grey flood plain soils parent material, Brahmaputra River borne deposits to maximize yield of boro rice cultivation. From efficiency point of view bensulfuron methyl + acetachlor, pretilachlor, pyrazosulfuron ethyl, ethoxysulfuron, bispyriback sodium, bensulfuron methyl + bispyriback sodium, penoxsulam, pyrazosulfuron ethyl + pretilachlor may control weed efficiently and gave maximum yield.

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