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Research Article

Evaluation of Pre and Post Emergence Herbicides Efficacy on Upland rice (*Oryza sativa* L.) Weeds in Fogera Hub, Ethiopia

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ABSTRACT

Rice (*Oryzae sativa* L.) is by far the most important stable food crop for over half of the world population for both developing and developed nations, where its consumption has increased considerably due to food diversification and its calorie demand. However, its productivity and quality are highly limited by the occurrence of diseases, insect pests and high weed infestations. Weeds can reduce rice yield by over 30% and this makes farmers to incur 70% of their cost to manage it because of the availability of ample moisture with in the rice field and long period of infestation. The objective of this study was aimed to evaluate the efficacy of broadleaf and grass weed targeted herbicides of upland rice and recommend the most effective ones. An experiment was conducted at Fogera National Rice Research and Training Center experimental station for two consecutive years (2017-2019) using NERICA 4 Variety. It was carried out in aerobic soil condition. Eight treatments, two pre-emergences (S-metolachlor 290 g/l + atrazine 370 g/l and S-metolachlor 960 g/l) herbicides, four post-emergence herbicides (Bispyribac-sodium 10% SC, Pyroxsulam45 g/l, Lodosulfuron-methyl-sodium 7.5g/l+ Mesosulfuron methyl 7.5 g/l and 2,4-D dichlorophenoxy acetic acid 720 g/l acid), two times manual weeding and control check (weedy check) were used for evaluation. The treatments were arranged in randomized complete block design with three replications. Weed population and agronomic parameters data were recorded. The result revealed that post-emergence herbicides were highly effective over pre-emergence herbicides to manage upland rice weeds. Two times of manual hand weeding followed by Bispyribac-sodium 10% EC and Pyroxsulam45 g/l herbicides treatments gave high grain yield (3243.4 and 3063.6 kg ha^{-1}), respectively. Therefore, it can be concluded that Bispyribac-sodium 10% EC could be recommended for upland weeds management followed by Pyroxsulam45 g/l herbicide with integration of other management practices.

Keywords: Post-emergence herbicides; Pre-emergence herbicides; Upland rice; Weed; Weed infestation; Weed management

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food for the people of Asian countries. It provides 35-80% of total calorie requirement and it occupies an enviable prime place among the food crops cultivated around the world, it is grown in an area of 167 million hectares with a production of 678 million tons [1]. Rice is the second most common staple food in East Africa, after corn. The annual consumption exceeded 1.8 million metric tons by 2014. Production, however, stood at 1.25 million metric tons [2].

Rice is expected to contribute to ensuring food security in Ethiopia among the target commodities which have received due focus in promoting agricultural development. Even though, it is a recent introduction to the country, rice is considered as the "Millennium crop" and has shown promising adoption and advantage to be among the major crops that can immensely contribute towards ensuring food security in Ethiopia. The country has large ecologies suitable for rice production, along with the possibility to grow it where other food crops are not doing well. Based on GIS techniques and agro-ecological requirements of rice, the potential rain-fed rice production area in Ethiopia is estimated to be about thirty million hectares [3]. Rice is compatible with various traditional food recipes, such as pasta, soup, "*enjera*," and local beverages (such as "*tela*" and "*areki*"). As the crop is labor intensive, the country also has a competitive advantage in growing rice because of the availability of massive and cheap rural labor. Farmers as well as private investors who often request improved varieties for different ecosystems [3] with better diseases, insect pests and weed management recognize

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the value of rice as a food security crop, source of income and job opportunity due to its relative high productivity compared to other cereals.

Rice production is constrained by several factors: technological, bio- physical, socio economic, institutional and financial. Of these constraints, biotic and abiotic factors are considered to be the most important rice production limiting ones. Abiotic stresses include: erratic rainfall, with drought and flooding occurring during the same season; coastal lowland poorly drained soils, and alkalinity in arid areas. Biotic stresses include: weeds, insect pests (stem borers such as stalk-eyed flies, African rice gall midge and rice bugs), diseases (blast, brown spot, and viral diseases), rats and birds [4].

Weed has been identified as leading constraint of rice production in Ethiopia. The infestation of weed is mostly high in upland rice which has paramount as compare to lowland rice potential area in Ethiopia. In direct seeded aerobic rice, weed infestation and competition are more serious compared with transplanted rice, because of the reasons *viz*., land is exposed during initial crop growth stages, aerobic soil conditions, dry tillage practices and alternate wetting and drying make the conditions more conducive for germination and growth of weeds. Direct seeded aerobic rice is highly infested with grasses, broad leaved weeds and sedges [5]. Farmers have incurred 70% of their cost for rice weed management in Fogera, Dera and Libokemkem districts and they are already managing through hand weeding which ranges as 3 to 5 times in a season (unpublished). The upland rice production is highly reduced by weed infestation since the weed species are not suppressed by water and compete throughout the crop growth period.

Unlike transplanted rice early and timely weed control is essential in aerobic rice; otherwise the yield loss is to an extent of 82.00% due to crop weed competition [6]. Timely weed control plays an important role among the agronomic requirements for improving the aerobic rice yield levels. Traditional method of weed management practices are widely adopted for control of weeds in aerobic rice. These practices are tedious, time consuming, labor intensive, costly and not possible to practice over an extensive area. Further, due to high labor wages as a result of limited income, rapid industrialization and urbanization, traditional weed management practices are being impracticable.

Addition of safe and effective herbicide in integrated weed management is believed to increase efficiency in weed management [5]. Access to herbicides for rice weed management is very less in the country due to unavailability of registered herbicide specifically for rice weed management. However, many herbicides have been registered for wheat, barley and tef weed management in Ethiopia. Because of the similar morphological character of rice with the stated cereal crops, the registered herbicides may work for weed management in upland rice. Therefore, the major objective of this study was to evaluate some pre and post weed emergence herbicides and identify the most effective herbicides that can be integrated with other management practices.

MATERIALS AND METHODS

Description of the study area

Fogera district description

Fogera woreda is one of the 151 woredas of the Amhara Regional State found in South Gondar Zone (Figure 1). It is situated at

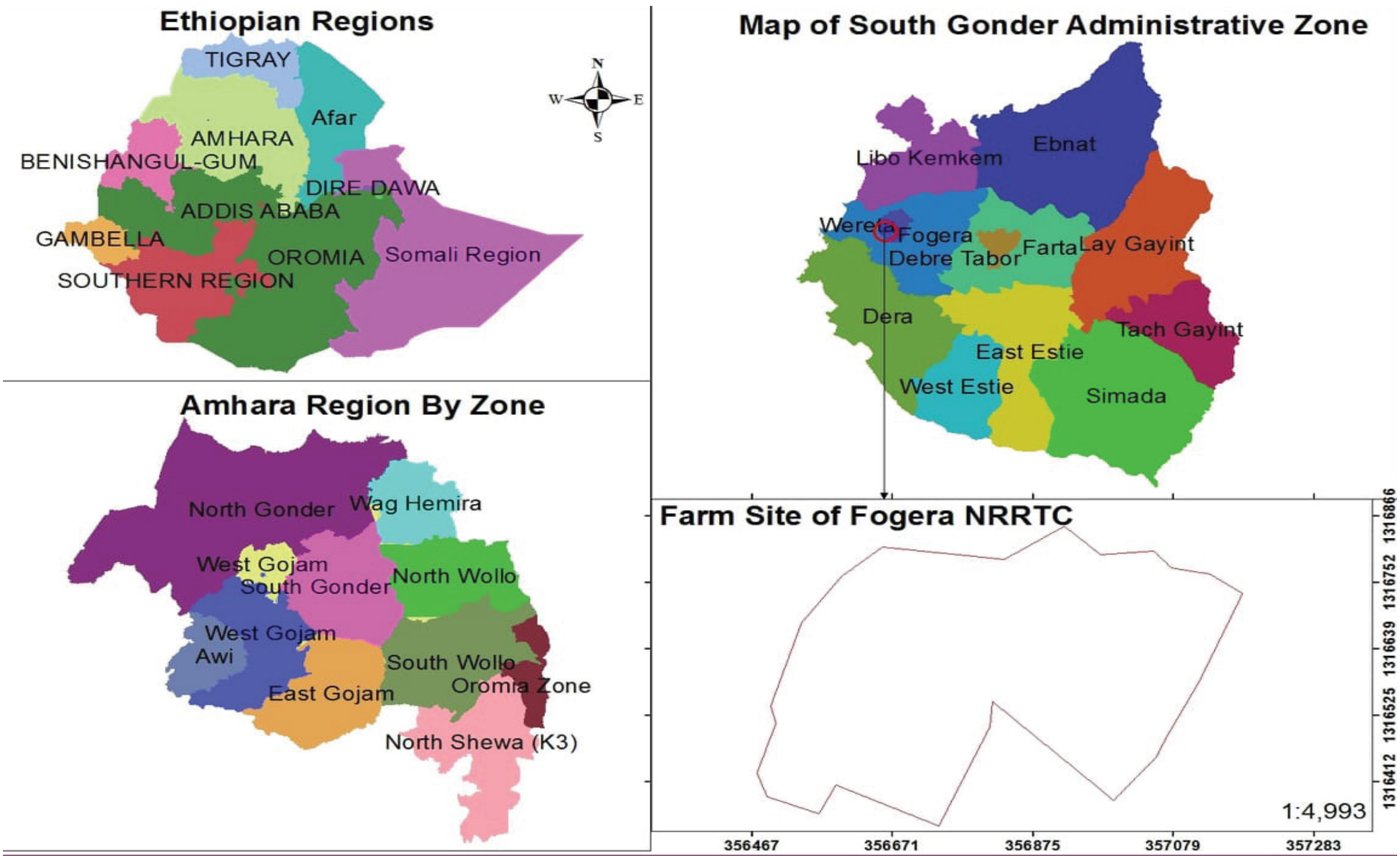

Figure 1: Map of the study area (Source: Amare Alemnew).

11°46 to 11°59 latitude North and 37°33 to 37°52 longitude East. Altitude ranges from 1774 to 2410 metres above sea level (masl) and is predominantly classified as Woina-Dega. Based on the existing digital data, mean annual rainfall was 1216 mm ranging from 1103 to 1336 mm from both the short (March and April) and long rains (June to September). Farmers depend on long rainy (Kremt) season for crop production [7].

Description of Fogera National Rice Research and Training Center

The study had conducted at Fogera National Rice Research and Training Center (FNRRTC) South Gondar zone of Ethiopia, located 565 Km far from the capital city of Addis Ababa and about 55 Km north of Bahirdar; the capital city of Amhara regional state. Geographically the experimental site is located at latitude of 11° 58′ N and longitude of 37° 41′ E with an altitude of 1817 m above sea level and it receives average annual rainfall of 1230 mm. Mean minimum and maximum temperature of the area is 12 and 28˚C, respectively. The soil is brown clay (vertisol) rich in underground water [8] (Figure 1).

Experimental design and treatments

An experiment was conducted in aerobic rice ecosystem under rain fed condition by using NERICA 4 rice variety. The treatments were arranged in randomized complete block design with three replications (Table 1). The plot size was 3 meters with 2.4 meter (7.2 m^2) and the block size was 28.5 meter with 11 meters (313.5 m^2). A spacing of 0.5 meter and 1 meter was used between plots and blocks respectively and the space between rows was 20 cm. In this experiment, eight (8) treatments were evaluated, of which four were post emergence herbicides, the other two were pre mergence herbicides and two times hand weeding as well as control check. Randomization was held independently for each replication by which treatments were assigned completely at random as described by Kwanchai et al. [9] and Poduska [10]. The pre emergence herbicides were Primagram gold 660SC (S-metolachlor 290 g/l + atrazine 370 g/l) and Dual gold 960 EC (S-metolachlor 960 g/l) whereas the post emergence herbicides were Pride 100 SC (Bispyribac-sodium 10% SC), pallas 45 OD (Pyroxsulam 45 g/l), Atlantis OD 37.5 (Lodosulfuron-methyl-sodium 7.5g/l+ Mesosulfuron methyl 7.5g/l) and Agro 2,4-D amin 720 SL (2,4-D dichlorophenoxy acetic acid 720 g/l acid). In addition, two times hand weeding, which was a standard check practiced with in the farmers and the control check; unsprayed and not weeding by any methods were used as treatments to evaluate them with the above herbicides (Table 1).

Experimental procedure

The study was conducted at the rainy season (summer season) of Ethiopian climatic condition. The land was prepared a head of the onset of rain and it was ploughed more than three times. The NERICA 4 variety was used and the recommended seed rate by which the experiment conducted was 80 kilograms per hectare from which 58 grams was used for each plot. Furthermore, the 60.5 kilogram per hectare Nitrogen, phosphorus and sulfur (NPS with grade of 19N-38P-7 S) fertilizer and 130 kilograms per hectare recommended granular urea fertilizer rates were applied. All plots were received 43.56 gram of Nitrogen, phosphorus and sulfur (NPS

Table 1: Type of herbicides used their dose and time of application.

Code	Trade name	Herbicide name	Herbicides methods of application	Target weeds	Dose of herbicide and water/ ha	Time of Application
T=1	Pride 100 SC	Bispyribac-sodium 10 % SC	Post emergence	Broad leaf weeds in wheat		At 5 – 6 leaf stage of the crop
T=2	Pride 100 SC 660 SC	S-metolachlor 290g/ l + atrazine 370 g/l	Pre-emergence	Broadleaf and grass weeds in maize and sugarcane	3.5lit+300lit H_2O	After one day of sowing
T=3	Pallas 45 OD	Pyroxsulam45gm/l	Post emergence	Grass weeds, annual broad leaf weeds on wheat and tef	500ml+220lit H_2O	30 to 35 days after seedling emergence
T=4	Dual Gold 960 EC	S-metalachlor 960g/l	Pre-emergence	Broad leaf weeds in haricot bean	1.3lit+200lit	After one day of sowing
T=5	Atlantis OD 37.5	Lodosulfuron-methyl-sodium 7.5g/l + Mesosulfuron methyl 7.5g/l	Post emergence	Grass & broad leaf weeds in wheat	1lit+120lit H_2O	At 2 – 4leaves stage of the weeds
T=6	Manual weeding	Two times hand weeding	Farmer practice	All (grass&broads leaeves)		At tillering and panicle initiation stage
T=7	Atlantis OD 37.5 720 SL	2,4-D dichlorophenoxy acetic acid 720 g/l acid	Post emergence	Braod leaves	1.5 L + 200 L H_2o	At 15 – 25cm height of the crop
T=8	Untreated check		Unsprayed			

with grade of 19N-38P-7S) and 93.6 gram of granular urea fertilizer rates per plot. The seed was sown through drilling in a row and the fertilizers were also applied as soon as the seed was drilled.

The pre emergence herbicides were applied one day after seed sowing in between each row. A line was made by hoe in the space between rows and the prepared herbicides solution was sprayed on it. The herbicides were applied with hand sprayers through measuring the distance by tape meter whereas, the post-emergent herbicides were applied based on the time of application in the recommendation which was described on the label. All herbicides were sprayed once a season and two times hand weeding was carried out at the initial of tillering stage (30-35 days after sowing) and the end of panicle initiation or start of heading stage (65-70 days after sowing).

Data collection and statistical analysis

Weed species, agronomic and phenological parameters data were collected in both the pre and post emergence herbicides application. The number of weeds species were taken at three quadrants for each plot before and after chemical spray. The weed species frequency, dominance and abundance were calculated based on the collected data. Days to emergency, days to heading, plant height, panicle length, number of spike per plant, number of fertile tillers per plant, number of filled grains per panicle, number of unfilled grains per panicle, thousand grain weight, grain yield, grain moisture content data were taken during the process.

Moreover, the weed species sample plants were preserved. The weed species were recorded before and after the herbicides have been applied. It was held at the crop tillering and panicle initiation stages at which the intensity, type of species and infestation had varied each other. The other parameters were taken in each critical times at which the data to be collected accordingly.

Weed population

The weed population count of grasses, broad leaved weeds and sedges and their total weed population was recorded at 35 Days after Sowing (DAS) and at harvest from 0.5 m × 0.5 m quadrant permanently marked in gross plot area and it was converted to square meter.

Fresh and dry matter production of weeds

The fresh and dry matter biomass of all weeds flora was recorded in each plot with a sample area of 0.25 m^2 (0.5 m × 0.5 m) at 35 days after sowing and at maturity stage of the crop which was 130 days after sowing. Fresh weeds were collected from the specified plot sample area and weighed as soon as collected whereas the dry matter was weighed after the weeds had been dried through solar radiation for three weeks.

Weed index

Weed index denotes the reduction crop yield due to crop weed competition as compared to weed free plots. It was worked out as by using the formula which was given by Gill and Vijaya Kumar [11].

Weed index (%) = (X-Y/X) × 100

Where, X = Grain yield of weed free plot

Y = Grain yield from treatment for which weed index is to be worked out

Crop toxicity ratings

The visual observation toxicity ratings were recorded at 14 and 35 days after the herbicides spray. The scores were taken from 1 to 5 scales by comparing crop tolerance to a particular herbicide treatment and weedy check plot. It was carried out as per European Weed Research Society (EWRS) classification scale as described below [12]. The visual observation toxicity ratings were recorded at 14 and 35 days after the herbicides spray. The scores were taken from 1 to 5 scales by comparing crop tolerance to a particular herbicide treatment and weedy check plot. It was carried out as per European Weed Research Society (EWRS) classification scale as described below [12] (Table 2).

RESULTS AND DISCUSSION

The result of the study revealed that the post emergence herbicides were by far better to control upland rice weeds. There was significance difference among the two types of herbicides to inhibit rice weeds growth and to have direct effect on yield and yield related characteristics. The highest grain yield was obtained from the plot that was weeded by two times of manual weeding followed by Bispyribac-sodium 10% EC and Pyroxsulam45 g/l herbicides (3243.4, 3063.6 and 2933.2 kg ha^{-1}, respectively. This was directly resulted from good control of weeds which were emerged early in the seedling and tillering as well as panicle initiation to booting stages. On the same fashion, a plot treated with Bispyribac-sodium 10% EC (post emergence) herbicide was provided the best biological yield even if it has provided ideal comparative grain yield. Two times hand weeding and Pyroxsulam 45 g/l were also given preferable crop biomass yield next to the best one indicated above.

On the contrary side, the pre emergence applied herbicides were not effective since they had phytotoxic effect both on the rice and weeds seed. Almost all of herbicides were not effective to control weeds which were emerged after the stand water has been dried.

Table 2: Scale of crop toxicity ratings (EWRS classification scale).

S. No.	Level of injury	Scale	Grade
1	None	0.00	None
2	Slight discoloration, few plants lost, stunted growth, injury more pronoun but effect short period	1.0-3.0	Slight
3	Moderate injury, recovery possible, non-recoverable injury	4.0-6.0	Moderate
4	Severe injury with some plants lost	7.0-9.0	Severe
5	Complete destruction	10.0	Complete

The number of tillers per square meter was high for those plots sprayed with pre-emergence herbicides (S-metolachlor 290 g/l + atrazine 370 g/l and S-metalachlor 960g/l). This was due to the fact that undamaged rice plants had more space and no competition for nutrients to produce a lot tillers because of the rice and weeds seeds were eliminated by its toxicity. The plant height and panicle length of the two pre emergence inputs were also greater than experimental plots which were treated with post emergence herbicides due to the above reason (see the numerical data below).

The control check showed better percent of harvest index over herbicides treated and manually weeded plots. It was as a result of high weed competition for nutrients, water, and no aeration in the plot and this led to be plant growth stunted. The time of application for pre germination weeds control herbicides was not appropriate as it was observed and approved in three parameters (time of application, row interval and dose of the chemical) separately. The observation showed that an application of it in four rows interval was promising to control weeds regardless of the crop damage. All in all, the study results implied that two times hand weeding was the most effective rice weed management option and environmentally ideal to the aquatic life in the swampy area (Table 3).

Weed population

As it is described below the weed flora population was minimum in plots treated with S-metolachlor 290 g/l + atrazine 370 g/l active ingredient (a.i), S-metalachlor 960 g/l a.i and Lodosulfuron-methyl-sodium 7.5g/l+ Mesosulfuron methyl 7.5 g/l a.i respectively. On the other hand, the weed population was high in plots which were sprayed by Pyroxsulam 45 g/l a.i (326.67 in number), control check (315.33 number of weed population) and Bispyribac-sodium 10% EC a.i (312 number of weed population) consecutively. This has been implied that pre emergence herbicides were by far better than those herbicides which applied by foliar (Table 4).

However, the weed population before and after post germination herbicides was varied due to the moisture status difference and the weed species natural characteristics. Sedge type of weeds, for instance were infested the plots early in the season where as *Echinochloa colonum, Dactyloctenium aegyptium* and *Digitaria marginata* had to come lately. Furthermore, the number of weeds type was mostly varied from location to location as per the weed seed bank available in the soil and management taken in the last cropping season (Table 5).

Dry matter production of weeds and weed index

The dry crop biomass production was high in plots that had been sprayed with bispyribac-sodium 10% EC (6481.5 kg ha^{-1}) followed by two times hand weeding and pyroxsulam 45 g/l (6481.5, 6210.1 and 6101.9 kg ha^{-1} respectively). Whereas the pre-emergent herbicides had negative impact for the dry matter productivity as it is shown below.

However, the maximum grain yield reduction due to weed competition was recorded from plots treated with pre-emergent herbicides (S-metolachlor 290 g/l and S-metalachlor 960g/l) in 52.81 and 52.54 percent's respectively. This study result has revealed that the two pre-emergent herbicides had great yield reduction impact since they mostly damaged the rice and weeds seeds with in the soil before germination. This led to the presence of a few rice plants and high weed infestation via weeds planted lately. On the other hand, two times hand weeding which had the lowest grain yield reduction was considered as weed free treatment. Moreover, bispyribac-sodium 10% EC and pyroxsulam 45 g/l post-emergent herbicides had low effect on weed index in percent (Table 6 and Figure 2).

Crop toxicity ratings

The pre-emergent herbicides were not toxic to rice plants since it was applied with in the soil and their residual effect was not obser stunted due to its effect. As a result, the yield and yield components were reduced as per its dose and time of application (Table 7).

PARTIAL BUDGET ANALYSIS

As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the rewarding

Table 3: The effectiveness of pre and post emergence herbicides on upland rice agronomic parameters.

Treatments	TPP	PH (cm)	PL (cm)	NSPP	DM	TGW (g)	BY (kg/ha)	GY (Kg/ha)	HI (%)
Bispyribac-sodium 10% EC	4.13^{b}	55.03^{c}	15.03^{b}	10.53^{abc}	131.67^{b}	25.84	6481.5^{a}	3063.6^{a}	47.40^{abc}
S-metolachlor 290 g/l+ atrazine 370 g/l	10.97^{a}	62.27^{ab}	18.03^{a}	11.56^{a}	144.33^{a}	25.06	4175.9^{c}	1530.5^{c}	37.94^{c}
Pyroxsulam 45 g/l	4.77^{b}	56.08^{c}	14.66^{b}	8.50^{d}	133.33^{b}	24.94	6101.9^{a}	2933.2^{a}	48.68^{abc}
S-metalachlor 960 g/l	9.43^{a}	66.27^{c}	17.66^{a}	10.83^{ab}	142.00^{a}	25.03	3486.1^{c}	1539.2^{c}	43.26^{bc}
Lodosulfuron-methyl-sodium 7.5 g/l+ Mesosulfuron methyl 7. g/l	3.87^{b}	53.67^{c}	14.43^{b}	9.00^{cd}	134.83^{b}	26.92	5375.0^{b}	2289.3^{b}	43.40^{bc}
2 times hand weeding	4.7^{b}	56.10^{c}	14.60^{b}	9.20^{bcd}	133.33^{b}	24.92	6210.1^{a}	3243.4^{a}	52.60^{ab}
2,4-D dichlorophenoxy acetic acid 720 g/l acid	3.63^{b}	57.23^{bc}	15.56^{b}	15.56^{b}	135.17^{b}	26.63	4953.7^{b}	2112.2^{b}	42.90^{bc}
Untreated check	3.33^{b}	61.67^{ab}	15.80^{b}	15.80^{b}	15.80^{b}	131.67^{b}	4067.9^{c}	2194.6^{b}	54.93^{a}
LSD (p<0.05)	2.51	5.05	1.49	1.83	4.34	2.69	697.7	344.6	11.04
CV (%)	38.32	7.36	8.11	16.17	2.74	8.96	11.68	12.46	20.35
Total mean	5.6	58.54	20.6	9.68	135.8	25.64	5106.51	2363.25	46.39
P-value	0.0001	0.0001	0.0001	0.0092	0.0001	0.66	0.0001	0.0001	0.066

Note: PH: Plant Height (cm), PL: Plant Length (cm), TPP: Number of tillers per plant, NSPP: Number of spikelet per panicle, TGW: Thousand Grain Weight (gram), BY: Biological Yield, GY: Grain Yield in ton/ha, HI: Harvest Index, LSD: Least Significant Difference at 5% Significance Level, CV: Coefficient of Variation in Percent

Table 4: The effect of herbicides on weed population after their application.

Code	Trade name of herbicides	herbicide name	Weed population (Number of weeds m^{-2})
T=1	Pride 100 SC	Bispyribac-sodium 10% EC	312.00
T=2	Primagram gold 660 SC	S-metolachlor 290 g/l+ atrazine 370 g/l	92.67
T=3	Pallas 45 OD	Pyroxsulam 45 g/l	326.67
T=4	Dual Gold 960 EC	S-metalachlor 960 g/l	159.33
T=5	Atlantis OD 37.5	Lodosulfuron-methyl-sodium 7.5g/l+ Mesosulfuron methyl 7.5g/l	178.67
T=6	Manual weeding	Two times hand weeding	245.33
T=7	Agro 2,4-D amin 720 SL	2,4-D dichlorophenoxy acetic acid 720 g/l acid	271.33
T=8	Untreated check		315.33

Table 5: Common weed species observed and collected during the period of experiment implementation.

S. No.	Common name	Scientific name
1	Wuha anqur	*Commelina diffusa*
2	Guaro atifa	*Ageratum conyzoides*
3	Wonberet	*Launaea cortuna*
4	Getetie	*Ipomoea Aquatica*
5	Korach	*Bolboschoenus maritimus (L.)*
6	Chanfa	*Cyperus postulatus*
7	Gicha	*Cyperus esculentus*
8	Zuraha	*Oryza barthii*
9	Molalie	*Sackiolepis africana*

Table 6: The effect of herbicides on rice biological yield and yield reduction due to weed competition.

Code	Treatments	Dry matter yield (kg/ha)	Weed index (%)
T=1	Bispyribac-sodium 10 % EC	6481.5	5.54
T=2	S-metolachlor 290g/l	4175.9	52.81
T=3	Pyroxsulam 45gm/l	6101.9	9.56
T=4	S-metalachlor 960g/l	3486.1	52.54
T=5	Lodosulfuron-methyl-sodium 7.5g/l + Mesosulfuron methyl 7.5g/l	5375	29.42
T=6	Two times hand weeding	6210.1	0
T=7	2,4-D dichlorophenoxy acetic acid 720 g/l acid	4953.7	34.87
T=8	Untreated check	4067.9	32.34

treatments. Yield from experimental plots was adjusted downward by 10% for management and plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment.

Two years' average market grain price of rice (14 ETB per kg) and labor valued at ETB 50 per person day were used. The rice field management and the fertilizers application were the same for all treatments (28 person-days per hectare and the N and P fertilizers price were 11 ETB per kg and 12.6ETB kg^{-1} respectively. The result of the partial budget analysis is described in Table 6. The economic analysis revealed that the highest net benefit of was obtained from the application of post emergent herbicides Bispyribac-sodium 10% EC (birr 29292.34 ha^{-1}) followed by Pyroxsulam 45 g/l (27886.16-birr ha^{-1}) and two times hand weeding (26109.66-birr ha^{-1}).

As the marginal rate of return showed that invest one birr for the spray of bispyribac-sodium 10% EC and pyroxsulam 45 g/l to control weeds yield reduction has been enabled to gain one birr plus 709 and 534% extra birr, respectively. This was more than seven and five times of birr that was invested. Thus, it was highly profitable as compared to manual weeding, whereas, the post-emergent herbicides (S-metolachlor 960 g/l and S-metolachlor 290 g/l + atrazine 370 g/l) have been proven to provide negative rate of return (-5.65 and -4.09). Moreover, the application of 2, 4-D dichlorophenoxy acetic acid 720 g/l acid and lodosulfuron-methyl-sodium 7.5 g/l+ mesosulfuron methyl 7.5 g/l herbicides was costed 158 and 12% extra ETB apart from the invested money, respectively (Table 8).

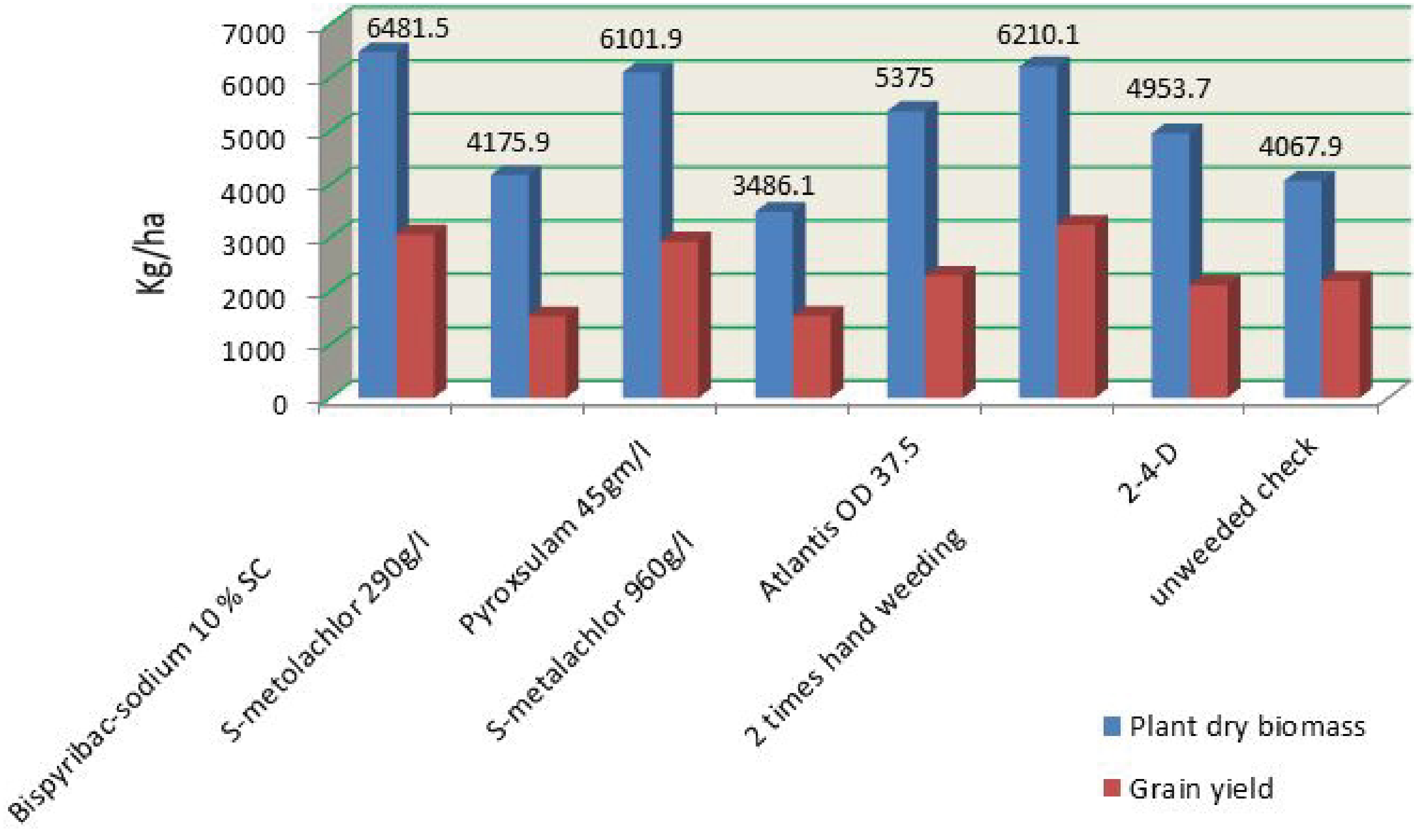

Figure 2: The impact of herbicides on NERICA 4 rice variety grain yield and plant dry matter.

Table 7: The toxicity levels of pre and post-emergent herbicides including the weedy check.

Code	Treatments	Toxicity ratings Scale	Grade
T=1	Bispyribac-sodium 10 % EC	1.00-3.00	Slight
T=2	S-metolachlor 290g/l	0	None
T=3	Pyroxsulam 45gm/l	4.00-6.00	Moderate
T=4	S-metalachlor 960g/l	0	None
T=5	Lodosulfuron-methyl-sodium 7.5g/l + Mesosulfuron methyl 7.5g/l	7.00-9.00	Severe
T=6	Two times hand weeding	0	None
T=7	2,4-D dichlorophenoxy acetic acid 720 g/l acid	4.00-6.00	Moderate
T=8	Untreated check	0	None

Table 8: Partial budget analysis and marginal rate of return of fungicides [5].

Inputs	**GY (kg/ ha) = A**	AGY kg/ha (A*0.9)=B	**CPR (ETB)=C**	**GFB Birr/ha (B*C)=D**	TVIC / Ha=E	**NB Birr/Ha ((B*C)-E)=F**	CNB Birr/Ha CNB Birr/Ha	**CTVIC Birr/Ha (E-control)=H**	**MRR=I**
Bispyribac-sodium 10% EC	3066.6	2194.6	11	30359.34	1067	29292.34	7565.8	1067	709
S-metolachlor 290 g/l+ atrazine 370 g/l	1530.5	1377.45	11	15151.95	2127.5	13024.45	-8702.09	2127.5	-409
Pyroxsulam 4 g/l	2933.2	2639.88	11	29038.68	1152.5	27886.18	6159.64	1152.5	534
S-metalachlor 960 g/l	1539.2	1385.28	11	15238.08	1394.5	13843.58	-7882.96	1394.5	-565
Lodosulfuron-methyl-sodium 7. g/l + Mesosulfuron methyl 7. g/l	2289.3	2060.37	11	22664.07	1065	21599.07	-127.47	1065	-12
2 times hand weeding	3243.4	2919.06	11	32109.66	6000	26109.66	4383.12	6000	73
2,4-D dichlorophenoxy acetic acid 720 g/l acid	2112.2	1900.98	11	20910.78	1397.5	19513.28	-2213.26	1397.5	-158
Untreated check	2194.6	1975.14	11	21726.54	0	21726.54	0	0	0

Note: GY: Grain Yield, AGY: Adjusted Grain Yield, CPR (ETB): Current Price of Rice in Ethiopian Birr, GFB: Gross Farm gets Benefit, TVIC/Ha: Total variable input cost per hectare, NB Birr/Ha: Net benefit in birr per hectare, CNB Birr/Ha: Change in net benefit in birr per hectare, CTVIC Birr/Ha: Change in total variable input cost in birr per hectare, MRR: Marginal Rate of Return (%)

CONCLUSION

In general, the study was conducted appropriately and its result showed that the highest grain yield was obtained on plots treated two times manual weeding (3243.4 kg ha^{-1}) followed by Bispyribac-sodium 10% EC (3063.6 kg ha^{-1}) and Pyroxsulam45 g/l (2933.2 kg per hectare) herbicides, respectively. But, pre emergence herbicides were not too much poor to provide good grain yield and crop dry matter product regardless of damaging seeds with in the soil. Bispyribac-sodium 10% EC was best in terms of crop biomass yield and weed index (yield reduction due to weed competition). On the other hand, the highest yield reduction due to weed competition was recorded in plots sprayed with 2, 4-D dichlorophenoxy acetic acid 720 g/l acid and Untreated check (34.87% and 32.34%), respectively. However, the partial budget analysis proved that Bispyribac-sodium 10% EC (it enables to gain 709% extra birr apart from production cost cover) and Pyroxsulam45 g/l (534%) were promising post emergence herbicides in terms of marginal rate of return to cultivate upland rice. Thus, pre weed emergence herbicides were not effective to manage upland rice weeds though the application row interval and time had its own effect for their inhibition to the crop. Therefore, based on all parameters assessed post emergence herbicides, Bispyribac-sodium 10% EC is recommended for upland weeds management followed by Pyroxsulam 45 g/l herbicide at the dose specified. These herbicides have limitations of very good control since they have been applied once a season and this enables some weeds flora to come up lately. But, very effective weed control, sustainable productivity and eco-friendly to the environment can be achieved by the use of integrated management.

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