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Research Article

CORRELATION ANALYSIS ON GROWTH AND STRAW YIELD OF RICE (*ORYZA SATIVA* L.) VARIETIES GROWN UNDER INFLUENCE OF THREE POST EMERGENCE HERBICIDES IN ALIERO SUDAN SAVANNAH ZONE OF NIGERIA

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Abstract

Background: Rice is an important crop for resource poor farmers across Africa and Asia. The crop is susceptible to weeds that severely reduce yields, because of their competition with the crop for moisture, nutrients, sunlight and space. **Methodology:** The trial was conducted in the screen house of Teaching and Research Farm of Kebbi State University of Science and Technology Aliero located at Jega during the rainy season of 2018/2019 to evaluate three selected post emergence herbicides for weed control on rice (*Oryza sativa* L.) in Sudan Savanna zone of Nigeria. Treatments consisted of two rice varieties (Faro 44 and Faro 52), three herbicides namely BRACER, BRACERPLUS and NOMINEEGOLD. Each of the herbicides were applied at three levels; BRACER 250ml/ha, 275ml/ha and 300ml/ha, BRACERPLUS 129ml/ha, 142ml/ha and 155ml/ha NOMINEEGOLD 200ml/ha, 300ml/ha and 400ml/ha; with hand weeding at 4 and 8WAS` and weedy check as control. Ten kilogram (10kg) of the soil was measured and filled into each of the sixty-six pots that were placed equidistant to one another in the screen house. **Results:** The correlation coefficient values showed highly significant relationship. Crop dry matter or straw yield showed positive correlation with number of leaves at 10 weeks after sowing (WAS) (r=0.4228), leaf area index at 10 WAS (r=0.4796). Similarly positive correlation exists with the leaf area at 10 WAS (r=0.2218). Weed dry matter at 10 WAS showed positive correlation to weed dry matter at 6WAS(r = 0.0778), Weed density at 6 WAS, was negatively correlated to weed control efficiency (r = -0.0693) and leaf area at 10 WAS (r = -0.2216). **Conclusion:** The correlation obtained between the straw yield and other crop growth parameters were significant and positive while the correlation between the straw yield and weed parameters were significant but negative this indicates that the relationship between crop growth parameters and those of weeds were not positive but negative.

Keywords: Aliero, Correlation coefficient, Evaluation, Post emergence herbicide, Rice varieties, Sudan savanna, Weed control.

INTRODUCTION

Rice is a staple for more than 60 % of the worlds' seven billion people and more than 90% of this rice is consumed in Asia (Mohanty, 2013; Chauhan *et al.*2014). During the year 2017 nearly 482 million metric tonnes of paddy were produced worldwide (Anon., 2018a). Although rice protein ranks high in nutritional quality among cereals, protein content is modest. The minerals, vitamins and other constituents of rice except carbohydrate are reduced by milling (Anon. 2012). In Nigeria, rice is important for several reasons including being a major contributor to internal and sub- regional trade (Oko *et al.*, 2012). Two types of rice have been mainly cultivated in Nigeria; the African rice (*Oryza glabberrima)* and Asian rice (*Oryza sativa*) (Oko *et al.*, 2012). In recent times, however new rice varieties have also been introduced including the West African Rice Development Association's (WARDA) hybrid rice varieties e.g. New rice for Africa (referred to as NERICA) which are inter specific hybrid between the African and the Asian rice. Rice farmers choose varieties adapted to the region's length of growing season, soil, altitude and the depth of water in the field (Oko *et al.,* 2012). Farmers in developing countries usually sow rice seeds in small seed beds, then transplant the seedling into flooded field that have been levelled. For this study, Faro 44 and Faro 52 were chosen because of their yield potentials and adaptability in the study Area. Of the biotic and abiotic stresses that pose constraints to rice production, weeds are the most prominent of them across the ecologies in terms of yield reduction, labour demand and cost of control (Akinyemiju and Igori 1986; Pandey, 2009). Oyebanji and Oluyemisi (2018) cited in Islam *et al* (2005) that about 20% of production costs incurred by farmers are attributed to weed control during growing season. In sub-Saharan Africa, 2.2 million tonnes of rice yield is lost annually as a result of uncontrolled weeds (Oyebanji and Oluyemisi 2017). About 28-74% of rice yield is lost due to uncontrolled weed growth in transplanted lowland rice, while 48-100% loss in upland ecosystems (Rodenburg and Johnson 2009). Weeds are real constraints to rice production (Kwesi and De Datta, 1991). Improved weed control can increase rice yields by 15-23% depending on the agro-ecosystem (Rodenburg and Johnson 2009). As an alternative to hand weeding and other methods of controlling weeds among farmers, herbicides offer a practical and economical option for reducing crop losses and production cost (Akinyemiju and Igori, 1986; Akobundu, 1987, Kolo, 2004). The use of herbicides in rice cultivation is gaining widespread acceptance among rice farmers worldwide including Nigeria. The conventional method of weed control in

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rice, i.e. hand weeding is very laborious, expensive and inefficient. Chemical weed control can be considered as a better alternative (Singh, and Singh 1993). Use of chemicals to control weed has been found to be effective and economical (Singh and Mani, 1981). Brar and Mishra (1989) reported that chemical weeding is easier, saves time and economical as compared to hand weeding alone. Weed control using herbicides offers an advantage to save labour and money. It is regarded as cost effective method of weed control as opined by Ahmed *et al,* (2000). Sharma and Bhunia (1999) stated that herbicides gave significant control of weeds when applied one day after transplanting rice. Post emergence herbicides are a major tools used to control weeds in rice. The growth stage of weed species may have an effect on herbicide efficacy by influencing uptake and metabolism of herbicides (Singh and Singh, 2004). Diclofop, for example, was more effective on green foxtail (*Setaria viridis* (L.) Beauv.) and wild oat (*Avena fatua* L.) when applied at an early growth stage (Friesen *et al*., 1976). Conversely, trifloxysulfuron was more effective on yellow nut sedge (*Cyperus esculentus* L.) at late application stages (Singh and Singh 2004). Generally, the herbicide efficacy is lower when applied on bigger weeds. The herbicide degradation rate may be faster in big plants, and herbicide rates may need to be increased to achieve the desired level of control (Singh and Singh, 2004). Therefore, optimum time of herbicide application and range of herbicides may help control these weeds effectively (Gopal *et al*., 2010). New herbicides for weed control in rice have been developed and there is the need to test their efficacy. The herbicides BRACER 10 SC, BRACER PLUS 16 OD and NOMINEE GOLD 10 SC all have same active ingredient known as *bispyribac at* different concentration. These herbicides are selective and post emergence.

BRACER; has active ingredient as bispyribac-sodium (chemical name 2,6-bis{(4,6-dimethoxy-2-pyrimidinyl oxy} benzoicacid 100g a.i./l , it kills weed growing with rice. The herbicide is effective on sedges, grasses and broadleaves its dosage rate ranges from 250-300ml ha^{-1}, while its spray rate (L/ha in water volume) is between 160-320 l. Its time of application is 7-15days after seeding/transplanting. Its dilution rate is 10ml per 16l of water. Rate and spray volume can be increased when spraying is going to be done 10 days after planting. The herbicide has a pre-harvest interval period of 60 days. BRACERPLUS 16 OD (160 g a. i /l.) is the second herbicide to be tested in this study, in addition to bispyribac sodium 4%, it has an additional active ingredient which is called cyhalofop (chemical name (R)-2-[4-cyano-2-fluorophenoxy] propanoic acid)-butyl-12%. The herbicide is also effective on sedges, grasses, and broadleaves weeds. Its dosage rate ranges from 129-155 ml ha^{-1}, its time of application is 10 days after sowing, dilution rate is 8ml per 16l.Both Bracer and Bracer plus are manufactured in China by Hefei Xiangyu Chemical Company Limited. NOMINEEGOLD 10 SC. It is Post Emergence herbicide for Rice, its active ingredient is bispyribac sodium (100g a. i./l), dosage rate is 300ml ha^{-1}. The herbicide is applied when the soil is saturated with water but not flooded. Irrigation should be done 1-3 days after application and should be kept flooded for at least 3-4 days. Best application is achieved when weeds have between 3 and 5 leaves. The dilution rate of the herbicide is 100-200l ha^{-1} of water for good application. It is used for the control of broadleaves, grasses and sedges in rice field. Weed control is one of the major labour demanding farm operations in rice production; the labour requirement is very costly and may not be available at the time of need (Yawale *et al.,* 2019). Although no single weed control method can give effective and satisfactory weed control in all ecologies, however, chemical weed control may provide a better alternative, because it is fast, cheap, easy and more effective, Lagoke, *et al.* (1991). The aim of the study is to evaluate three selected post emergence herbicides on rice varieties at different concentration of the herbicides, while the specific objectives are to:

i. Determine effect of herbicides on weed suppression on growth of rice
ii. Evaluate effect of variety on weed suppression on growth of rice
iii. Identify weeds associated with rice growth in the Study area.

MATERIALS AND METHOD

Experimental site

Experiment was conducted during the dry season of 2019/2020 in the Screen house of Teaching and Research Farm of Kebbi State University of Science and Technology Aliero located at Jega (lat. 12^0 18.64'N: long.04^0 29.85', 262 m above sea level). The area is characterised with erratic and scanty rainfall that lasts for about 5 months (May – September) and long dry period (October – April). The climate of the area is semi-arid with average rainfall of 550-650mm per annum. The relative humidity ranges from 21- 47% and 51- 79%during the dry and rainy seasons respectively. Temperature averages between 14 – 30 ^{0}C during dry season and 27-41^{0}C during the rainy season (NNN, 2012).

Treatments and Experimental Design

Treatments consisted of two rice varieties (Faro 44 and Faro 52), three herbicides namely BRACER(Bispyribag sodium, chemical name 2,6-bis{(4,6-dimethoxy-2-pyrimidinyl)oxy} benzoic acid 100g a.i./l), BRACERPLUS(chemical name 2,6-bis{(4,6-dimethoxy-2-pyrimidinyl)oxy}benzoic acid (40g a.i./l) -4% and cyhalofop (chemical name (R)-2-[4-cyano-2-fluorophenoxy] propanoic acid)- butyl(120g a.i./l)-12% and NOMINEE GOLD (Bispyribag sodium, chemical name 2,6-bis{(4,6-dimethoxy-2-pyrimidinyl)oxy}benzoic acid 100g a.i./l). Each of the herbicides will be applied at three levels; BRACER 250ml(25g a.i./l), 275ml(27.5g a.i./l) and 300ml (30g a.i./l), BRACERPLUS 129ml(20.64g a.i/l.),142ml(22.72 g a. i./l) and 155ml(24.8 g a.i./l) NOMINEE GOLD 200ml(20.0 g a.i./l), 300ml(30 g a. i./l) and 400ml(40 g a.i./l); with hand weeding at 4 and 8WAS and weedy check imposed as control. The treatment was laid out in a completely randomised design with three replications.

Cultural practice

Seed sowing: Three seeds each were sown directly into five holes (that are 15 cm from one another) drilled into each plastic pot. Ten days after germination, the fifteen seedlings were thinned to five plants per pot. Supplying was done where poor germination of rice seedlings was observed.

Watering: Watering was done using a 10-litre watering can. Irrigation was done at as when due.

Hand Weeding: Hand weeding was done at 4 and 8Weeks After Sowing (WAS) according to treatment. Weeds were washed cleaned air dried and fresh weight was recorded and subsequently oven dried at 70 ^{0}C weighed until a constant weed dry matter weight was achieved.

Fertilizer Application: Application of 100:50:50 kg ha^{-1} NPK was done in split doses. The first half application of N (50 kg), and full dose of P_2O_5 and K_2O (50 kg) were applied at the basal stage. The second half of N was applied at maximum tiller stage and at panicle initiation stage using urea (46%) as source.

Herbicide Application: Each of the herbicides was applied at three levels; BRACER 250ml ha^{-1}, 275ml ha^{-1} and 300ml ha^{-1}, BRACERPLUS 129ml ha^{-1},142ml ha^{-1} and 155ml ha^{-1}; NOMINEE GOLD 200ml ha^{-1}, 300ml ha^{-1} and 400ml ha^{-1} according to treatment at 6- weeks after sowing. Application was done once only during the cultivation period. This was done by arranging the pots with similar treatment together and herbicide will then be applied after calibration. The rice crop was harvested at 10 weeks after sowing (WAS) manually by carefully by uprooting the crops after a soaking watering to avoid losing the roots.

Data Collection

Observation for Weed Parameters

Weed Identification: Weed incidence in the pots were assessed, identified and recorded with the aid of weed album by Akobundu and Agyakwa, (1987).

Weed count: Weed Count was taken and weeds were classified into broadleaved, grasses and sedges.

Weed dry Matter: Weed dry matter were taken after application of treatment at six weeks after sowing when the affected weeds were completely dry and at harvest to determine weed biomass after the study. The weed samples collected will be 10 WAS oven dried at 70^{0}C to a constant weight and weighed to obtain the weed dry matter.

Weed Control Efficiency (WCE): It is a derived parameter that compares different treatments of weed control on the basis of weed dry weight across them. It is an estimate of weed competition/control in crops

$$\mathbf{WCE}=\frac{\mathrm{DMC}-\mathrm{DMT}}{\mathrm{DMC}}\ \mathrm{X}\ 100$$

Where, DMC is weed dry matter in unweeded treatment and DMT is weed dry matter in a weed control treatment (Das, 2008).

Observation for Crop growth parameters

Plant Establishment count: Plant establishment count was taken 10 (ten) days after sowing (DAS). Re-supplying was done where poor germination of rice seedlings was observed.

Phytotoxic effect on Crop: Crop injury was scored on a scale of 0-5. 0 represents no crop killed or affected while 5 means all the crops are killed per pot.

Crop dry matter at 10WAS: The Straw yield or crop dry matter was taken from the five plants of each pot after harvesting at 10 WAS and means was calculated.

Data Analysis

Data generated was subjected to analysis of variance procedure (ANOVA) as described by Steel and Torrie (1984) and differences between treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability as described by Gomez and Gomez (1984). The relationships between characters were determined through simple correlation analysis as described by Little and Hills (1978).

RESULTS

Weed species identified in the pot experiment at Jega during the dry season of 2019/2020 and their phytosociological characters are presented in Table 1. A total of 13 weed species were identified in the pot experiment conducted in the screen house of the Teaching and Research Farm of Kebbi State University of Science and Technology Aliero located in Jega. Among the weeds 8 (61.54%) were broad leaf, 4 (30.77%) were grasses and 1 (7.79%) was sedge.

The results obtained showed that *Digitaria horizontalis, Alternanthera sessilis, Hackelochloa granularis Vicoa leptoclada* and *Ludwigia hyssipifolia* followed each other in their densities. Although *D. horizontalis* was the most frequent of all the weeds, it was followed by *A. sessilis,, H. granularis, V. leptoclada and Celosia leptostachya* in that order. Although *D. horizontalis* is most frequent (F), *V. leptoclada* was on the other hand most abundant followed by *C. leptostachya.*

Table 1. Correlation matrix showing the relationship between crop dry matter and some growth and weed parameters

Parameter	SC	CDM	W6WAS	W10WAS	WD6WAS	WCE	ET8WAS	LA10WAS	LAI10WAS	NLV8WAS
SC	1.0000									
CDM	0.0468ns	1.0000								
W6WAS	0.0077ns	0.0728ns	1.0000							
W10WAS	0.1438*	0.1919ns	0.2667*	1.0000						
WD6WAS	0.0248ns	0.5715ns	0.0249ns	0.0778ns	1.0000					
WCE	0.0735ns	0.1624*	0.2772*	-0.9635*	-0.0693ns	1.0000				
ET8WAS	0.0274ns	0.6105*	-.0026ns	0.0132ns	- 0.8093*	-0285ns	1.0000			
LA10WAS	0.2684*	0.2218ns	-.0713ns	-0.1322*	-0.2216ns	0.1446*	0.2172ns	1.0000		
LAI10WAS	0.2770*	0.4796*	-.0636ns	-0.0854*	-0.1892*	0.0956*	0.2553*	0.7060*	1.0000	
NLVS8WAS	0.0529ns	0.4326*	-.0370ns	-0.0731ns	-0.4325*	0.0428ns	0.6178*	0.0436*	0.6418*	1.0000

SC = Stand count, CDM = Crop Dry matter or straw yield, W6WAS = Weed Dry matter 6WAS, WD10WAS= Weed Dry matter10WAS, WD6WAS =Weed density6WAS, WCE = Weed control efficiency, ET8WAS = Effective tillers 8WAS, LA10WAS = Leaf area 10WAS, LAI10WAS = Leaf area index 10WAS, NLVS8WAS = Number of leaves 8WAS

Table 2. Effect of weed control treatments and variety on plant establishment count, crop injury score and crop dry matter @ 10WAS at Jega 2019/2020

Treatment	Rate (l ha^{-1})	Plant establishment Count	Crop Injury Score	Crop Dry matter 10WAS (g)
Weed control treatments				
Bracer-1	0.250	73.33	1.33ab	20.91cd
Bracer-2	0.275	75.56	1.17ab	24.68bcd
Bracer-3	0.300	72.22	1.50a	22.71bcd
Bracerplus-1	0.129	72.22	1.16ab	26.25bcd
Bracerplus-2	0.142	76.67	0.50ab	34.83b
Bracerplus-3	0.155	76.67	0.83ab	32.31b
NomineeGold-1	0.200	70.00	1.50a	25.4bcd
NomineeGold-2	0.300	68.89	1.00ab	24.00bcd
NomineeGold-3	0.400	67.78	1.83a	15.91d
Handweeded	-	81.11	0.00b	58.10a
Weedy check	-	68.69	0.00b	31.30bc
SE±		7.397	0.413	3.693
Significance Variety		NS	*	*
Faro 44		59.59b	0.57b	33.65a
Faro 52		86.46a	1.39a	23.87b
SE±		3.144	0.175	1.569
Significance		*	*	*
Interaction				
W x V		NS	NS	NS

Means followed by the same letter(s) in a treatment group are not significantly different at 5% level of significance using DMRT NS= non significant

Table 3. Effect of weed control treatments and variety on number of leaves at Jega 2019

Treatment	Rate (l ha^{-1})	Number of leaves			
		4 WAS	6 WAS	8 WAS	10 WAS
Weed Control Treatments					
Bracer-1	0.250	6.86b	11.67b	14.73b	15.83b
Bracer-2	0.275	6.63b	11.05b	14.93b	15.50b
Bracer-3	0.300	7.37b	12.57b	15.43b	15.66b
Bracerplus-1	0.129	7.56b	12.97b	16.55b	13.71b
Bracerplus-2	0.142	7.06b	12.37b	15.56b	14.77a
Bracerplus-3	0.155	7.37b	11.10b	14.26b	14.05b
NomineeGold-1	0.200	8.10b	13.33b	15.25b	13.69b
NomineeGold-2	0.300	6.67b	12.20b	14.40b	13.19b
NomineeGold-3	0.400	7.50b	13.47b	15.45b	13.47b
Handweeded	-	8.57a	19.67a	19.95a	21.00a
Weedy check	-	4.13c	9.07c	12.33c	10.33c
SE± Significance		0.472	1.115	0.928	0.816
		*	*	*	*
Variety					
Faro 44		7.63	13.12	16.12	16.45
Faro 52		7.06	13.12	15.12	15.67
SE±		0.200	0.474	0.394	0.347
Significance		NS	NS	NS	NS
Interaction					
W x V		NS	NS	NS	*

Means followed by the same letter(s) in a treatment group are not significantly different at 5% level of significance using DMRT

Table 4. Effect of Weed control treatments and variety on effective tillers at Jega 2019

Treatment	Rate (l ha^{-1})	Effective tillers			
		4 WAS	6 WAS	8 WAS	10 WAS
Weed Control Treatments					
Bracer-1	0.250	4.20	15.00b	18.16c	22.50c
Bracer-2	0.275	3.50	13.33b	17.00c	21.67c
Bracer-3	0.300	3.96	14.50b	19.33c	24.16c
Bracerplus-1	0.129	3.50	15.50b	19.67c	21.50c
Bracerplus-2	0.142	4.20	16.50b	24.83c	35.16b
Bracerplus-3	0.155	3.36	14.50b	17.50c	21.16c
NomineeGold-1	0.200	3.76	15.16b	19.33c	23.67c
NomineeGold-2	0.300	4.00	14.67b	16.33c	20.50c
NomineeGold-3	0.400	3.70	14.67b	15.17c	18.33c
Hand weeded		3.96	22.67a	33.50a	45.50a
Weedy check		3.86	4.83c	7.33d	9.83d
SE±		0.284	1.490	1.661	2.278
Significance		NS	*	*	*
Variety					
Faro 44		4.00a	16.42	19.44	24.42
Faro 52		3.61b	16.27	19.36	25.39
SE±		0.120	0.633	0.706	0.968
Significance		NS	NS	NS	NS
Interaction					
W x V		NS	NS	NS	*

Means followed by the same letter(s) in a treatment group are not significantly different at 5% level of significance using DMRT; NS= Non significant

Correlation Analysis

Results showing the correlation matrix of rice crop dry matter and some growth and weed components were presented in table 1. The correlation coefficient values showed significant relationship. There was significant and positive correlation between crop dry matter and effective tillers (r = 0.6105*) at 8 weeks after sowing (WAS) and with number of leaves at 8 weeks after sowing (WAS) (r=0.4228). Number of leaves at 8 WAS (r = 0.4326*) also significantly and positively correlates with crop dry matter at 10 WAS. Effective tillers at 8 WAS positively and significantly correlates with leaf area index at 10WAS (r = 0.2553*), and number of leaves at 8WAS(r = 0.6158*), while leaf area at 10WAS significantly and positively correlates with leaf area index at 10WAS. On the other hand weed dry matter at 6WAS positively correlates with weed dry matter at 10 WAS (r = 0.2667*), it has negative correlation with weed control efficiency(r = -02772*). Negative and significant correlation was observed between weed parameters and crop parameters; weed dry matter at 6WAS negatively correlated with effective tillers at 8WAS(r = -0.8093*). Weed density at 6WAS negatively correlates with effective tillers at 8 WAS(r= -0.8093*). Weed control efficiency significantly and positively correlates with leaf area at 10WAS (0.1446*) and leaf area index at 10WAS (0.0956*).

Conclusion

The correlation obtained between the crop dry matter and other crop growth parameters were significant and positive while the correlation between the straw yield and weed parameters were significant and negative this indicates that the relationship between crop growth parameters and those of weeds are negative.

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