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Investigating the Combined Effects of Pendimethalin, Atrazine and Supplement Hoe Weeding on Maize Yield

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Abstract:- This work investigates the effect of the chemical weed control techniques on the growth and yield of the maize at International Institute of Tropical Agricultural, Ibadan, Oyo State, Nigeria. The experimental design was 3 x 5 factorial in a randomized complete block design (RCBD) with three (3) replications. The treatments were administered to five weed control techniques (Pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha, pendimethalin at 1.5kg/ha + Atrazine + supplement hoe weeding, manual weeding at 3, 6 and 9 WAP and weedy check). The statistical analysis was carried out using SPSS and the result obtained showed that weed density, growth and yield related traits of maize were significantly affected by different treatments at *P<0.05*. From the study, the maize plants were observed to have similar plant heights and number of leaves throughout the period of measurement. Maize grown in the weedy check plots were observed to have reduced plant height, number of leaves, stem girth and leave area. The fresh, dry cob weight and cob length were also reduced in maize grown in weedy check plots which resulted in lower grain yield (0.53 t/ha). Pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha + supplement hoe weeding at 6 WAP produced optimum yield more than manual weeding at 3, 6 and 9 WAP and weedy check. It can be concluded that the use of chemicals in these combinations to control weeds increases crop productivity in maize production.

Keyword:- *Chemical, Weed, Technique, Productivity and Maize.*

I. INTRODUCTION

Maize (*Zea mays* L.) is the world's highest supplier of calorie with caloric supply of about 19.5%. It provides more calorie than rice (16.5%) and wheat (15.0%) (Girei *et al*., 2018). There is evidence of sustained production rate of maize in Nigeria Maize production in Nigeria stood at 10.7 million metric tons in 2015 and 10.5 million metric tons in 2017 as reported in Girei et al (2018). Maize has the ability to thrive under different ecological conditions, hence the widespread in its production across different parts of the country (FAO, 2017). Maize crop is sensitive to weed competition during early growth period due to slow growth in the first 3 – 4 weeks. Critical period of weed competition is up to 40 – 45 days. Hence, managing weeds during this period is most critical for higher yields. Maize yield was reduced as much as 25 – 60% due to weed infestation (Surinder, 2016). Crop losses due to weed competition throughout the world as a whole, are greater than those resulting from combined effect of insect-pests and diseases. Excessive growth of weeds in maize field leads to 66% to 80% reduction in crop yield (Adigun, 2001; Ford and Pleasant, 1994). Worldwide maize production is hampered up to 40% by competition from weeds which are the most important pest group of this crop (Oerke and Dehne, 2004).

The major constraints of maize production in include both biotic (weeds, plant pathogens, insect pests, rodents, wild animals) and abiotic factors (drought, hailstorm, flood, nutrient deficiency, soil type, topographic features). However, weed infestation is supreme importance among biotic factors that are responsible for low maize grain yield. Worldwide maize production is hampered up to 40% by competition from weeds which are the most important pest group of this crop (Amare *et al*., 2014). Weeds compete with the crop plants for space, light, moisture, nutrients and carbon dioxide which reduced not only the yield, grain quality and hinder harvest operations but also increase the cost of production (Rutta *et al*., 1991).

Control of weeds in the fields of maize is very essential for obtaining good crop-harvest. Weed control practices in maize resulted in 77 to 96.7% higher grain yield than the weedy check (Amare *et al*., 2014). Different weed control techniques have been used to manage the weeds, but mechanical and chemical techniques are more frequently used for the control of weeds than any other control technique. Mechanical techniques including hand weeding are still useful but are getting expensive due to laborious and time-consuming form of the operation. Unwillingness of the young people to be involved in agriculture is a factor affecting this technique. Meanwhile, Herbicides which are strong chemical products not only act on their target weeds but also may display significant toxicity to organisms and other component factors of the soil. Among these are the bacteria present in the rhizosphere which potentially affect plant growth, herbicide degradation capacity of the soil, and the ability of soils to improve crop yield (José *et al*., 2014). Atrazine and Pendimethalin are herbicides used for weeds control in many crops ranging cereal to vegetable crops.

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Manual weeding which is a form of cultural technique is tedious and associated with drudgery and time consuming. Therefore, this study is aimed at investigating the effect of weed control techniques on growth and yield of maize using a chemical control technique.

II. METHODOLGY

➢ *Area of the Study*

The field experiment was conducted at the International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria located at latitude 7^0 25'0" N, longitude $3^0$39'4" E and altitude 225 m above sea level. Agro-meteorological data of the site such as temperature, sunshine hour, average rainfall, and average relative humidity were taken from the month of January to August. The experiment was carried out in a humid tropical zone characterized by temperature ranging between 21 – 42^0C with a maximum temperature of 26.46^0C and relative humidity of 74.55%. The rainfall regime was bimodal with peaks in the months of June and September with total annual rainfall of 1420.06 mm. The soil belongs to the order of Ultisol and the rainfall started appreciably in April and ended in October with a little break in August (August break) leaving November through March as a dry period.

➢ *Sample Preparation*

The soil samples were taken using a sampling auger and air-dried at room temperature for 5 days and crushed into powder to pass through a 2 mm mesh sieve. The samples were analysed to determine the physical and chemical properties of the soil. The sample analysis was done at IITA's lab and the following physio-chemical properties of the site were taken such as textural class, clay, silt, sand, and pH (physical properties) and exchangeable cations: Ca, Mg, K, Na, Zn, Mn, Cu, Fe, ECEC, and exchangeable acidity.

➢ *Experimental Design*

The design of the experiment was a factorial laid out in a randomized complete block design (RCBD) with three (3) replications. There were fifteen treatments combinations as shown below: W_1 Pendimethalin at 2.0 kg/ha + Atrazine at 2.0 kg/ha; W_2 Pendimethalin at 1.5 kg/ha + Atrazine at 1.5 kg/ha; W_3 Pendimethalin at 1.5 kg/ha + Atrazine at 1.5 kg/ha + Supplementary hoe weeding at 6 WAP; W_4 Manual weeding at 3, 6 and 9 WAP; W_5 Weedy check. The experimental field was mechanically ploughed and harrowed using a tractor. Each plot was measured in 3 m x 4 m with spacing 0.5 m apart. Allay of 1 m separated one block from one another. The total number of plots laid out in the entire experiment was 45. Maize seeds (ACR 91 SUWAN 1 hybrid) were obtained from the Institute (IITA), Ibadan. The maize seed was sown at the depth of 2 cm per hole and thinned down to 2 plants per stand after the emergence. Blanket application of compound fertilizer, nitrogen, phosphorus and potassium (NKP) 15:15:15 were applied four (4) weeks after planting at the rate of 400 kg/ha. Weeding was carried out following the treatment structures outlined.

➢ *Data Collection*

The following data were collected: growth parameters such as plant height was taken using a measuring tape; leaf area was taken using a Saxena and Singh's equation (length and width upper flag leaf and multiplied by 0.75, a constant); days to 50% tassle was recorded by counting the number of maize plants in all of the replicated plots at the growth stage of the plants when 50% of the plants on the plot had developed tassels; days to 50% silk was recorded by counting the number of maize plants in all the replicated plots when 50% of maize plants on the plot had developed silks. Similarly, the yield parameters such as fresh cob weight; dry cob weight; shelling percentage; grain yield were taken. While the weed fresh and dry weight were also determined at 3, 6 and 9 WAP. Weed samples were collected with 0.5 m^2 quadrate in a diagonal transect in each of the plots twice. The weeds were then named, sorted into their morphological group (broadleaves, grasses and sedges), counted and weighed before and after oven drying at 70^0C to a constant weight.

➢ *Statistical Analysis*

The data collected were statistically analyzed using the analysis of variance (ANOVA) described by Steel and Torrie (1980) while mean separation for significant means was done using Duncan's Multiple Range Test (DMRT). Pearson correlation was used to determine the relationship between the weed dry matter, growth and yield parameters.

III. RESULTS

➢ *Effect of the Chemical Weed Control Techniques on the Growth Parameters*

The result obtained from this study showed that chemical weed control treatments used had a significant effect on the height of the maize plant in 3, 6, and 9 WAP. Similarly, there was no significant difference on the number of leaves in the maize plants in 3, 6, and 9 WAP. However, manual weeding in the 9 weeks after planting (WAP) had a significant difference on the rest of the results (Table 1).

Treatment	Plant Height (cm)			No of Leaves		
	Weeks after planting					
	3	6	9	3	6	9
W1	44.00a	99.00a	194.50a	4.73ab	10.64a	13.93ab
W2	45.56a	100.40a	192.60a	4.84a	10.24a	13.56b
W3	43.67a	99.50a	198.40a	4.78ab	10.18a	13.58b

W4	45.11a	97.70a	197.30a	4.64ab	10.53a	14.22a
W5	41.89a	96.40a	182.20b	4.44b	10.14a	13.8ab
SED	1.69	4.08	5.49*	0.166	0.365	0.217*
LSD (0.05)	Ns	Ns	Ns	Ns	Ns	ns
S x W	0.407ns	0.402ns	0.723ns	0.0ns	0.44ns	0.14ns
SED	2.928	7.06	9.51	0.06ns	0.44ns	0.14ns

Table 1:- Effect of Chemical Weed Control Techniques on the Growth Parameters.

W1: pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha
W2: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha
W3: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha + supplementary hoe weeding at 6WAP
W4: Manual weeding at 3, 6 and 9WAP
W5: Weed Check

- *Effect of Chemical Weed Control Techniques on the Developmental Parameters*

The result obtained showed that the chemical weed control treatments applied had no significant effect (*P<0.05*) on the maize number of days to 50% silking and tasselling. But there was a significant difference in the ear length of the maize plants in all the treatments (Table 2).

Treatment	Days to 50% tasselling	Days to 50% Silking	Ear Length
W1	60.22a	63.64a	16.20a
W2	60.89a	63.00a	19.22a
W3	60.33a	64.00a	18.87a
W4	60.11a	63.33a	18.22a
W5	60.67a	64.56a	17.69a
SED	0.23	0.21	1.42
LSD(0.05)	Ns	Ns	ns
S x W	0.96ns	1.29ns	8.36ns
SED	1.637	2.14	0.25

Table 2:- Effect of the Chemical Weed Control Techniques on Developmental Paraments

W1: pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha
W2: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha
W3: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha + supplementary hoe weeding at 6WAP
W4: Manual weeding at 3, 6 and 9WAP
W5: Weed Check

- *Effect of the Chemical Weed Control Techniques on the Yield Components of the maize Plant*

The result obtained from the study showed that there was a significant difference *(P< 0.05)* observed among the weed control treatments on the fresh cob weight of maize. W_3 (pendimethalin at 1.5 kg/ha + Atrazine at 1.5nkg/ha + supplementary hoe weeding at 6 WAP) had higher fresh cob weight (2.20 g) than maize grown in weedy check plot (1.64 g). Also, the result of the weed control treatments had no significant effect on the dry cob weight and cob length of the maize, though a reduced dry cob weight was observed in weedy check plot (0.21 g) (Table 3).

Treatment	Fresh Cob Weight (g)	Dry Cob Weight (g)	Cob Length (cm)	Shelling percentage	Grain Yield (t/ha)
W1	2.01ab	0.37a	20.29a	56.20a	0.68a
W2	1.89ab	0.35a	20.18a	58.20a	0.57a
W3	2.20a	0.29a	20.37a	59.70a	0.503a
W4	1.93ab	0.26a	19.27a	58.10a	0.534a
W5	1.64b	0.21a	19.58a	61.20a	0.534a
SED	0.37	0.13	2.12	4.94	0.043
LSD(0.05)	0.366*	Ns	Ns	Ns	ns
S x W	0.63ns	0.11ns	2.02ns	8.55ns	0.435
SED	0.9	0.02	0.25	4.94	0.075

Table 3:- Effect of the Chemical Weed Control Techniques on the Yield Components of the Plant

W1: pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha
W2: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha
W3: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha + supplementary hoe weeding at 6WAP
W4: Manual weeding at 3, 6 and 9WAP
W5: Weed Check

➢ *Effect of the Chemical Weed Control Techniques on Weed Parameters*

The chemical weed control treatments applied had no significant effect *(P< 0.05)* on both weed fresh weight and dry weight at 3, 6 and 9 WAP (Table 4)

Treatment	Weed Fresh Weight (g)			Weed dry weight (g)		
	Weeks after planting					
W1	0.15a	0.35a	0.35a	0.06a	0.05a	0.07a
W2	0.15a	0.25a	0.37a	0.03a	0.05a	0.07a
W3	0.14a	0.29a	0.33a	0.04a	0.05a	0.07a
W4	0.16a	0.30a	0.37a	0.03a	0.05a	0.07a
W5	0.17a	0.29a	0.35a	0.03a	0.05a	0.07a
SED	0.015	0.026	0.031	0.003	0.005	0.007
LSD (0.05)	0.366*	Ns	Ns	Ns	ns	ns
S x W	0.028ns	0.045ns	0.054ns	0.0054ns	0.0013ns	0.0013ns
SED	0.00	0.01	0.01	0.00	0.00	0.00

Table 4:- Effect of the Chemical Weed Control Techniques on the Weed Parameters

W1: pendimethalin at 2.0kg/ha + Atrazine at 2.0kg/ha
W2: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha
W3: pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha + supplementary hoe weeding at 6WAP
W4: Manual weeding at 3, 6 and 9WAP
W5: Weed Check

IV. DISCUSSIONS

For the plant height, in the 3 weeks after planting (WAP), the treatment W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha was found to have the highest result of the plant height (45.56 cm) while the treatment W_5, the weedy check in contrary, has the lowest plant height (41.89 cm). Similarly, in 6 WAP W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha tops the plant height with 100.40 cm while W_5, the weedy check takes the lowest result at 96.40 cm. Also, in 9 WAP, W_3, pendimethalin at 1.5 kg/ha + Atrazine at 1.5 kg/ha + supplementary hoe weeding was found with the highest result (198.40 cm) while the W_5, the weedy check still possessed the lowest result of the plant height (182.20 cm). This confirms with the similar result obtained by Rana *et al.,* (2016) where Atrazine at 1.5 and 2.0 kg/ha were used to reduce the effects of the weed in the field over a weedy check. On the number of leaves of the maize plant as a growth parameter, the treatment W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha was found to have the highest number of plant leaves in 3 WAP (4.85) as W_5, the weedy check had the lowest (4.44). In 6 WAP, W_1, pendimethalin 2.0kg/ha + Atrazine 2.0kg/ha had the highest plant leaves numbers (10.64) while W_5, the weedy check got the lowest plant leaves number (10.14). Also, as was observed in 9 WAP, the treatment W_4, manual weeding had the highest number of plant leaves (14.22) while the W_5, the weedy check had the lowest (13.80). As reported in Rana *et al.,* (2016), that these were possible due to better weed control efficiency in the pre-emergence treatments over the weedy check.

The development parameters presented in table 2 above described the tasselling and silking percentage of the maize plant. From the result obtained, it was observed that the treatment W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha applied gave the highest tasselling percentage of 60.89 while W_4, manual weeding had the lowest percentage (60.11). The maximum percentage silking of the plant (64.56) was gotten when W_5, the weedy check treatment method was applied. While the lowest silking percentage (63.00) was obtained when the treatment W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha was applied. Also, the maximum ear length of the plant (19.22cm) was gotten when W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha was introduced whereas the lowest result (16.20 cm) was found when W_1, pendimethalin 2.0kg/ha + Atrazine 2.0kg/ha was applied. The above resulted corroborated with the findings of Kumar *et al.*, (2012); Kolage *et al*., (2004) and Rana *et al.*, (1998).

On the yield components of the maize plant presented in the Table 3 above revealed W_2, pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha had the highest yield of fresh cob weight at 2.20g while W_5, the weedy check treatment had the lowest result at 1.64g. A similar result was reported in an article written by Rana *et al.*, (2016) and Kumar *et al*., (2012). Although there was no significant difference in dry cob weight of the plant at $p < 0.05$, however, W_1, pendimethalin 2.0kg/ha + Atrazine 2.0kg/ha applied had the highest result at 0.37g while the W_5, the weedy check treatment had 0.21g as the lowest result of the dry cob weight. Rana *et al*., (2016) conformed with the above result. For the cob length yield, it was discovered that W_3 pendimethalin at 1.5kg/ha + Atrazine at 1.5kg/ha +

supplementary hoe weeding is good combination which gave the highest yield (20.37 cm) while W_4 gave the lowest yield (19.27 cm). In terms of shelling percentage, the W_5 treatment had the highest percentage at 61.20 and W_5 treatment gave the lowest result of percentage shelling at 56.20. Finally, on the account of the grain yield, W_1 treatment gave the highest yield per hectare at 0.68 t/ha while W_2 treatment had the lowest yield at 0.503 t/ha. According to the Rana *et al.*, (2016) and Kumar *et al*., (2012), this was possible due to better weed control efficiency in the W_1 treatment.

On the weed parameters, there was no significant difference observed at $p < 0.05$ when the treatments were applied in 3, 6, and 9 weeks after planting. But for the fresh weed weight, W_5 treatment offered highest result of the fresh weed weight (0.17g) and W_3 treatment was found to be the lowest fresh weed weight (0.14g). Similarly, for the dry weed weight, W_1 treatment gave the highest dry weed weight result (0.06g) but the W_2 treatment had the lowest result (0.03g). This means that the higher the concentration of the chemicals, the higher the dry weed weight. A similar result was recorded by Rana *et al.*, (2016) where a higher pre-emergence application of Atrazine at 2.0 kg/ha gave a higher dry weed weight and grain yield. Kolage *et al.*, (2004) and Kumar *et al.,* (2012) also conformed with this finding.

V. CONCLUSION

Worldwide maize production is hampered up to 40% by competition from weeds which are the most important pest group of this crop. Weeds reduce crop yield and quality because of competition and as well serve as alternate host for disease causing organisms. As a result of these implications of weed on agricultural practices, a lot of devices and methods have been developed to either control, eradicate or manage weed to a threshold of economic safety. From the study, the maize plants were observed to have similar plant height and number of leaves throughout the period of measurement. The weed control methods used in this study significantly influenced the growth parameters of the maize plant such as the plant height at 9 WAP, number of leaves, stem girth and leave area. Maize grown in the weedy check plots were observed to have reduced plant height, number of leaves, stem girth and leave area. Also, the fresh, dry cob weight and cob length were also reduced in maize grown in weedy check plots which resulted in lower grain yield observed. This could be as a result of weed infestation that competes with the maize for space, light, moisture, and nutrients which cause reduction in the grain yield.

RECOMMENDATIONS

As it was observed in this study, all the weed control methods enhanced the growth yield of maize plant. However, it was further detected that the chemicals when combined with other cultural practices like supplementary hoe weeding is more effective, therefore, this treatment measure is highly recommended in reducing weed competition, crop losses and labour costs. Also, this study suggests that the appropriate combination of pendimethalin and Atrazine is a good treatment measure that should be adopted always when controlling weed in a maize farm.

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