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EFFECTS OF DIFFERENT HERBICIDES ON THE GROWTH AND YIELD OF MAIZE (*Zea mays L*) IN LAFIA, NASARAWA STATE, NIGERIA

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Abstract
Weed is a man-made problem and therefore herbicide use is significant in optimizing agricultural resources to satisfy human needs. It is therefore important to study the effect of herbicide on maize performance, for proper management and long-time productivity. The field experiment was conducted in the rainy season of the year 2021. The experiments were laid out in randomized complete block design with five treatments and replicated three times given a total of 15 plots. The treatments were represented as T_1 (Atrazine), T_2 (Diuron), T_3 (Metolachlor), T_4 (Butachlor) and T_5 (Control), respectively. Treatments were applied at the same experimental plots equally. Data was also collected on growth and yield parameters and were subjected to analysis of variance The results of the experiment showed that butachlor (T_4) recorded the highest value in leaf area (286.00 cm^3), plant height (121.27 cm), numbers of leaves (13.70), stem girth (28 cm) and yield parameters (weight of dry maize, weight of dry maize/plot, weight dry seed, weight of wet maize, weight of wet maize/plot with values of 188.67g, 2873.50g, 44.00g, 207.17g and 3033.67g), respectively While Diuron (T_2) had the lowest values on all yield parameters (0.00 g).There was statistically high significant difference among treatments means. It can be concluded that butachlor application performed best with the highest improvement in the growth and yield of maize.
Key words: Herbicides, Maize, Ecology, Performance and Weeds

Introduction

Several million people in the developing world consume maize as an important staple food and derive their protein and calories requirements from it. It holds a great promise for increasing production (Abdulraheem *et al.*, 2012). Maize is a member of the family *Graminae* and it is an annual crop serving as a good source of food for human consumption in the form of maize powder, maize meal and confectionaries such as bread, biscuits and cakes. Maize is world's one of the three most popular cereal crops. It is grown worldwide on approximately 130 million/ha annually with a production of 574 million metric tons (Itos, 1998). It occupies an important position in world economy and trade as a food, feed and an industrial grain crop. Maize is the most highly distributed cereal in the world used for human and animal feeds as well as industrial purposes. The demand for maize is always higher than what is being produced in the country. Maize is essentially an important component of the farming systems and the diet of many people in the tropics and can be processed into different products for various end uses both at the traditional level and industrial scale, though a large production of products utilized in developing countries is obtained via traditional processing while industrial processing meets the bulk of the demand in developed countries (Abdulraheem and Charles, 2013)

The major environmental problem associated with the cultivation of maize, according to Silva, (1994) is the temperature as it affects directly the growth and distribution of the plant. Wind also, as an environmental problem affects the level of rainfall and causes serious damage to the crop in form of lodging while too much of rainfall can lead to erosion. Biotic factors such as parasites, weeds, pests and diseases and soil organisms reduce the income of the farmers. Weed is a man-made

problem, though disturbance of ecology where undesirable plant emerges (Abdulraheem and Charles, 2018)

The global drive for sustainable agricultural system involves optimizing agricultural resources to satisfy human needs at the same time maintain the quality of the environment and sustain natural resources. In other to achieve this optimization, herbicide use is significant. Herbicides are substances or cultured biological organisms used to kill or suppress the growth of unwanted plant vegetation (Abiloye *et al.,* 2018).

In recent times, the rate at which herbicides are applied to control weeds at residential areas in urban environment has increased rapidly especially in Nigeria (Bulu *et al.,* 2017). This aggressive application has been reported to have adverse effect on the environment. The increasing use of herbicides with high potential mobility, may pose serious environmental problems through offsite transport (Bulu *et al*., 2019). The purpose of modern industrial herbicides is to control weeds. The species of weeds that plague crops today are a consequence of the historical past, being related to the history of the evolution of crops and farming practices. Chemical weed control began over a century ago with inorganic compounds and transitioned to the age of organic herbicides (Kraehmer *et al.,* 2014)

Weeds can be defined as plants which are undesirable, persistent, damaging and interfere with growth of other crop plants thus, affecting human activities, agriculture, natural processes and economy of the country. These plants influence the produce of farmers in several ways such as competing for light, moisture and nutrients affecting quality and quantity of produce, interfere with and damage harvesting equipment, harbours pests and diseases, toxic properties of weeds cause health problems to humans and animals, contaminate aquatic resources, interferes and adversely affects natural ecosystem (Sharad, 2014). Human race got familiar to weeds since they started to cultivate crops around 10,000 B.C (Hay, 1974) and almost simultaneously these unwanted plants were recognized as a problem. This initiated the conflict between mankind and weeds. Looking at the global scenario, the major contributors of crop loss are again weeds, followed by animals and pathogens (Oerke, 2006).

The use of herbicides in agriculture has over the years contributed tremendously to both food and cash crop production all over the world of which Nigeria is not an exception. But one of the challenges undermining the farming business (Ntow *et al.,* 2006), has been the invasion of many common weed species due to favourable environmental conditions such as abundance of rainfall, adequate sunlight and fertile soil in Nigeria. As a result, manufactures have adopted flooding the agrochemical market with all kinds of herbicides that are meant for the elimination of different kinds of weeds, at different stages of their growth (Sebiomo *et al.,* 2011). Perhaps, the efficacy of these herbicides in controlling the target weeds has resulted in the application of these chemicals by most farmers. It is important to study the effect of herbicide on the growth and yield of maize, for proper management and long-time productivity.

Materials and Methods

Study Area

The study was conducted at the Faculty of Agriculture Demonstration Farm of Nasarawa State University, Keffi, located at Shabu - Lafia, Nasarawa State, Nigeria. It lies on latitude 08^{o} 33'N, longitude 08^{0} 32'E at an altitude of 181.53m above sea level (Jayeoba, 2013). The area is located in southern – guinea savannah characterized by a sub-humid tropical climate with wet and dry seasons. The mean annual temperature is 28.75^{o}C with mean minimum and maximum

temperatures of 24.5ºCand 33ºC, respectively. The relative humidity fluctuates between 43.2 and 86.3%. The average rainfall ranges from 1,138.0 to 1595.7mm per annum.

Land Preparation and Field Layout
The experimental plots were marked out after land clearing and tilled manually using hoe. Each plot was measured 4 m x 3 m and separated from one another with a space of 1 m.

Experimental Design
The experiment was laid in randomized complete block design with five treatments and three replications. The treatments were represented by T_1, T_2, T_3, T_4 and T_5, where T_1 was Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine), T_2 - Diuron [3- (3, 4-dichlorophenyl)-1, 1-dimethylurea], T_3 - Metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide], T_4 - Butachlor [N-(butoxymethyl)-2-chloro-N-(2,6-diethyl-phenyl) acetamide] and T_5 was the control treatment.

Laboratory Analysis
The soil samples collected was air-dried, crushed gently using a mortar and pestle and then sieve through a 2mm mesh. The sieved samples were subjected to physical and chemical analyses.

Herbicides Selection and application
The herbicides were obtained from a local agricultural input dealer in Nasarawa state. Glyphosate was applied before planting except for the control plots that was not applied. The herbicides (Atrazine, Diuron, Metolachlor, and Butachlor) which serve as treatment were applied two weeks after planting.

Crop Establishment
Two seeds of maize were sown per hill. The maize seeds were sown at a spacing of 30cm by 75cm between plants and rows respectively at 2 – 5cm depth. The seedlings were thinned to one plant per hill two weeks after germination and missing plants were replaced.

Fertilizer Application
Split fertilizer application was done using the band placement method at the rate of 200kg/ha NPK (15:15:15) at two weeks after planting and top dressed before tasselling.

Harvesting
The green cobs were harvested at physiological maturity, weighed and kept to dry

Data Collection
Growth and yield parameters
Growth parameters were collected at 4, 6 and 8 weeks after sowing (WAS) on five randomly selected plants from each plot and recorded.

Plant height (cm)
The height of the selected plant was measured from the soil surface to the terminal bud using a meter rule and the mean recorded.

Leaf area (cm^2)
The leaf area was determined by multiplying the manually measured length and maximal width of tagged plants with a shape factor, k, empirically determined to be 0.75 for maize.

Number of leaves per plant
The number of leaves on each selected plant was counted manually and the mean recorded**.**

Plant girth (cm)
The girth of each plant was measured using a vernier calliper and the mean recorded.

Seed weight per cob (g)
The weight of seed from each cob of selected plant was taken and the mean recorded

Weight of Dry Maize
The weight of dry maize of selected plant was taken and the mean recorded

Weight of Dry Maize/Plot
The weight of dry maize per plot was taken and the mean recorded.

Weight of Wet Maize
The weight of wet maize of selected plant was taken and the mean recorded.

Weight of Wet Maize/Plot
The weight of wet maize per plot was taken and the mean recorded.

Statistical Analysis
The data was analysed using analysis of variance for complete randomized block design using GEN-STAT (2014) procedures. The differences among the treatments were determined using least significant difference.

Results
Table 1 shows the effect of different herbicides on the leave area of plant. It was shown that there was a high significant difference ($P<0.05$) among treatments at week four and no significant difference at week six to eight However, T_4 maize has the highest leave area (286.00cm^3) compare to T_2 having the least value (138.20cm^3).

TABLE 1: Effect of Different Herbicides on Leave Area

TREATMENT	WK 4	WK 6	WK 8
T1: Atrazine	144.7	232.0	282.0
T2: Diuron	138.2	0.000	0.000
T3: Metolachlor	121.7	124.8	152.0
T4: Butachlor	137.6	231.5	286.0
T5: Control	118.4	188.8	272.0
LSD (0.05)	11.88	54.42	78.8
CV%	1.20	5.90	6.60
Grand mean	132.1	155.4	198.0

LSD = Least Significant Difference, CV= Coefficient of Variation

Table 2 shows the effects of different herbicides on number of leaves of the plant. It was shown that the mean treatment from 4 and 6 WAS had a high significant difference but there were no significant differences ($p>0.05$) between T3, T4 and T5 at week eight. T4 had the highest number of leaves at 6 to 8 WAS with values of 10.27 and 13.70, respectively. Diuron (treatment 2) had the lowest numbers of leaves at 6 and 8 WAS with values 0.00.

TABLE 2: Effects of Different Herbicides on Number of Leaves

TREATMENT	WK 4	WK 6	WK 8
T1: Atrazine	6.40	10.07	12.53
T2: Diuron	6.93	0.00	0.00
T3: Metolachlor	6.53	9.73	12.97
T4: Butachlor	5.93	10.27	13.70
T5: Control	6.93	9.20	12.80
LSD (0.05)	1.483	1.827	1.026
CV%	4.20	4.40	4.70
Grand mean	6.55	7.85	10.40

LSD = Least Significant Difference, CV= Coefficient of Variation

Table 3 shows the effect of different herbicides on plant height. It was shown that there was a high significant difference among treatments from 4 to 6 WAS and no significant differences among treatments at week eight. However, T4 had the highest height (121.27 cm) compare to the other treatments while T2 had the lowest plant height (0.00 cm).

TABLE 3: Effect of Different Herbicides on Plant Height

TREATMENT	WK 4	WK 6	WK 8
T1: Atrazine	26.60	60.50	113.50
T2: Diuron	30.40	0.00	0.00
T3: Metolachlor	27.67	35.20	80.53
T4: Butachlor	27.57	62.10	121.27
T5: Control	26.30	53.00	98.67
LSD (0.05)	2.868	9.86	30.33
CV%	0.60	5.50	19.46
Grand mean	27.71	42.20	82.79

LSD = Least Significant Difference, CV= Coefficient of Variation

Table 4 shows the effect of different herbicides on stem girth. it was shown that there was a significant difference in stem girth among treatment mean from 4 and 6 WAS with no significant difference at week eight. Maize in T4 had the highest stem girth at 6 and 8 WAS with values 23.8 cm and 28 cm, respectively compared to other treatments while T2 at 6 and 8 WAS had the lowest stem girth of 0.00 cm all through. The control (treatment 5) had the highest stem girth (13.67cm) at 4 WAS.

TABLE 4: Effect of Different herbicides on Stem Girth

TREATMENT	WK 4	WK 6	WK 8
T1: Atrazine	12.70	22.50	25.30
T2: Diuron	13.20	0.00	0.00
T3: Metolachlor	12.23	17.10	19.50
T4: Butachlor	12.25	23.80	28.00
T5: Control	13.67	22.90	25.90
LSD (0.05)	1.978	12.89	14.21
CV%	2.3	15.20	17.70
Grand mean	12.81	17.30	19.70

LSD = Least Significant Difference, CV= Coefficient of Variation

Table 5 shows the effect of different herbicides on maize yield. Maize in T4 had the highest yield parameters (Weight of dry biological yield of Maize (188.67 g), Weight of dry biological yield of Maize/Plot (2873.50 g), Weight of dry Seed (44.00 g), Weight of fresh biological yield of Maize (207.17 g), and Weight of fresh biological yield of Maize/Plot (3033.67 g). Maize in T2 had the lowest values on yield parameters all through (0.00 g). There was significant difference ($P<0.05$) among treatments means in terms of Weight of dry biological yield of Maize and Weight of fresh biological yield of Maize with no significant differences among treatments on Weight of dry biological yield of Maize/Plot, Weight of dry Seed and Weight of fresh biological yield of Maize per plot.

TABLE 5: Effect of Different Herbicides on Maize Yield Parameters

		(g)			
TREATMENT	WDM	WDM/P	WDS	WFM	WFM/P
T1: Atrazine	64.47	2066.27	35.00	102.57	2636.67
T2: Diuron	0.00	0.00	0.00	0.00	0.00
T3: Metolachlor	39.80	1174.67	23.33	54.33	1261.67
T4: Butachlor	188.67	2873.5	44.00	207.17	3033.67
T5: Control	62.27	1705.33	32.67	85.53	2427.33
LSD (0.05)	31.46	907.31	17.61	43.85	991.93
CV%	8.80	12.2	14.10	10.30	9.90
Grand mean	71.04	1563.95	27.00	89.92	1871.87

WDM = Weight of dry Maize, WDM/P = Weight of dry Maize/Plot, WDS = Weight dry Seed, WWM = Weight of fresh Maize, WFM/P = Weight of fresh Maize/Plot; LSD = Least Significant Difference, CV= Coefficient of Variation

Discussion

From the study, it was observed that maize in T4 (Butachlor treatment) performed best having highest leave area (286.00 cm^3). It also had the highest number of leaves (13.70), plant height (121.27 cm) and stem girth (28.00 cm). This is consistent with the findings of Bature *et al.* (2016) who stated that application of butachlor can serve as an alternative to hoe weeding and significantly reduced mean weed population and increased the growth and yield of maize. This is probably due to the fact that weed control via herbicides application caused significant reduction in weed growth (Devine *et al.,* 2000). All the weed control methods caused significant reduction in weed growth by improving growth parameters except for T2 (Diuron treatment 2) as observed in leave area (138.20 cm^3). It also had the lowest number of leaves (0.00), plant height (0.00cm) and stem girth (0.00cm). The observations made with regard to the performance of Diuron in the control of weeds in the field as well as its effects on field crops, were consistent with earlier reports of Adriana, (2009), Ferrel *et al*. (2004), and USEPA (2004). This may be due to the known interference of

Diuron with chlorophyll synthesizing systems of crops (Ferrell *et al*., 2004; Hess and Warren, 2002). With regard to crop response to Diuron application, death of all maize plants that emerged after pre-emergence application of Diuron was as a result of the herbicide's ability to attack young germinating plants and interfere with their chlorophyll synthesizing system, thereby starving them to death, confirming its non-suitability for use as a post-plant pre-emergence herbicide in field crops production (Hess and Warren, 2002; Ferrel *et al*., 2004).

It was observed that maize in T4 (Butachlor treatment) performed best having highest in the yield parameters. This is in accordance with the findings of Bature *et al.* (2016), who reported that application of Butachlor can serve as an alternative to hoe weeding and significantly reduced mean weed population and increased the growth and yield of maize. This is possibly due to the fact that weed control via herbicides application caused significant reduction in weed growth (Devine *et al.,* 2000) thereby, increasing the yield of maize. This is similar to the findings of Sutton *et al*. (2002), who stated that chemical method of weeding is very easy, flexible and cheaper than using costly labours for weeding purpose. Furthermore, this method is very useful in different climatic and edaphic conditions and shows effective results compared to tedious manual method of weeding. Both by increasing herbicide use efficiency and reducing injury to crop by applying recommended doses, an individual can improve his economy, maximizing yield of crop and reducing weed infestation easily by chemical method. This is also similar to the findings of Ishaya, (2004) and Mahadi, (2011) as they stated that weed competition decreases growth and yield of maize plant. In spite of the efficient weed control on maize plots by Diuron, the herbicide was very toxic to plants at even the recommended rate resulting in a significant reduction in grain yield. Khare *et al*. (1986) reported similar observations in sorghum. The pre-emergence application of Diuron allows weed seeds to germinate normally, but interferes with chlorophyll formation, which then leads to starvation and death of the young plants (Ferrell *et al*., 2004; Hess and Warren, 2002)

Conclusion

From the results obtained, it could be concluded that Butachlor application performed best with the highest improvement in the growth and yield of maize. All the weed control methods caused significant reduction in weed growth and increase in the yield of maize parameters except Diuron. In spite of efficient weed control on maize plots by Diuron, the herbicide was very toxic to plants at even the recommended rate resulting in a significant reduction in grain yield. Thus, weed control with Diuron at its field recommended rate gave an indicator response showing the treatment caused mortality (crop failure) after application. Diuron can therefore be classified as a toxic herbicide causing severe damage as seen in this experiment. Therefore, Butachlor could be recommended as a safe herbicide thus, may be used to control weed with little or no toxic effects on the crops.

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