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Growth and Yield Response of Maize (Zea *mays* L.) To Different Weed Control Methods in the Western Highlands of Cameroon

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Abstract

Weed control is an important agronomic practice that improves growth and maximizes yield in maize. An experiment was carried out to investigate the 'effect of different weed control methods on the growth and yield of maize (Zea mays L.) in the western highlands of Cameroon. The work was carried out during the 2017/2018 main cropping season from the 14th of March to the 14th of July at the Institute of Agricultural Research for Development (IRAD) Bambui experimental field. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The experiment comprised of seven treatments: weedy check or control (T1), constant hand hoeing (T2), delay hand hoeing (T3), pre-emergence herbicide application of Atrazine 90 DF (0.9 kg ha-1) (T4), post-emergence herbicide application of Ultramais 100 SC (1.9 litre ha-1) (T5), pre- herbicide application of Atrazine 90 DF (0.9 kg ha-1) + Ultramais 100 SC (1.9 litre ha-1) (T6) and delay post-emergence herbicide application of Ultramais 100 SC (1.9 litre ha-1) (T7). The white maize variety CHC 201 ("KASAI") was used during the experiment and sown in plot sizes of 4 m x 5 m with a planting density of 80cm by 50cm with 2 plants per station with the aim of achieving a plant population of 50,000 plants ha-1. All agronomic practices were followed from planting to harvesting. The data recorded were plant height, number of green leaves per plant, leaf area, stem girth, days to 50% tasseling, days to 50% silking, ear height, ear length, ear girth, number of gain rows per ear, number of gains per ear, 1000 grain weight and grain yield.. The data collected were analyzed with the aid of STATGRAPHICS Plus 5.0 Software and ANOVA was run to find the differences between the various treatments. The highest 1000 grain weight (314.13g) came from the pre-emergence plus post-emergence herbicide application treatment and did not differ significantly (P>0.05) from the constant hand hoeing treatment (307.83g). The lowest 1000 grain weight (234.67g) was seen in the weedy check treatment. The constant hand hoeing had the highest grain yield (6.27 ton ha-1) and this did not differ significantly (P>0.05) from the pre-emergence plus post-emergence herbicide application treatment (6.07 ton ha-1). The lowest grain yield (3.18 ton ha-1) was seen in the weedy check treatment. From the study, the pre-emergence plus post-emergence herbicide application may be recommended for increasing maize yield particularly in the case of high scale production.

Keywords: Maize; Growth and yield; Herbicide; Weed control.

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1. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated in the world as a source of human food, feed, industrial uses and bio-energy [1]. In the developing world such as the Sub-Saharan Africa (SSA), maize is mostly grown for food by small holder farmers under rain-fed conditions and low production inputs like fertilizers and phytosanitary products [2]. About 69.6% of the countries in the world with the highest per capita consumption of maize are found in SSA [3]. In Cameroon, maize production greatly contributes to food security and employment. It is the most produced and consumed cereal crop with over 700,000 farm families involved in its cultivation [4]. In Cameroon, maize serves in a variety of traditional dishes (con fufu, corky corn, corn chaff…) as well as drinks (corn beer, scha, pap…).

Maize production in the Western highlands of Cameroon is constrained by a number of factors like diseases, insect pests, low soil fertility, soil acidity, environmental degradation and weed infestations [5]. The global maize production is reduced to about 40% due to the weed infestations, which are the most common pests [6]. Weeds compete with crops for space, nutrients, light, moisture and carbon dioxide, reducing not only yields, grain quality and hinder harvest operations but also increase cost of production [7, 8]. Many methods such as mechanical, cultural, biological and chemical are used to reduce weeds. The cultural method is very tedious and time wasting.

Most maize producers in the Western highlands of Cameroon do not know the appropriate weed control method of the crop or the critical period of weed control. The present study was aimed at investigating the growth and yield response of maize to different weed control methods in the highlands of Cameroon.

2. Materials and Methods

2.1. Study Site

The study was carried out in the experimental farm of the Institute of Agricultural Research for Development (IRAD) Bambui, at the Nfonta Sub-station in the North West Region of Cameroon. Nfonta is a low land located at the elevation of 1250m above sea level with savanna vegetation. This area is characterized by moderate rainfall of 2230mm/annum uniformly distributed from mid-march to mid-November with the highest peak of 380mm occurring in the month of July and August. The temperatures are slightly cold with an average minimum and maximum of 18-28^{o}C respectively. It has an average humidity of 75% and 52% in the rainy and dry season respectively. This area has a well drained soil which is good for maize production.

2.2. Land Preparation

The land was ploughed with a tractor and harrowed with hoe to pulverize the soil. Plots were then marked out in the land. Each plot size was 4.m x 5m with a distance of 0.5m between plots and 1m separating one block (replication) from the other. The whole experimental field measured 36.6m x 17m (622.2m^2).

2.3. Experimental Design

The experiment was laid out in a randomized complete block design (RCBD). There were seven treatments (Table 1) replicated three times.

Table-1. The seven experimental treatments and their treatment modes

Treatment code	Treatment	Treatment mode
T1	Control (weedy check)	No weeding
T2	Constant hand hoeing	Weeds removed weekly
T3	Delayed hand hoeing	Weed removed regularly as from 45 DAS
T4	Pre-emergence herbicide (Atrazine 90 DF) (0.9kg ha^{-1})	Sprayed 3days before sowing
T5	Post emergence herbicide (Ultrmais 100 SC) (1.9 litre ha^{-1})	Sprayed immediately after weed emergence
T6	Pre-emergence followed by Post emergence herbicide (Atrazine 90 DF, 0.9 kg ha^{-1} + Ultramais 100 SC, 1.9 litre ha^{-1})	Pre-emergence sprayed 3 days before sowing and post emergence sprayed immediately after weed emergence
T7	Delayed Post emergence herbicide (Ultramais 100 SC, litre ha^{-1})	Sprayed 45 DAS

2.4. Planting and Cultural Practices

Maize seeds (“KASAI” or CHC 201), an open-pollinated variety obtained from the Institute of Agricultural Research for Development (IRAD) Bambui were sown. Three to four seeds were sown per station at a depth of 5cm in a planting distance of 80cm row to row and 50cm plant to plant. Immediately after germination, thinning was done (unhealthy seedlings discarded) to maintain two seedlings per station with the aim of achieving a plant population of 50,000 plants per hectare. NPK 14-24-14 fertilizer was applied 14 days after sowing (DAS) at the rate of 200kg per hectare and Urea fertilizer was applied 43 DAS at the rate of 100kg per hectare. The application dose for herbicides is shown in Table 1 above. All other agronomic practices were equally followed for each of the treatments until harvesting.

2.5. Data Collection

Data collection began three weeks after sowing (WAS). The growth and yield parameters recorded at different stages of the crop growth cycle were: plant height, number of green leaves, leaf area, stem girth, ear length, ear girth, number of grain rows per ear, number of grains per ear, grain weight per ear, 1000 grain weight and grain yield. The various parameters were taken as follows: Plant height: It was taken from ten randomly selected middle row plants marked in each plot. A carpenter's tape was used to measure the height from ground level to the uppermost leaf and the mean plant height calculated for each plot. Number of green leaves: Visual counting of green leaves was made from the ten marked leaves and the average calculated for each plot. Stem girth: It was measured from the ten marked plants using a thread and the actual length determined using a carpenter's tape. The mean girths were then calculated for each plot. Days to tasseling: It was recorded when 50% of the plants in a plot have developed tassels with pollens. Silking: It was recorded when 50% of the plants in a plot have developed 5cm long silks. Ear height. It was taken from ten randomly selected middle row plants marked in each plot. A carpenter's tape was used to measure the height from ground level to base of the uppermost ear and the mean ear height calculated for each plot. The leaf area: It was determined from length x width method [9] using the formula

Leaf area = 0.75(length x width), where 0.75 is a constant. Ten leaves were measured with a tailor's tape from each plot and the mean leaf area determined. Ear girth: The Ear girths for ten dehusked ears from each plot were measured as described above for stem girth. Number of grain rows and number of grains per ear: These were determined from the ten marked cobs from each plot and the average for each plot calculated. 1000-grain weight: One thousand grains were counted from each plot and their dry weight measured. Grain yield: The dry weights of maize grains harvested from $1m^2$ in the middle rows of each plot were weighed and the yield estimated using the formula:

$$\text{Grain yield} = \left\{ \frac{\text{Dry weight of maize grains from 1 square metre in kg x 10,000}}{1000} \right\} \text{ton ha}^{-1}$$

2.6. Data Analyses

The data analyses were executed with the aid of the STATGRAPHICS Plus version 5.0 Software. The analysis of variance (ANOVA) was run to find the differences between the various treatments and the LSD Fisher's test at 95% confidence level was used to compare the different treatments.

3. Results and Discussion

3.1. Effect of Different Weed Control Methods on Maize Plant Height

The results shown in Table 2 reveal that the plant height increased along the growth stages for all the treatments. At 3 WAS, the mean plant height from the weedy check plot did not differ significantly (P>0.05) from post-emergence herbicide application and delay post-emergence application treatments. The constant hand hoeing treatment had the highest plant height (22.90cm) and significantly differed (P< 0.05) from those of the other treatments. At 5 WAS, the plant height (36.00cm) from the control plot was the lowest showed significant difference (P< 0.05) from those the rest of the treatments. The plant heights from the constant hand hoeing, delay hand hoeing, pre-emergence herbicide application and delay post emergence herbicide application treatments showed no any significant difference. The plant height (44.27cm) from the pre-emergence plus post-emergence herbicide application was the highest and differed significantly from those of the other treatments At 7 WAP, 9WAS and 11WAS, there were no significant difference in the plant heights for all treatments. At 11 WAS, the control plot had the lowest plant height (170.13cm) while the pre-emergence plus post emergence herbicide application recorded the highest plant height (191.63cm). The variation of plant height of maize in all weed control treatments might be due to varying effect of weed competition duration for available resources offered by weeds in the weedy checks. These our findings are in line with Tahir, *et al.* [7] and Akhtar, *et al.* [10] who revealed that minimum plant height was in the weedy checks.

Table-2. Plant height of maize (cm) as influenced by effect of different weed control methods

Treatment code	Treatment	Mean ± SD at 3 WAS	Mean ± SD at 5 WAS	Mean ± SD at 7 WAS	Mean ± SD at 9 WAS	Mean ± SD at 11 WAS
T1	Control (weedy)	21.97±0.21[cd]	36.00±2.31[b]	60.10±3.35[a]	96.63±9.84[a]	170.13±17.79[a]
T2	Constant hand hoeing	22.90±0.46[a]	43.10±5.27[ab]	68.27±7.36[a]	114.77±15.02[a]	187.03±10.91[a]
T3	Delay hand hoeing	21.40±0.72[d]	38.67±1.88[ab]	65.90±4.68[a]	108.30±14.81[a]	183.27±3.87[a]
T4	Pre-emergence herbicide	22.13±0.12[bc]	39.50±3.40[ab]	64.40±0.84[a]	100.03±16.44[a]	175.90±12.86[a]
T5	Post-emergence herbicide	21.9±0.30[cd]	41.17±7.75[ab]	61.83±1.54[a]	105.80±6.77[a]	174.47±6.18[a]
T6	Pre-emergence+post-emergence herbicide	22.8±0.26[ab]	44.27±2.14[a]	66.87±8.47[a]	114.33±25.27[a]	191.63±15.08[a]
T7	Delay post-emergence herbicide	21.63±0.32[cd]	37.47±3.84[ab]	66.33±11.61[a]	111.43±20.03[a]	182.03±17.28[a]

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

3.2. Effect of Different Weed Control Methods on Maize Number of Green Leaves Per Plant

The data presented in Table 3 show that the number of green leaves per plant increased across the plant growth stages for all the treatments. At 3 WAP, the number of green leaves in the control treatment did not differ significantly (P>0.05) from those of the delay hand hoeing and post emergence herbicide application treatments. At 5WAS, 7WAS and 9WAS, the number of green leaves per plant did not differ significantly for all treatments. At 11 WAS, the lowest number of green leaves (10.73) was seen in the control treatment but did not differ significantly from the number of green leaves in the delay hand hoeing and the pre-emergence herbicide application treatments. The highest number of green leaves (11.87) was recorded in the pre-emergence herbicide plus post-emergence herbicide application treatment and differed significantly from the number of green leaves from the rest of the treatments. The lower number of green leaves per plant in the weedy check might be attributed to high competition of weeds for growth resources which rendered the plant inefficient to utilize resources and consequently affected growth. These results are in line with Shailendra [11] that showed that the number of green leaves per plant in the weedy check was smaller than those in the weed control treatments.

Table-3. Number of green leaves at different growth stages as influenced by effects of different weed control methods

Treatment code	Treatment	Mean ± SD at 3 WAS	Mean ± SD at 5 WAS	Mean ± SD at 7 WAS	Mean ± SD at 9 WAS	Mean ± SD at 11 WAS
T1	Control (weedy)	4.57±0.00^{c}	6.53±0.42^{a}	7.37±0.12^{a}	9.67±0.50^{a}	10.73±0.23^{b}
T2	Constant hand hoeing	5.27±0.12^{a}	7.13±0.12^{a}	8.07±0.31^{a}	10.9±0.20^{a}	11.33±0.42^{ab}
T3	Delay hand hoeing	4.60±0.10^{c}	6.73±0.23^{a}	7.80±0.35^{a}	10.20±0.53^{a}	11.07±0.23^{b}
T4	Pre-emergence herbicide	4.87±0.12^{bc}	6.83±0.15^{a}	7.53±0.23^{a}	10.20±0.53^{a}	11.13±0.31^{b}
T5	Post-emergence herbicide	4.73±0.23^{c}	6.60±0.60^{a}	7.93±0.12^{a}	10.00±0.91^{a}	11.20±0.35^{ab}
T6	Pre-emergence+post-emergence herbicide	5.13±0.23^{ab}	7.20±0.60^{a}	8.20±0.72^{a}	10.47±0.76^{a}	11.87±0.58^{a}
T7	Delay post-emergence herbicide	4.60±0.20^{cd}	6.93±0.31^{a}	8.07±0.50^{a}	10.13±0.50^{a}	11.33±0.50^{ab}

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

3.3. Effect of Different Weed Control Methods on Maize Leaf Area

The data presented in Table 4 reveal that the leaf area increased from 3WAS to 9WAS and dropped at 11WAS for all treatments. At 3WAS, the weedy check showed the smallest leaf area (41.73 cm^2) and differed significantly (P≤0.05) from those of the other treatments. At 5WAS, 7WAS and 9WAS, there were no significant differences (P>0.05) in the leaf area for all treatments. At 11WAS, the control plot showed the lowest leaf area (471.57cm2) while the pre-emergence herbicide application plot recorded the highest leaf area (595.13cm^2) and differed significantly from those of the other treatments. The lower leave are in the weedy check might be due to high competition of weeds for growth resources which rendered the plant inefficient to utilize resources and consequently affected growth. These results are similar to Shailendra [11] who revealed that the leaf area in the weedy check was smaller than those in the weed control treatments.

Table-4. Leave area (cm^2) of maize at different growth stages as influenced by effect of different weed control methods

Treatment code	Treatment	Mean ± SD at 3 WAS	Mean ± SD at 5 WAS	Mean ± SD at 7 WAS	Mean ± SD at 9 WAS	Mean ± SD at 11 WAS
T1	Control (weedy)	41.73± 2.85d	121.60±17.52^{a}	305.97±56.75^{a}	514.43±28.81^{a}	471.57±23.77^{c}
T2	Constant hand hoeing	48.93±1.70^{a}	158.07±36.89^{a}	332.47±46.40^{a}	585.80±28.58^{a}	559.03±21.05^{ab}
T3	Delay hand hoeing	42.97±0.64^{cd}	128.27±7.09^{a}	328.07±26.80^{a}	581.93±38.66^{a}	549.40±69.00^{ab}
T4	Pre-emergence herbicide	45.07±0.47^{bc}	126.57±7.45^{a}	309.47±10.23^{a}	554.47±29.01^{a}	595.13±46.14^{bc}
T5	Post-emergence herbicide	44.57±1.99^{bcd}	129.90±23.13^{a}	308.73±17.66^{a}	520.17±28.47^{a}	507.00±25.47^{bc}
T6	Pre-emergence+post-emergence herbicide	46.10±1.21^{ab}	154.17±30.90^{a}	335.47±69.53^{a}	582.90±114.39^{a}	578.90±38.92^{a}
T7	Delay post-emergence herbicide	42.20±1.80^{cd}	123.90±15.84^{a}	322.40±40.64^{a}	581.43±69.82^{a}	538.13±22.72^{abc}

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

3.4. Effect of Different Weed Control Methods on Maize Stem Girth

For all growth stages, there was no significant difference (P>0.05) in the stem girth for all the treatments. At 11WAS, the lowest stem girth (7.63 cm) was seen in the control while the highest stem girth (8.17 cm) was seen in the pre-emergence plus post-emergence treatment (Table 5). The weedy check recorded the lowest stem girth because of the high presence of weeds which might have used up most of the available resources available for the crop, thereby resulting to poor growth. These findings are in line to Fuksa, *et al.* [12] who reported that the maize stem girth in weed control plots were higher than the stem girth in the weedy check treatment.

Table-5. Stem girth (cm) of maize at different growth stages as influenced by effect of different weed control methods

Treatment code	Treatment	Mean±SD at 3 WAS	Mean±SD at 5 WAS	Mean±SD at 7 WAS	Mean±SD at 9 WAS	Mean±SD at11WAS
T1	Control (weedy)	2.23±0.06^{a}	3.60±0.10^{a}	5.53±0.71^{a}	6.93±0.51^{a}	7.63±0.21^{a}
T2	Constant hand hoeing	2.37±0.06^{a}	4.30±0.50^{a}	6.27±0.40^{a}	7.80±0.24^{a}	8.13±0.23^{a}
T3	Delay hand hoeing	2.23±0.06^{a}	3.70±0.30^{a}	6.27±0.40^{a}	7.83±0.81^{a}	7.90±0.89^{a}
T4	Pre-emergence herbicide	2.30±0.00^{a}	3.97±0.06^{a}	5.77±0.45^{a}	7.23±0.25^{a}	7.70±0.10^{a}
T5	Post-emergence herbicide	2.27±0.15^{a}	3.77±0.15^{a}	5.87±0.29^{a}	7.23±0.12^{a}	7.67±0.35^{a}
T6	Pre-emergence+post-emergence herbicide	2.37±0.06^{a}	4.23±0.64^{a}	6.13±0.57^{a}	7.80±0.36^{a}	8.17±0.32^{a}
T7	Delay post-emergence herbicide	2.27±0.06^{a}	3.83±0.59^{a}	5.77±0.60^{a}	7.33±0.81^{a}	7.87±0.31^{a}

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

3.5. Effect of Different Weed Control Methods on Tasseling, Silking and Ear Height

Days to 50% tasseling: The control plot took the highest time (84 days) for half of the plants to develop tassels. This differed significantly (P<0.05) from the number of days for the rest of the treatments to reach 50% tasseling. The number of days (78 days) for the constant hand hoeing to reach 50% tasseling was the lowest with respect to the other treatments but did not differ significantly(P>0.05) from the number of days for the pre-emergence plus post-emergence and delay post-emergence treatments to reach 50% tasseling (Table 6). The number of days for the delay hand hoeing, pre-emergence herbicide and post-emergence herbicide application treatments also showed no significant difference.

Table-6. Days to 50% tasseling, days to 50% silking and ear height as influenced by effect of different weed control methods

Treatment code	Treatment	Mean ± SD for days to 50%tasseling	Mean±SD for days to 50% silking	Mean±SD for ear height
T1	Control (weedy)	84.00±5.20^{a}	87.67±4.16^{a}	85.70±12.48^{c}
T2	Constant hand hoeing	78.00±1.73^{b}	81.67±1.53^{cd}	117.63±9.28^{a}
T3	Delay hand hoeing	80.67±0.58^{ab}	84.33±2.08^{abcd}	107.77±9.94^{ab}
T4	Pre-emergence herbicide	81.67±1.15^{ab}	85.67±4.04^{abc}	92.37±10.19^{bc}
T5	Post-emergence herbicide	80.67±0.58^{ab}	86.00±2.89^{ab}	98.47±10.16^{bc}
T6	Pre-emergence+post-emergence herbicide	78.33±2.13^{b}	81.00±1.00^{d}	122.17±6.96^{a}
T7	Delay post-emergence herbicide	79.67±2.13^{b}	83.33±2.08^{bcd}	108.43±9.05^{ab}

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

Days to 50% silking: Just as the tasseling, the control plot took the highest time (87.67 days) to attain 50% silking. This was significantly different (P<0.05) from the number of days for the rest of the treatments to reach 50% silking. The pre-emergence plus post emergence herbicide application treatment took the shortest time (81 days) to reach 50% silking and differed significantly for the number of days of the rest of the treatments to attain 50% silking (Table 6). For all treatments, the number of days to reach 50% silking differed significantly.

Ear height: The control plot recorded the lowest ear height (85.70cm) and this differed significantly (P<0.05) from those of the other treatments. The highest ear height (122.17cm) was attained in the pre-emergence plus post emergence herbicide application treatment. This was followed by the ear height in the constant hand hoeing treatment, which differed significantly from the later. Delay hand hoeing and delay post emergence herbicide application showed no significant difference (P>0.05) in plant height (Table 6). A similar situation was observed in the pre-emergence and post emergence herbicide application treatments

3.7. Effect of Different Weed Control Methods on Maize Yield and Yield Components

3.7.1. Ear Girth (cm)

The highest ear girth (16.13 cm) was seen in the constant hand hoeing treatment (Table 7) and was significantly different (P<0.05) from the others. This was followed by the pre-emergence plus post-emergence herbicide treatment which did not differed significantly (P>0.05) from the delay hand hoeing, post emergence herbicide application and delay post emergence herbicide application treatments. The lowest ear girth (12.70 cm) was seen in the weedy check treatment. These our results are in line to Amare, *et al.* [13] who revealed lower ear girth in weedy checks and higher ear girth in weed control treatments.

3.7.2. Ear Length (cm)

There were significant differences in the ear length among the treatments (Table 7). The highest ear length (17.83 cm) was seen in the constant hand hoeing treatment and this was significantly different (P<0.05) from the other treatments. This was followed by the pre-emergence plus post-emergence herbicide treatment which also differed significantly from the others. The weedy check had the lowest ear length (12.97 cm). These results are similar to Abdullahi, *et al.* [14] and Amare, *et al.* [13] who reported lower ear length in weedy checks and higher ear length in weed control treatments.

3.7.3. Number of Grain Rows Per Ear

There was no significant difference (P>0.05) in the number of grain rows per ear for all the treatments (Table 7). The post emergence herbicide application plot had the highest number grain rows (12.80) per ear and the weedy check plot had the lowest number grain rows (11.60) per ear. The results showed that appropriate weed control practices result to more number of grain rows per ear and eventually higher yields These observations are in line to Tahir, *et al.* [7] and Sulewska, *et al.* [15] who reported that weed control treatments resulted to increased number of grain rows per ear.

3.7.4. Number of Grains Per Ear

The number of grains per ear differed significantly among the treatments (Table 7). The constant hand hoeing plot recorded the highest number of grains per ear 406.80) and it differed significantly (P<0.05) from the others. This was followed by the pre-emergence plus post emergence herbicide application plot which also differed significantly from the others. The lowest number of grains (270.80) was seen in the weedy check treatment. The highest number of grains per ear in constant hand hoeing was due to the least number of weeds in the treatment and consequently the availability of the availability of more photosynthates for plant growth and development. These findings are in accordance to Tahir, *et al.* [7] and Tanveer, *et al.* [16] who revealed that all weed controlled treatments significantly increased the number of grain rows and grains per ear.

3.7.5. Thousand Grain Dry Weight (g)

The weight 1000 grains differed significantly among the treatments (Table 7). The highest 1000 grain weight (314.13g) came from the pre-emergence plus post-emergence herbicide application treatment and did not differ significantly (P>0.05) from the constant hand hoeing treatment. The lowest 1000 grain weight (234.67g) was seen in the weedy check treatment. The higher 1000 grain weight in weed control plots than weedy check might be due to better growth and development of maize plants and availability of more nutrients which resulted to more seed assimilates. These results are in conformity to those of to Abdullahi, *et al.* [14]; Kawsar, *et al.* [17] and El-Bially [18] who reported that chemical and mechanical control plots resulted to maximum grain yield as compared to weedy checks.

3.7.6 Grain Yield (ton ha^{-1})

The grain yield differed significantly among the treatments (Table 7). The constant hand hoeing had the highest grain yield (6.27 ton ha^{-1}) and this did not differ significantly (P>0.05) from the pre-emergence plus post-emergence herbicide application treatment. The lowest grain yield (3.18 ton ha^{-1}) was seen in the weedy check treatment. The lowest grain yield in the weedy check plot might be attributed to the fact that higher weed infestations compete for nutrient with the maize. These our findings are in accordance to Amare, *et al.* [13]; Abdullahi, *et al.* [14]; Kawsar, *et al.* [17]; and El-Bially [18]; who revealed that hand weeding and herbicide application plots all resulted to increase in maize yields

Table-7. Yield and yield components of maize as influenced by effect of different weed control methods

Treatment Code	Treatment	Mean ± SD for ear length	Mean ± SD for ear girth	Mean ± SD for No of grain rows per ear	Mean ± SD for No of grains per ear	Mean ± SD for 1000 grain weight	Mean±SD for grain yield
T1	Control (weedy)	12.97±0.55[d]	12.70±0.98[c]	11.60±1.44[a]	270.80±29.90[d]	234.67±9.66[e]	3.18±0.38[d]
T2	Constant hand hoeing	17.83±0.61[a]	16.13±0.64[a]	13.10±1.01[a]	406.80±25.70[a]	307.83±8.23[a]	6.27±0.56[a]
T3	Delay hand hoeing	14.47±1.58[cd]	15.27±0.68[ab]	12.27±0.23[a]	297.17±42.45[cd]	283.67±9.97[b]	4.23±0.60[c]
T4	Pre-emergence herbicide	14.43±1.32[cd]	14.57±0.70[b]	11.87±0.46[a]	327.00±35.65[bcd]	252.40±6.55[d]	4.12±0.40[cd]
T5	Post-emergence herbicide	14.90±1.42[c]	14.90±0.66[ab]	12.80±0.80[a]	357.73±31.23[abc]	260.40±8.77[cd]	4.65±0.40[c]
T6	Pre-emergence+post-emergence herbicide	17.07±0.67[ab]	15.90±1.06[ab]	12.53±0.92[a]	391.27±39.24[ab]	314.13±4.92[a]	6.07±0.55[a]
T7	Delay post-emergence herbicide	15.43±0.75[bc]	15.13±0.35[ab]	12.57±1.17[a]	363.03±77.20[abc]	272.67±9.56[bc]	4.93±0.98[c]

Means and standard deviations (SD) are shown. In a column, means with the same letters are not significantly different (Fisher's multiple range test 5%)

4. Conclusion

This study confirms the role of weeding and different weeding techniques in increasing maize growth and grain yield. From the study, constant hand hoeing gave the highest grain yield and did not differ significantly from the pre-emergence plus post emergence herbicide application treatment. The pre-emergence plus post emergence herbicide application may be recommended since it is less tedious and rapid. This may be beneficial to large scale maize producers who have difficulties of getting casual workers for hand hoeing.

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