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Effect of weed control methods on weed biomass and grain yield of maize (*Zea mays* L.) under rainfed condition in Basketo Special District, Southern Ethiopia

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Abstract

Maize (*Zea mays* L.) is a major crop grown in Basketo Special district by smallholder farmers. However, its production and productivity is challenged by many factors of which weeds are the key factor that reduce the productivity of maize in the district. Therefore, field experiment was conducted at Basketo Special district during 2017 main cropping season under rainfed condition to evaluate weed control methods on weed biomass and grain yield of maize. The experiment consisted of six treatments namely; once hand hoeing at 20 days after crop emergence (DACE), twice hand hoeing at 20 and 40 DACE, Primagram Gold 660SC + once hand hoeing at 40 DACE, Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE, farmer practice and weedy check. It was laid-out in Randomized Complete Block Design with four replications. Weed and crop parameters were collected. The highest maize grain yield and the lowest weed biomass were obtained from Primagram Gold 660SC + twice hand hoeing without significant difference with Primagram Gold 660SC + once hand hoeing whereas the lowest grain yield and highest weed biomass were found in weedy check. Moreover, the results revealed that integration of Primagram Gold 660SC with once (at 40 DACE) and twice (at 40 and 60 DACE) hand hoeing significantly reduced weed density and biomass and gave better maize grain yield and maximize net benefit. Therefore, these two treatments could be recommended to improve maize productivity and net income of the farmers in the study area.

Keywords: Basketo; Hand hoeing; Integrated weed management; Maize

1. Introduction

Maize (*Zea mays* L.) is one of the most important food security crops of the world including Ethiopia. According to Central Statistical Agency report [1], maize production and productivity in Ethiopia is increasing from time to time with significant yield increment. Accordingly, the total production of maize in Southern Nation, Nationalities and Peoples Regional State and Basketo Special district was 1,085,725.55 and 5036.15 tons, respectively from an area of 322,714.36 and 1891.56 hectares, respectively in 2017 main cropping season [1]. The productivity of maize was remained low in the region and in the district with an average yield of 3.36 and 2.66 t ha^{-1}, respectively [1]. This low yield of maize in the district is attributed to several factors of which weed infestation is the most yield-limiting factor for maize production.

Maize is mostly sensitive to weed competition at early growth stages. It grows slowly during the first three to four weeks. Weeds are strongly competing with maize for limited resources (light, space, soil moisture and nutrients) and cause significant yield loss [2]. In major maize growing areas of Ethiopia (South, Southwestern and West parts of the country), the estimated maize yield loss due to weeds ranged between 46-100% including parasitic weeds attack which reported as 100% yield loss [3].

In Ethiopia, many efforts have been made to solve weed problem. However, due to climate change (which affects the biology, distribution, diversity and nature of weeds) and weed population dynamics from time to time and location to

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location, still it needs research in maize field to tackle the problems through identifying effective weed control methods. Therefore, this experiment was conducted to evaluate the effect of weed control methods on weed biomass and grain yield of maize in Basketo Special district under rainfed condition.

2. Material and methods

2.1. Description of the study area

This study was conducted at Basketo Special district (Angila-4 and Sasa Kebeles), Southern Ethiopia during 2017 main cropping season under rainfed condition. Geographically, the district is located at 6° 14' latitude and 36° 34' longitude at an elevation ranging from 780 to 2200m. The district received an average annual rainfall of 1200mm with the minimum and maximum temperature of 15 and 27°C, respectively. In the lowland areas of the district, the major crops cultivated are maize, sesame and sorghum [4].

2.2. Experimental treatments and design

The experiment was consisted of six treatments namely; once hand hoeing at 20 days after crop emergence (DACE), twice hand hoeing at 20 and 40 DACE, Primagram Gold 660SC + once hand hoeing at 40 DACE, Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE, farmer practice and a weedy check (control). The treatments were laid out in a Randomized Complete Block Design with four replications. Primagram Gold 660SC (3.0 lit ha^{-1}) was used as a pre-emergent herbicide for integration with hand hoeing and sprayed a day after maize seeds sown. Maize variety BH-140 was used for this study with its full-recommended agronomic practices [5] other than weeding.

2.3. Data collected

Data were recorded on weed density m^{-2}, dry weed biomass weight (kg m^{-2}), plant height (cm), number of cobs $plant^{-1}$, aboveground crop biomass yield (t ha^{-1}), 100 seed weight (g) and grain yield (t ha^{-1}). Data regarding weed parameters were recorded prior to hand hoeing time of respective treatments by using a quadrate having a size of 0.5 x 0.5m ($0.25m^2$) which was placed randomly on each plot; weeds inside the quadrate were counted to determine weed density and then converted into m^2. After cutting the weeds at ground level in the quadrate, weed samples were prepared and oven dried at 105°C until constant weight attained for dry weed biomass. Data on weed control efficiency were determined based on the following formula developed by Das [6].

$$\text{WCE}(\%) = \frac{DWB\ in\ a\ weedy\ check - DWB\ in\ a\ particular\ treatment}{DWB\ in\ a\ weedy\ check} \text{X } 100$$

Where; WCE= Weed control efficiency; DWB= Dry weed biomass.

Plant height was recorded at the time of physiological maturity of the plants from ten randomly selected plants in the four central rows by using meter tape. Number of cobs $plant^{-1}$ was recorded through counting the number of cobs from ten plants and then averaged. Dry weight of maize stalks were recorded after one week of sun dried from each plot and then converted into ton ha^{-1} to record data on aboveground crop biomass yield. Hundred seeds weight was measured for hundred seeds randomly taken from each plot and weighed by using sensitive balance. The grain yield was determined by harvesting four central rows in each plot and converted to ton ha^{-1}.

2.4. Data analysis

The collected data were subjected to analysis of variance (ANOVA) following the procedures described by [7] using statistical analysis software version 9.2 [8]. Mean comparisons for significant treatment means were done by using Least Significant Difference (LSD) test at 5% level of significance.

2.5. Partial budget analysis

Partial budget analysis was used for economic analysis of weed control methods. In partial budget analysis, only costs that vary due to proposed treatments were considered [9]. Partial budget analysis was done by using standard procedures described and developed by CIMMYT [9]. Labor, purchase of herbicide, herbicide application and spray rent were considered as total variable costs due to alternative treatments. In the study area, the wage rate per worker was 50 Ethiopian birr per day during 2017 cropping season. Maize grain yield was considered to calculate gross field benefit. Price of maize grain yield during cropping season was 14 Ethiopian birr per kilogram. The price of herbicide was 400 Ethiopian birr per liter during cropping season.

3. Results and discussion

3.1. Weed density

The analysis of variance (ANOVA) revealed that weed density was significantly (P<0.05) affected by weed control methods. All treatments were effectively reduced weed population per unit area as compared to weedy check. The lowest weed density (10 m^{-2}) was observed in plots treated by Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE (Table 1). Conversely, the highest weed density (98.25 weeds m^{-2}) was recorded in weedy check (control plot). The higher weed density in weedy check plots might be due to freely emergence and aggressive growth of weed seeds from the soil seed bank. Moreover, weed density in plots treated by Primagram Gold 660SC + twice hand hoeing was decreased by about 76.88% as compared with farmer practice. Therefore, integration of Primagram Gold 660SC with once or twice hand hoeing had considerable effects on weed density and reduced weed population to a significant level as compared to other treatments. This result is in harmony with [10] who reported that application of herbicide and hand weeding lowered the weed density in maize field. Hassan et al. [11] also observed reduced weed infestation through combined application of pre and post herbicides with other cultural practices.

3.2. Dry weed biomass

Weed control methods were significantly (P<0.05) affect dry weed biomass weight. Accordingly, the lowest dry weed biomass weight (0.13 kg m^{-2}) was recorded in Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE, which was statistically similar with Primagram Gold 660SC + once hand hoeing at 40 DACE (0.34 kg m^{-2}). In contrast, the highest (3.08 kg m^{-2}) dry weed biomass was recorded in weedy check (Table 1). Similar trend was found in case of weed dry biomass as observed in weed density. This might be due to Primagram Gold 660SC, the pre-emergent herbicide, inhibited the germination of weed seeds and the timely removal of the germinated weeds by hand hoeing at critical crop growth stages which subsequently resulted in less weed competition. In addition, the weeds in these plots were might be destroyed through the failure of weed seeds to germinate due to pre-emergent herbicide used which abort the weed seeds in the soil and hand hoeing to remove emerged/germinated weeds at the critical period. This indicates weeds were effectively controlled in plots treated with integration of Primagram Gold 660SC and hand hoeing at specified time. Integration of selective pre and post emergence herbicides with other cultural practices reduced weed biomass in maize field [11]. This result is also in line with Gul et al. [12] who reported that combined application of herbicide and hand weeding significantly lowered the weed biomass and density when applied at appropriate growth stages of the crop.

3.3. Weed control efficiency

Table 1 Weed parameters as affected by weed control methods during 2017 main cropping season under rainfed condition in Basketo Special district (Angila-4 and Sasa Kebeles), Southern Ethiopia

Treatment	Weed density(no m^{-2})	Dry weed biomass (kg m^{-2})	WCE (%)
Once hand hoeing @ 20 DACE	73.50^{b}	2.14^{b}	27.70^{d}
Twice hand hoeing @ 20 and 40 DACE	35.51^{d}	1.10^{c}	62.72^{b}
Primagram Gold 660SC + once hand hoeing @ 40 DACE	21.75^{e}	0.34^{d}	88.50^{a}
Primagram Gold 660SC + twice hand hoeing @ 40 and 60 DACE	10.00^{f}	0.13^{d}	95.75^{a}
Farmer Practice	43.25^{c}	1.52^{c}	48.31^{c}
Weedy check (Control)	98.25^{a}	3.08^{a}	0.00^{e}
LSD(0.05)	6.42	0.45	10.11
CV (%)	19.05	21.60	13.20

Means with the same letter in each column are not significantly different. DACE= Days after crop emergence; WCE= Weed control efficiency; LSD (0.05)= Least significance difference at 5% probability level; CV (%)= Coefficient of variation in percent.

Weed control efficiency (WCE) was significantly (P<0.05) influenced by weed control methods. All weed control treatments were caused the significant reduction in weed infestation as compared to the weedy check (Table 1). The minimum WCE (0.00%) was observed in weedy check/control whereas the maximum (95.75%) was in Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE, which was statistically non-significant with Primagram Gold 660SC +

once hand hoeing at 40 DACE (88.50%). This result revealed that weeds could be efficiently controlled through appropriate weed control methods at critical maize growth stages. Moreover, weed density and dry weed biomass were efficiently reduced when Primagram Gold 660SC integrated with once (at 40 DACE) and twice (at 40 and 60 DACE) hand hoeing. This result further indicates that pre-emergent herbicide such as Primagram Gold 660SC is more effective in reducing weed density and biomass when integrated with hand hoeing as compared to farmer practice and weedy check. This is in agreement with Amare et al. [13] and Tesfay et al. [14] who observed high weed control efficiency in plots received herbicide and hand weeding as compared to control treatment in maize.

3.4. Crop growth, yield and yield components

Weed control methods significantly ($P<0.05$) affected plant height (PHT), number of cobs per plant (NCPP), aboveground crop biomass yield (CBY), hundred seed weight (HSW) and grain yield (GY) of maize. The highest PHT (204.35 cm), NCPP (2.50), CBY (19.01 t ha^{-1}) and GY (3.54 t ha^{-1}) were recorded in Primagram Gold 660SC + twice hand hoeing @ 40 and 60 DACE, which were statistically not different with the Primagram Gold 660SC + once hand hoeing @ 40 DACE. On the contrary, the lowest CBY (7.94 t ha^{-1}) and GY (1.16 t ha^{-1}) were recorded from the weedy check. The use of Primagram Gold 660SC + twice hand hoeing alone increased the grain yield of maize by 20.34% and 67.23% over the farmer practice and weedy check, respectively.

The possible reason for the highest grain yield in the integrated use of Primagram Gold 660SC and hand hoeing might be due to less competition of weeds in well-managed maize field and better availability of resources (space, light, moisture and nutrients) to the maize plants, which encourages growth and yield components of the crop. In addition, integrated use of Primagram Gold 660SC and hand hoeing might provide a better growth environment for maize by reducing weed density and subsequently increased the grain yield. The lowest maize grain yield recorded in weedy check and once hand hoeing plots might be due to high weed infestations, which compete for limited resources and thereafter decrease the growth, yield and yield components of the crop. These results are consistent with Amare et al. [13] and Tesfay et al. [14] who reported that the number of cobs per plant, aboveground crop biomass and hundred seed weight of maize were improved under good weed management condition. The grain yield and yield-related traits of maize are improved through effective weed management practices applied at appropriate growth stages of the crop [2, 10-17].

Table 2 Effect of weed control methods on yield and yield components of maize during 2017 main cropping season under rainfed condition in Basketo Special district (Angila-4 and Sasa Kebeles), Southern Ethiopia

Treatments	PHT (cm)	NCPP	CBY (t ha^{-1})	HSW (g)	GY (t ha^{-1})
Once hand hoeing at 20 DACE	139.75^{c}	0.75^{d}	11.81^{c}	21.51^{e}	1.43^{d}
Twice hand hoeing at 20 and 40 DACE	163.51^{b}	1.50^{c}	16.67^{b}	29.75^{c}	2.39^{c}
Primagram Gold 660SC + once hand hoeing at 40 DACE	198.75^{a}	2.00^{ab}	18.26^{a}	32.00^{b}	3.30^{a}
Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE	204.35^{a}	2.50^{a}	19.01^{a}	35.75^{a}	3.54^{a}
Farmer Practice	196.00^{a}	1.75^{bc}	15.28^{b}	25.25^{d}	2.82^{b}
Weedy check	111.75^{d}	0.50^{d}	7.94^{d}	18.50^{f}	1.16^{d}
LSD (0.05)	12.07	0.42	1.594	1.71	0.34
CV (%)	14.74	18.68	17.13	11.17	9.40

Means followed by the same letter in the column are not significantly different. DACE= Days after crop emergence; PHT= Plant height; NCPP= Number of cobs per plant; CBY=Aboveground crop biomass yield; HSW= Hundred seed weight; GY= Grain yield; LSD (0.05) = Least significance difference at 5% probability level; CV(%)= Coefficient of variation in percent.

3.5. Partial budget analysis

The net benefit estimate for six treatments is presented in Table 3. Based on the partial budget analysis result, all weed control treatments gave higher net benefit as compared to weedy check/control (Table 3). Primagram Gold 660SC + twice hand hoeing had the highest net benefit of 41,804.00 ETB followed by the net benefit obtained from Primagram Gold 660SC + once hand hoeing (39,380.00 ETB). In contrast, the lowest net benefit (17,418.00 ETB) was obtained from

once hand hoeing @ 20 DACE as compared to other weed control treatments, but it was higher than that of weedy check (control)**.** The low net benefit obtained from hand hoeing once might be due to the low grain yield. The profitability analysis revealed that the use of Primagram Gold 660SC herbicide along with once and twice hand hoeing had higher net benefit with acceptable minimum rate of return.

Table 3 Partial budget analysis of different weed control methods for maize production during 2017 main cropping season under rainfed condition in Basketo Special district (Angila-4 and Sasa Kebeles), Southern Ethiopia

Treatment	Av.GY (kg/ha)	Ad.GY (kg/ha)	TVC (ETB/ha)	GFB (ETB/ha)	NB (ETB/ha)	MRR	MRR (%)
T1	1,160	1,044	0.00	14,616.00	14,616.00		
T2	1,430	1,287	600.00	18,018.00	17,418.00	4.67	467
T3	2,340	2,106	1,200.00	29,484.00	28,284.00	18.11	1811
T4	2,820	2,538	1,900.00	35,532.00	33,632.00	7.64	764
T5	3,300	2,970	2,200.00	41,580.00	39,380.00	19.16	1916
T6	3,540	3,186	2,800.00	44,604.00	41,804.00	4.04	404

Av.GY=Average grain yield; Ad.GY=Adjusted grain yield; TVC= Total Variable Costs; GFB= Gross Field Benefit; NB= Net Benefit; MRR= Marginal Rate of Return; T1= Weedy check; T2= once hand hoeing at 20 days after crop emergence (DACE); T3= Twice hand hoeing at 20 and 40 DACE; T4= Farmer practice; T5= Primagram Gold 660SC + once hand hoeing at 40 DACE; T6=Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE

4. Conclusion

Maize is a dominant crop grown mainly by smallholder farmers in Basketo Special district, Southern Ethiopia. Effective weed control is one of the most important practices to increase maize productivity. Weed control methods had a significant effect on the entire weed and crop parameters considered in this study. Generally, the two treatments (Primagram Gold 660SC + once hand hoeing at 40 DACE and Primagram Gold 660SC + twice hand hoeing at 40 and 60 DACE) had better weed control efficiency, improved yield and yield components of maize in addition to maximize net income. These two treatments also drastically reduced weed density m^{-2} and dry weed biomass. These results revealed that weed control through the integrated use of Primagram Gold 660SC with hand hoeing increased grain yield of maize and maximize the net benefit by efficiently controlling weeds. Thus, integration of Primagram Gold 660SC with once (at 40 DACE) and twice (at 40 and 60 DACE) hand hoeing was more effective not only in reducing weed population per unit area but also in increasing grain yield of maize. Therefore, the use of one of these treatments is advisable and could be appropriate for weed infestation reduction, better yield and more profitable (higher net benefit) to growers from maize production in the study area. Further research should be conducted more than two cropping seasons and across different districts to determine weed flora and its dynamics in maize field at the study area.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

References

[1] CSA (Central Statistical Agency of the Ethiopia). Report on Area and Production of Major Crops (Private Peasant Holdings, 'Meher' Season). Agricultural Sample Survey. Volume I, Statistical Bulletin 584. Addis Ababa, Ethiopia. 2017.

[2] Ali R, Khalil SK, Raza SM, Khan H. Effect of Herbicides and Row Spacing on Maize (*Zea mays* L.). Pakistan Journal of Weed Science Research. 2003; 9: 171-178.

[3] Grief S. Weed Control for Sustainable Crop Production in Ethiopia. Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia. 2015. 108p.

[4] BSpDOANRM (Basketo Special District Office of Agricultural and Natural Resource Management). General Overview of the Basketo Special district. Annual report. Laska, Ethiopia. 2017.

[5] EARO (Ethiopian Agricultural Research Organization). Directory of Released Crop Varieties and their RecommendedCultural Practices. Addis Ababa, Ethiopia. 2004.

[6] Das TK. Weed Science. Basics and Application. NewDelhi. Jain brothers. 2008. 901p.

[7] Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd Ed. John Willey and Sons, Inc. New York. 1984. 641p.

[8] SAS Institute Inc. SAS/Stat Guide for Personal Computers, Version 9.2 SAS Institute Inc., Cary, North Carolina. USA. 2009.

[9] CIMMYT (International Maize and Wheat Improvement Center). Farm Agronomic Data to FarmerRecommendations: An Economics Training Manual.Completely Revised Edition. DF: CIMMYT, Mexico D.F. 1988. 124p.

[10] Ali K, Munsif F, Husain Z, Khan I, Ahmad N, Khan N, Shahid M. Effect of Different Weed Control Methods on Weeds and Maize Grain Yield. Pakistan Journal of Weed Science Research. 2011. 17(4): 313-321. https://doi.org/10.28941/pjwsr.v17i4.

[11] Hassan G, Tanveerl S, Khanand NU, Munir M. Integrating cultivars with reduced herbicide rates for weed management in maize. Pak J Bot. 2010. 42: 1923-1929.

[12] Gul B, Marwat KB, Saeed M, Hussain Z. Impact of Tillage, Plant population and Mulches on Weed Management and Grain Yield of Maize. Pak. J. Bot. 2011. 43(3): 1603-1606.

[13] Amare T, Mohammed A, Negeri M, Sileshi F. Effect of Weed Control Methods on Weed Density and Maize (*Zea mays* L.) Yield in West Shewa, Oromia, Ethiopia. African Journal of Plant Science. 2015. 9(1): 8-12.

[14] Tesfay A, Amin M, Mulugeta N. Management of Weeds in Maize (*Zea mays* L.) through Various Pre and Post Emergency Herbicides. Advances in Crop Science and Technology. 2014. 2: 151. https://doi.org/10.4172/2329-8863.1000151.

[15] Mojibade OP, Stephen OK. Effect of Integrated Weed Management on Weed Control and Yield Components of Maize and Cassava Intercrop in Southern Guinea Savanna Ecology of Nigeria. Australian Journal of Crop Science. 2009. 3(3): 129-136.

[16] Imoloame EO. Evaluation of Herbicide Mixtures and Manual Weed Control Method in Maize (*Zea mays* L.) Production in the Southern Guinea Agro-Ecology of Nigeria. Cogent Food and Agriculture. 2017. 3(1): 1375378. https://doi.org/10.1080/23311932.2017.1375378.

[17] Khan IA, Rehman OU, Khan SA, Alsamadany H, Alzahrani Y. Effect of Different Herbicides, Plant Extracts and Mulches on Yield and Yield Components of Maize. PlantaDaninha. 2020. 38. https://doi.org/10.1590/S0100-83582020380100028