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Economic analysis of different weed control methods used by smallholder maize farmers in Swaziland

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ABSTRACT

Weeds control is one of the expensive agronomical practices in maize production and has a direct effect on ultimate returns to especially the rural-poor small-scale farmers. Moreover, high weed infestation increases the cost of cultivation, lowers value of land, and reduces the returns to maize producers. This study was carried out to determine the most economic weeding technology used by maize farmers in Swaziland and determine the factors influencing farmers choice in choosing weed control methods. The study used primary data collected through personal interview from 240 randomly selected maize farmers in all the four agro-ecological zones of Swaziland. Descriptive statistics and a Multinomial logistic regression model was used to analyze the data. Gross margins and independent sample t-test were used to ascertain the most economic weed control method. About 65% of farmers interviewed were using only hand hoe (manual) method of weeding, 19% were mainly using herbicides and only 16% were using integrated approached (Herbicides + hand hoe) to weed their fields. With manual weed control method used as the base, factors influencing the choice of herbicides methods were; maize yields/ha, level of education, off-farm income, farmers' sex, intercropping as farming system and group membership. The choice of integrated weed control method was influenced by; grain yield per hectare, off-farm income, total variable cost/ha and group membership. The gross margins indicated that herbicides method had higher net benefits than the other methods. Thus, the study recommended that farmers choose herbicides weed control method to increase their economic benefits. Farmers should form strong association that would represent their interest and support their financial base. Moreover, the government should strengthen other economic activities in rural areas so to catalyze job creation and income generation. This will help farmers to have money for purchasing improved farming inputs.

Key words: Economic analysis, integrated control, herbicides, maize, multinomial logistic, weed control, Swaziland

RÉSUMÉ

Le contrôle des adventices est l'une des pratiques agronomiques coûteuses dans la production de maïs et a un effet direct sur les retombées finales, en particulier pour les pauvres ruraux petits producteurs. De plus, l'infestation élevée d'adventice augmente le coût de la production, diminue la valeur de la terre et réduit les rendements des producteurs de maïs. Cette étude a été effectuée pour déterminer la technologie de désherbage la plus économique utilisée par les producteurs de maïs au Swaziland et les facteurs qui influent sur le choix des méthodes de lutte contre les adventices par les producteurs. L'étude a utilisé des données primaires recueillies au moyen d'entretiens individuels auprès de 240 producteurs de maïs sélectionnés au hasard dans les quatre zones agro-écologiques du Swaziland. Des statistiques descriptives et un modèle de régression logistique multinomiale ont été utilisés pour analyser les données. Les marges brutes et le t-test d'échantillons indépendant ont été utilisés pour déterminer la méthode de lutte contre les adventices la plus économique. Environ 65% des producteurs interrogés n'utilisent que des méthodes de désherbage à houe à main (manuelle), 19% utilisent principalement des herbicides et seulement 16% utilisent une approche

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intégrée (Herbicides + houe à main) pour désherber leurs champs. Avec pour base la méthode manuelle de contrôle des adventices, les facteurs influençant le choix des méthodes d'herbicides sont le rendement en maïs/ha, le niveau de scolarité, le revenu non agricole, le sexe des producteurs, la culture associée en tant que système de culture et l'appartenance à un groupe. Le choix de la méthode de lutte intégrée contre les adventices est influencé par le rendement en grain par hectare, le revenu non agricole, le coût variable total/ha et l'appartenance à un groupe. Les marges brutes ont indiqué que la méthode des herbicides avait des bénéfices nets plus élevés que les autres méthodes. Ainsi, l'étude a recommandé aux producteurs de choisir la méthode de lutte contre les adventices par recours aux herbicides pour augmenter leurs bénéfiques économiques. Les producteurs devraient former une forte association qui représenterait leur intérêt et appuieront leur base financière. En outre, le gouvernement devrait renforcer d'autres activités économiques dans les zones rurales afin de catalyser la création d'emplois et de revenus. Ceci aiderait les producteurs à disposer d'argent pour acheter des intrants agricoles améliorés.

Mots clés: analyse économique, lutte intégrée, herbicides, maïs, logistique multinomiale, lutte contre les adventices, Swaziland

INTRODUCTION

Weeds are a serious constraint to crop production. Weeds grow in a field as unwanted plants and compete with the main crop in the absorption of light, water and nutrients (Nojavan, 2001). Controlling weeds is one of the expensive actions in maize production and has a direct effect on ultimate returns (Vissoh *et al.,* 2004). Moreover, high weed infestation increases the costs of cultivation, lowers value of land, and reduces grain value. Therefore, weed management remains as one of the most serious and widespread production problems facing smallholder farmers. Weeds directly affect crops and thus reduce crop yield. According to Gianessi and Williams (2011), uncontrolled weeds can cause maize losses of about 55-90% in Africa. In Swaziland, according to IRD (2013), the weed control technologies employed by smallholder maize farmers remain grossly inadequate in bringing weeds under control with estimated losses in maize yield of up to 70% based on field assessments. Maize farmers largely use traditional, outdated low productive technologies. These technologies include hoe weeding, slashing, burning and pulling weeds by hands and are labour intensive, associated with high costs and delayed timely weeding (Gianess and William, 2011). The delay in weed control and inefficiency of hoe-weeding method under wet conditions may lead to farmers abandoning part of their planted crops because they would have failed to deal with heavy weed infestation, and this may increase significantly the losses incurred by farmers.

Since the mid-1980s researchers have been promoting adoption of most productive weed control methods in Swaziland, but with limited impact (Ossom, 2003; IRD, 2013). Chemical weed control method and integrated weed control method are among those methods promoted although their usage is relatively low among the smallholder farmers. Nevertheless, researchers have associated these methods with increased economic returns. The use of herbicides was found to be crucial in reducing high cost of labour and helpful in addressing the decline in availability of labour in production (Tijani *et al.,* 2015). Adeosun and Lagoke (2005) postulated that appropriate application of herbicide could avert weed infestation from point of planting to harvesting and stimulate higher yields by allowing closer drop spacing and thus, increasing plant population. In a study in Nigeria by Mutambara (2013) integrated weed control yielded returns of 119 664.38 naira/ha whilst manual method yielded only 4211.63 naira/ha. Mouni (2012) in an experiment integrating manual and atrazine achieved higher economic benefits than when using manual method in maize production. This method moreover helped in reduction of the usage of herbicides and the negative influence on the ecosystem. The reduced herbicide dosages is especially beneficial to cash-strapped smallholder farmers. An understanding of the factors influencing farmer's decision in choosing weed

control method is essential in promoting these improved weeding technologies.

Existing literature have highlighted different factors that influence farmer's decision in choosing weed control method in other countries. According to Iheanacho *et al.* (2009) the intensity of weeding and weed control method adoption depend, among other factors, on the cost and returns implication of that particular method as well as the economic status of the farmer. Akudugu *et al.* (2012) grouped the factors into three categories namely; economic, social and institutional factors. Wilson *et al.* (2008) assumed that farmer's decisions will be based mainly on the quality of the information that is presented and that individuals can effectively use this information in their decision process. This study therefore focused on determining the factors influencing farmer's decision in choosing improve weed control methods and determined the most economic weeding technology used by maize farmers in Swaziland.

MATERIAL AND METHODS

The study was carried out countrywide. According to Ossom and Ryhkerd (2007) and Kierzek *et al.* (2012) the difference in weather and soil type affects the weed flora and influences farmer's practices. Thus, all the four Agro-ecological Zones of Swaziland, namely, Highveld, Middleveld, Lowveld and the Lubombo Plateau were considered. The targeted respondents were farmers who mainly sell their maize to the National Maize Corporation (NMC). The study used a cross sectional approach, using farmers production information of the 2014/15 cropping season. A sample of 240 farmers were selected from 543 farmers, 89 famers from the Highveld, 84 from the Middleveld, 31 from the Lowveld and 36 from the Lubombo Plateau. In selecting the sample farmers were stratified according to the four Agro-ecological Zones. Simple random sampling technique was then used to select the respondents in each strata/zone. Sampling sizes were proportionate to the different strata. Structured questionnaires were then administered to collect primary data about farmer's socio-economic characteristic and their production information. Multinomial logistic regression model was used to determining the factors influencing the choice of weed control method used by farmers. Gross margin analysis was used in estimating farmer's net benefits accrued to the different weed control methods in the maize enterprises. The Independent sample t-test was used to compare GM of the different weed control methods.

Empirical gross margins analysis. Gross margins focuses on the quantitative evaluation of the impact brought by the different weed control method on maize yields. This involve identifying and quantifying the Total Variable Costs (TVC) incurred by the farmers, and the Total Revenues (TR) realized in the production of maize using the three different weed control method. The TR is estimated using the prevailing market price of maize output (Py) multiplied by quantity of maize output sold (Qys) (Py * Qys). Total variable costs (TVC) is a summation of all input variable costs incurred by farmers in their maize enterprises, and the input variable cost is estimated as the prevailing market price of a given input (Pxi) multiplied by quantity of the input used (Qxi) (Pxi * Qxi). To get the gross margins the TVC was subtracted from the TR. Thus, Gross margin (GM) for each enterprise was calculated as:

$$GM = (P_y * Q_{ys}) - \sum_{i=1}^{n} (P_{xi} * Q_{xi})$$

Empirical multinomial logistic model. The multinomial logistic model is a regression model that is able to generalize regression analysis to problems with more than two discrete outcomes. In literature this model is known of a restrictive assumption that it is subjected to the assumption of independence of irrelevant alternatives (Wu and Babcock, 1998). This implies that the relative choice probability of any independent variable is independent of any of the outcome variables. On the bases of the study, the data indicated that there are three discrete method of weed control used by maize farmers in the country: namely herbicides method, manual/hoe method and integrated method. A successions of structured interviews with farmers suggested that farmers who uses integrated method are not farmer who have had failures in one method, but rather had chosen the method deliberately due to its yield benefits. This multiple outcomes motivated the use of the

multinomial logistic regression model.

With the dependent variables having three different categories, manual weed control method was used as the base category (k) and the probabilities of the farmers choosing the other method was referred to the base category. Here the predicted probabilities for y = 1, 2, and 3 are independent of the choice. The relative probability of y = 1 to the base category is:

$$\text{In}\left(\frac{P(y=1)}{p(y_i = k)}\right)$$

$$\text{In}\left(\frac{P(y=1)}{p(y_i = k)}\right) = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+\beta_{11}X_{11}+\beta_{12}X_{12}+\beta_{13}X_{13}+\beta_{14}X_{14}+\beta_{15}X_{15}+\beta_{16}X_{16}+\beta_{17}X_{17}+\varepsilon$$

Description of variables

$$Y = \text{In}\left(\frac{P(y=1)}{p(y_i = k)}\right)$$

Where Y = the choice of weed control method
X = independent variables
β = logistic coefficients
Ɛ = error term

The independent variables in the multinomial logistic model are specified as follows: X1= Age of respondents, X2= sex of respondents, X3= Household size, X4= Farming income, X5= Marital status, X6= Market proximity (transport cost), X7= Farm size, X8 = Off-farming income, X9 = yield per hector, X10= Experience in farming, X11= Major employment, X12= total input cost, X13= Farming system, X14 = Level of education, X15 =Decision maker on weeding, X16 = access to credit and X17= Group membership.

Descriptive of the Socio-economic characteristics of the respondents. The majority of sampled farmers in this study were female (about 58%), and 42% being male farmers (Table 1). These results were in line with most findings where women dominate most agricultural activities in African countries (FAO, 2011). This may be attributed to the fact that women in most rural households have become the breadwinners and growing number of single mother looking for ways to improve living situations at home. It is also thought that the majority of males migrate to the urban areas in search for more stable income generating job, other than relying on relatively what is termed as a risky farming business.

Furthermore, the results of the study indicated that the average age of the farmers was about 54 year, (Table 1). This imply that on average the farmers are above the youthful age of 35 years. 11.6% of the farmers were youth farmers with the age bracket ranging from 22-35 years. 31.2% were 36-50 years old, and 57.2% were above 50 years old. Age is said to be a primary dormant characteristic in adoption decisions, and there is argument on the effect of age. The ability of a farmer to bear risk, and be innovative has been found to decrease with age (Banabana-Wabbi, 2002).

Marital status results indicate that 14% were single, and 68% were married farmers. Most families in rural areas get into farming in order to support the household dependents for survival. Marriage in African context is regarded to be more responsible and important in decision making, especially when planning and implementation of ideas as compared to a farmer living a single life who may solely depend on his/her own ideas during decision making (Kyalo, 2012). Household size is the total number of individuals that live within and feed from the household. Mwangi and Kiriuki (2015) defined household size as a measure of household labor availability. The average household size of farmers in the study was 7 people, this almost match with the average household size mentioned by the Swaziland labour market profile dated 2012 which reported an average of 6 people per household. The maximum farmer's household size was 18 people per household with a minimum of 1 person per household.

In some literature, farming experience and education are key factors in enhancing human capital (Kibirige, 2013). The experience in farming measures the years a farmer has spent in maize farming. The majority of the farmers (43 %) had a farming experience of 21 to 40 years (Table 1). With 40% farmers had a farming experience

of less than 20 years. About 17% had farming experience of 41 to 60 years. The average farming experience of the farmers in the studied areas was 25 years. The more the farming experience the more the farmer is able to reduce risks involved in the enterprises since he/she has more knowledge about the business. On the level of education, % of the respondent had never attended school, 28% of the total respondent indicated that they attained primary school education, while the majority of the (45 %) reported to have attended high school. About 9.6% of the total respondent reported to have attained tertiary education. Based on the study finding, this study reflects that a majority of the respondents had attained high school education. This level is regarded as the basic education important for entrepreneurship management skills. Both basic and higher education are reported to be vital element because of its ability to guide someone's innovativeness and self-confidence (Kumar, 2010).

The minimum farm size was 0.5 ha with the maximum size being 8 ha (Table 1). On average, each farmer had 2.4 hectors of land used for maize production. On average farmers receive E1984.28 from other source of income rather than farming. The maximum income attained from these sources is E35000.00. Findings of the study indicated that about 14.6% of the total respondent have access to credit that help them to finance their farming activities. About 85.5% of the respondents reported that they do not have access to credits that can enhance them in their farming activities. Access to credit is assumed to increase the buying power of farmers and increase risk taking abilities through relaxation of the liquidity constraint (Simtowe and Zeller, 2006).

RESULTS AND DISCUSSIONS

Determining the factors influencing the choice of weed control method among the smallholder farmers. Estimates of the multinomial logistic model are presented in Table 2. Marginal effects from the multinomial logistic model were used in this section. The base chosen was Manual/hoe weed control method. The results from the model for each alternative are as follows:

The results from the model indicate that yield per hectare (Tonnes per HA) had a positive and significant ($p< 0.05$) influence on farmers' choices of herbicides over manual method. This implies that a 1% increase in farmers yield per hectare increases the probability of farmers to choose herbicides over manual/hoe weeding method by 7%. This can be attributed to that farmers are interested in agricultural practices that increase their yields from their farming. Moreover, with higher yields are translated into increased sales, availing some money to purchase farm inputs including the herbicides. The study indicated that sex of respondents significantly ($p<0.05$) influence farmers' choice on herbicides over hoe weeding method. Same results were identified by Tijani *et al.* (2015) on factors affecting the adoption of herbicides. The results show that an increase in male farmers by one farmer the probability of farmers to choose herbicides decreases by 14.9%. This reflects that female farmers are more likely to adopt herbicides over hoe weeding more than male farmers. This is probably because, it is mostly women who are responsible for weeding in the farms, with a burden of other home errands, therefore, there is a high probability of preferring herbicides to hoe weeding to save their time for other home tasks.

Off-farm income positively and significantly ($p <0.01$) influence farmers to choice herbicides than manual weed control method. This indicates that E1 increase on farmers' off-farm income increases the chance of farmers to choose herbicides by 0.04% compared to using manual method. This can be attributed to that, off-farm income can act as an approach to overcome credit constraints and provide farmers with liquid cash. Group membership also had a negative and significant influence at ($p<0.05$) on the probability of farmers choosing herbicides. The results reflected that the probability of a group member farmer to choice herbicides is less than a non-member by 17%.

Level of education of the respondent also had a significant at ($p <0.05$) influence on the choice of herbicides that manual method. This highlighted that a one year increases in the level of education acquired by the farmers, the probability of farmers choosing herbicides increase by 8.3% compared

to using manual/hoe method. This increase can be attributed to that educated farmers will not have difficulties in reading information about herbicides and education is believed to create a favorable mental attitude for the acceptance of new farming practices, thus creating a conducive environment for adoption of improved practices. The same findings were discovered by Mutambara (2013) and Ajewole (2010) that there is a positive correlation between education and adoption of modern weed control methods.

Farming system had a negatively significant influence on farmers' choice on herbicides over hoe weeding at 5% level. This indicated that the probability of farmer to choose herbicides decreases by 11% compared to using manual method with a shift from mono-cropping to Intercropping farming system. This could be because some farmers intercrop maize with other crops that share the same characteristics as the weeds (broad-leaf crops), therefore applying herbicide on that field can destroy those intercropped plants.

Concerning the choice of Integrated weed control method, the variables maize yield per hectare, total costs/ha and off-farm income indicated a positive and significant influence at 5%, and 1%, respectively. Considering the positive influence, the probability of a farmer choosing integrated weed control method increases by 4.3% with one unit increase in maize yield/ha. This can be attributed to the ability of integrated weed control method to result in high maize yield at lower cost, and the method also delays weed resistance in the fields due to the low application of herbicides. Studying factors influencing adoption of weeding technologies, Aminu, Babalola and aduba (2014) found that most of the farmers were interested on observing some forms of improvements in their farming activities; such as yield increments when choosing weed control technology.

Table 1. Socio-economic characteristic of the farmers

Variable	Category	Frequency	percentage	mean
Age	<22	0	0	
	22-35	28	11.6	
	36-50	77	32.1	53.5
	51-60	48	20	
	61-90	87	36.3	
Household size	1-18	240	100	7
Farming experience	1-20	97	40.4	
	21-40	103	42.9	25
	41-60	40	16.7	
Farm size	0.5-8	240	100	2.4
Off-farm income	00-35000	240	100	1984.28
Sex	Female	139	57.9	
	Male	101	42.1	
Marital status	Single	34	14.2	
	Married	164	68.3	
	Divorced	4	1.7	
	Widowed	38	15.8	
Level of education	Never attended school	42	17.5	
	Primary/Sebenta	68	28.3	
	High school	107	44.6	
	Tertiary	23	9.6	
Access to credit	Yes	35	14.6	
	No	205	85.4	

Source: own survey data 2016

Table 2 .Marginal effects from multinomial logistic regression estimates for the choice of weed control method

	Marginal effects (dy/dx)	Std. error	P-value
Herbicides			
Sex*	-0.149**	0.064	0.020
Age	-0.001	0.003	0.725
Marital status	-0.070	0.045	0.121
HH size	0.012	0.099	0.213
Lev. Education	0.083**	0.036	0.020
Source of employment	-0.002	0.031	0.951
Experience in farming	0.004	0.004	0.284
Farming system	-0.108*	0.056	0.053
Harvested area	-0.004	0.027	0.893
Decision making	0.042	0.051	0.409
Transport cost	0.001	0.0001	0.325
Farming income	-3.99	0.000	0.959
Off farm income	0.0004***	0.000	0.001
Access to credit	0.041	0.082	0.619
Group membership	-0.173**	0.069	0.012
T_V_C per HA	0.0002	0.0003	0.274
Tonnes per HA	0.071**	0.029	0.015
Integrated			
Sex*	-0.023	0.056	0.676
Age	0.002	0.003	0.539
Marital status	0.019	0.033	0.564
HH size	0.004	0.007	0.554
Lev. Education	0.021	0.028	0.454
Source of employ	0.003	0.024	0.891
Experience in farming	-0.007	0.003	0.828
Farming system	0.023	0.039	0.563
Harvested area	-0.025	0.022	0.246
Decision making	0.002	0.045	0.967
Transport cost	-0.000	0.002	0.613
Farming income	3.34	0.0001	0.513
Off farm income	0.0002**	0.0001	0.023
Access to credit	0.027	0.062	0.663
Group membership	-0.314***	0.057	0.000
T_V_C per HA	0.0004**	0.0002	0.047
Tonnes per HA	0.043**	0.022	0.049

Source: Results from STATA (Version 10) generated from field survey, 2016. Where *** = values statistically significant at 1% probability level, ** = values statistically significant at 5% probability level, * = values statistically significant at 10% probability level, Base reference category: Manual/hoe weed control method

Off-farm income has been identified to have a positive influence on farmers' decision on adoption of technology (Udensi, 2012). This study also finds that a one unit (E) increase in off farm income increases the probability of farmer decision to choose integrated weed control method by 0.02% compared to choosing manual method. This can be credited to that, off-farm income can acts as an important strategy for overcoming financial problems and be able to purchase required farming inputs (Beltran *et al.,* 2011).

Farmers that do not belong to certain groups or association reflected a negative interest in using

the integrated weeding method than hand hoe weeding. The probability of farmers that belong to groups to choose integrated weed management than hoe weeding method is higher than farmers who do not belong to any farmer group. Uaiene *et al.* (2009) suggests that group membership effects are important for individual decisions, thus those farmers who are not part of farmer group may lack some knowledge about the advantages of rooted on integrated method. A one unit (E) increase in total cost increases the probability of a farmer to choose integrated method by 0.04 %. This can be attributed to that farmers focus on minimizing cost of production thus, they opt for integrated weed control method which is associated with reduced cost of production while maximizing outcome. This finding support Iheanacho *et al.* (2009) findings that farming cost influence farmers' decision on choosing weed control method.

Cost benefit analysis of smallholder farmers' maize enterprises associated with the different weed control technologies. Table 3 shows the cost benefit analysis of the three weed control methods used by the farmers in the study areas. This analysis was based on the data obtained from farmers' enterprises. Prevailing local maize market price per tonne (E2900, 00) was used in ascertaining farmers' revenue based on tonnes per hectare produced under the different weed control methods. Herbicide control method has recorded the highest yield per hectare, and the highest net benefit among the three methods used by farmers. It recorded the net benefit of E 5075.00/ha, followed by the integrated method scoring a net benefit of E 3320.56/ha, the manual method recording the lowest net benefit of E 1361.39/ ha. Considering the Cost-Benefit Ratio (CBR), herbicide control method had a higher ratio (1: 2.3), and the least ratio being manual/hand hoe weeding method recording a CBR of (1:0.80). Similar results in Swaziland were found by Ossom, (2003), whereby he identified that that is added advantages on the use of herbicides in maize production.

Table 3. Cost and benefits comparison of different weed control methods used by maize farmers in 2014/2015cropping season

Weeding method	TVC (T)/ha $^{-1}$	Grain yield (E)/ha $^{-1}$	Revenue (E)/ha^{-1}	Net benefit (E)/ha^{-1}	Cost/benefit ratio
Manual/hoe method	1706.36	1.06	3067.77	1361.39	1:0.80
Herbicides	1797.99	2.37	6873.00	5075.00	1:2.82
Integrated method	2669.04	2.07	5989.62	3320.56	1:1.24

Source: computed using own survey data 2016

Table 4 . Gross margins comparison for the three different weed control methods

Weeding Method	N	Mean	Std. Deviation	Std.Error Mean	Mean difference	Sig (2-tailed)
Herbicides						
Integrated	45	5075.01	5010.92	746.98	1754.47	0.142
	39	3320.57	5944.08	951.82		
Herbicides	45	5075.01	5010.92	746.98	3713.61	0.000
Manual/hoe	156	1361.40	2987.06	239.16		
Manual/hoe	156	1361.40	2987.06	239.16	-1959.18	0.004
Integrated	39	3320.57	5944.08	951.82		

Source: computed own survey data 2016

Gross margins comparison for the three different weed control methods used by smallholder farmers When comparing the gross margins of the different methods, the independent samples t-test reflected that on average herbicides had higher net benefits than integrated method (Table 4). They had a mean difference of about E 1754.47, although this mean difference was not significant. The results further revealed that herbicides recorded a higher gross margin compared to manual weed control method. Herbicides recorded a mean difference of E 3713.61 and this difference was significant at 1% level. Kolo (2004) characterized this method as the method that make weeding effective and efficient resulting in higher yields and releasing farmers for other important tasks.

Moreover, the results showed that integrated weed control method yields better returns when compared with manual weed control method. These results indicated a mean difference of E 1959.18, which was significant at 5% level. This results support Hashemi *et al.* (2012) findings, in their study they found that Integration of herbicides and two- hoe weeding yielded a higher grain yield in the experiment and thus, a greater benefit/cost ratio.

CONCLUSION AND RECOMMENDATIONS

The results of the study indicated that female farmers have a higher probability of choosing herbicides method than male farmers. Intercropping as a farming system and group membership reduces the probability of farmers to choose herbicides over manual weed control method. Farmers harvesting higher yields are more likely to choose herbicides other than manual weeding method. Farmers' off-farm income also increases the probability of farmers to choose herbicides method over manual method. On Integrated versus manual method, maize yield per hector, off-farm income and total variable cost/ha had a positive influence on farmers decision to choose integrated weed control method over manual method, whilst group membership showed a negative and significant influence on farmer decision in choosing integrated method over manual weeding method. The study indicated that economies of scale exist in the use of herbicide as a weed control method. Herbicides weed control method recorded the highest net benefit on the farmers maize enterprises, although there was no significant difference between it and integrated method. Manual/hoe method recorded the lowest net benefits. These results therefore reflect that herbicides method is more effective and efficient in weed control.

The study has recognized that herbicides and integrated method generates higher returns over manual/hoe method respectively. Therefore, farmers should adopt these methods and stakeholders in the maize industry should advocate for the adoption of these methods by farmers. The study revealed that farmers lack access to credit, therefore farmers should form strong maize producer association that would represent their interest and should participate actively in the association so as to pool their resource together in order to improve their financial base to enable them meeting their production needs. Moreover, there is a need to improve policies that will increase farmers' access to farming credits. Government can help in this issue by enacting land policies. This can help farmers to use their land as security when they apply for farm loans. Sensitization of workshops and On-farm demonstration on the usage of the improved weed control technologies should be organized to educate maize farmers on the advantages of adopting these weeding technologies in order to help farmers surpass the challenges of weeds. The study also proved that off-farm income influences the adoption of the improved weeding technologies. Therefore, government should strengthen other economic activities in rural areas to catalyze job creation and income generation through economic sectors. This will help farmers to have money to purchase improved farming inputs.

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STATEMENT OF NO CONFLICT OF INTEREST

We the authors of this paper hereby declare that there are no competing interests in this publication.

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