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Effect of Various Weed Management Options on Weeds and Yield of Barley (Hordeum vulgare L.) at Shambo and Gedo, Western Oromia

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Abstract
A field experiments on weed control in barley were conducted during the main season of 2015/2016. Different weed management practices were evaluated with the hand weeding and weedy check, for weed competition and grain yield of barley. The trial was laid out in randomized complete block design with three replications. Results of the experiment revealed that Significantly lowest total weed density *(13.3m^{-2}) and (29.7 m^{-2})* and maximum grain yield of (*4312.5 and 4382.6 kg ha^{-1}) with (50.7 and 54.4 %) harvest index was recorded in* two times hand weeded plot at Shambo and Gedo sites, respectively. Additionally, the lowest total weed dry weight of *weight (20.3) and (17.8g m^{-2})* with highest control efficiency (*81.7 and 72.4 %*) was recorded for two times hand weeded plots followed by *Dical 720 gm/lt SL + Fenoxaprop-P-Ethyl 69 gm/lt* at these respective locations. In contrary, the highest weed density *(49.5m^{-2}) and (102.0 m^{-2})*, and lowest grain yield *(2525.7 kg ha^{-1}) and (2776.9 kg ha^{-1})* was obtained from weedy check at Shambo and Gedo, respectively. Economic analysis of the test depicted that the maximum rate of return (*36.4162 and 35.91566)* was also calculated for Dical followed by *Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL* (*4.080275 and 6.5375)* at Shambo and Gedo, respectively. It *can be concluded that integration of Fenoxaprop-P-Ethyl 69 gm/lt with Dical 720 gm/lt SL or one times hand weeding was quite effective to control major broad and grass weed species observed in barley fields.*

Key terms: - Integrated practices, Barley, weed reduction, Grain yield.

1. INTRODUCTION

Ethiopia is the second largest barley (*Hordeum vulgare* L.) producer in Africa, next to Morocco, accounting for about 25 percent of the total barley production in the continent (FAO, 2014). It is grown mainly in the highlands of the country and represents approximately an 11% share of the total area where grain is cropped (CACC, 2003). It is predominantly grown at altitudes ranging from 2000 to 3000 m.a.s.l in various regions of the country. It is also preferred by subsistence farmers because of its ability to grow on marginal farms, unlike other cereals.

Barley has a wide range of uses. Its grain is used as a staple food, for malting and for making local drinks, and is sold for cash. The grain is rich of Zinc, iron and soluble fibers and higher content of vitamin A and E than other cereals. Its straw and stem stubs are used for animal feed and thatching. The annual average national yield of the crop is only 1200 kg/ha (CSA, 2005). The low national average yield, which is far below the world average, could be partially attributed to poor weed management, which results in high competition from weeds. Yield gains from weed control, on the other hand, ranges from 14-60 percent depending on the location and type of weed (Negewo *et al*., 2011; Negewo *et al*., 2006). Weeds are an important constraint in agricultural production systems, acting at same tropic level as the crop; weeds capture a part of the available resources that are essential for plant growth (Oerke, 2006; Ryan *et al*., 2009; Smith *et al*., 2010). Weeds compete with crop plants for various resources such as water and nutrients, resulting in low yields (Jarwar *et al.,* 2005). By competing for light, water, space and nutrients, weeds can reduce crop yield and quality and can lead to billions of dollars in global crop losses annually (Das, 2008; Srinivasrao *et al*., 2014).

Weed control play an active role in raising grain yield, since weeds cause great losses in yield reached 48.9 % (Metwally *et al*., 2000) in barley. Effective weed management is critical to maintaining agricultural productivity (Ahmed *et al*., 2010; Verma, 2014). Weeds can be controlled through different management practices in barley fields. These include cultural, physical, chemical and integrated methods. Hand weeding is the most practiced weed control option in barley. Manual weed control is labour intensive and therefore limits the production area (Verma et al., 2008; Dubey, 2014). Chemical control is the most common, efficient and economical method of control (Dalley *et al.,* 2006; Marwat *et al.,* 2008). In many barley producing areas, barley fields are mostly treated with broadleaf herbicides. The herbicide 2, 4 dichlorophenoxy acetic acid (Dical) was the first to be introduced in rain-fed areas for the control of broadleaved weeds (Goetze 1976, Qasim 1982). Under partial weed management, it is common to observe barley fields infested with grass weeds, causing yield losses of up to 60% in some barley growing areas of Ethiopia (Alemu Hailye *et al.*, 1999).

El- Bawab and Kholousy (2003) reported that controlling weeds by herbicidal treatments increased grain yield by about 40.3 and 13.6%, compared with unweeded and hand weeding treatments, respectively. Several herbicides are available to control barley weeds. Metosulam and sulfamoylurea herbicides were introduced as new selective herbicides for controlling broadleaved weeds in cereals (El-Metwally, 2002). Fenoxaprop-p-ethyl and clodinafop-propargyl are two selective herbicides for control of grasses weeds in wheat and barley (Nassar, 2008). El- Metwally and El-Rokiek (2007) also found that the two herbicides provided control of narrow leaf weeds (97.7% reduction in dry weight after 90 DFS). Several combinations of herbicides are there that can provide good control of broad and narrow leaved weeds and cause significant reduction in their density and increase yield attributes as compared to check (Chaudhry *et al.,* 2008; Bostrom & Fogelfors, 2002; Khan & Rashid, 1994). Integrated weed management relies on weed management principles that have proved to be suitable for long term weed management by combining the use of cultural, mechanical, thermal, biological and chemical means based on ecological approaches (Singh, 2014; Kewat, 2014).

Despite of suitable environmental condition of Western Oromia highlands and importance of barley as food, malting and cash crop of farmers, weed infestation has been a major constraint to barley production in these areas. Both broad and grass weeds compete with barley in this areas. A few investigations indicated that most broadleaf weeds are effectively controlled by hand weeding because, they are easier to identify and also using cheaply available 2, 4-D herbicides. However, no effective and applicable technology has yet been adopted to control grass weed species in barley in these areas. Hand weeding failed to control most grasses, especially wild oat, which resembles the crop and cause the greatest damage as they compete with the barley crop throughout the growing season. In addition to this, it is not applicable in large scale farms. Hence, the introduction of any revised weed management technology which is economically and agronomical feasible, such as combination of herbicides and/or with hand weeding should be investigated for western Oromia barley growing areas. Thus, the objective of this study was to identify and develop effective weed management option/s in Barley (*Hordeum vulgare* L.) at Western Oromia.

2. MATERIALS AND METHODS

2.1. Description of the Study Areas

The experiments were conducted at Shambo and Gedo on farmers' field for one year (2015/16) during the main cropping season. Gedo site is found in Western Showa zone about 60 km North West of Ambo, the capital town of the zone. It is located at 09º012' 84" N latitude, 37º 26' 23.9" E longitude and altitude of 2438 masl. The soil is clay loam in texture. Shambo site is found in Horo-Guduru Wolega zone about 4 km northwest of Shambo, the capital town of the zone. It is located on geographic coordinates of 09º037'23.0'' N latitude, 370 40' 33.2''E longitudes and altitude of 2609masl.

2.2. Treatments, Experimental Design and Crop Husbandry

The experiment contains of seven treatments arranged in Randomized Complete Block Design (RCBD) with three replication on the plot size of 4m x 5m. Treatments comprised of post-emergence application of Fenoxaprop-P-Ethyl 69 gm/lt, Dical, Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding at 40 DAS, Dical 720 gm/lt SL + One times hand weeding at 40 DAS, Two times hand weeding at 25 and 40 DAS, and weedy check. Improved Food barley variety ", HB-1307" with seed rate of 85 kg ha^{-1} was used in the experiment. The herbicides were applied at 30 days after sowing or (between 2-4 crop leaves stage) using Knapsack sprayer fitted with flat fan nozzle by mixing 200 liters of water per hectare. Dical 720 gm/lt SL and Fenoxaprop-P-Ethyl 69 gm/lt was applied at the rates of 1 L and 1.25 L ha^{-1}, respectively.

Table 1. Trade and Common Name of Herbicides and Rates

Trade Name	Common Name	Rates per hectare
Dical	Dical 720 gm/lt SL	1 L
Ralon Super EW 144	Fenoxaprop-P-Ethyl 69 gm/lt	1.25

2.3. Data collection and Analysis

All agronomic practices were applied as per recommendation and necessary data were collected from both weed and barley crop. Weed infestation was assessed and scored by number and species by throwing quadrate with 50cm x 50cm area three times per plot as per method described by Cruz *et al.* (1986). Percentage of weed inhibition (PWI) was calculated by the formula:

$$Percentage\ of\ weed\ inhibition\ (PWI) = \left(NWC - \frac{NWT}{NWC}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots.(Eqn. 1)$$

Where, NWC &NWT are number of weeds (m^{-2}) in weedy check and any particular treatment, respectively.

Weeds within quadrant was harvested and dried in oven dry. The dry weight of each species was taken by an electrical balance and expressed in g m^{-2}. Weed control efficiency (WCE) was calculated using the following formula developed by Sawant and Jadhav (1985),

$$Weed\ control\ efficacy\ (WCE) = \left(\mathrm{WDC} - \frac{\mathrm{WDT}}{\mathrm{WDC}}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots..(Eqn. 2)$$

Where, WDC & WDT are weed dry weight (g m^{-2}) in weedy check and any particular treatment, respectively.

The collected data were subjected to analysis of variance (ANOVA) using SAS the statistical software (SAS, 2008) (version 9.2). The mean separation, in cases where there were significant differences among treatments, was done using LSD (0.05) to facilitate the comparison of all pairs of treatment means (Montgomery, 2001). Data of weed parameters were transformed in square root for statistical analysis $\sqrt{}$ x+0.5 (Panse and Sukhamet 1967).

3. RESULTS AND DISCUSION

3.1. Weed flora composition

Data shown that various weeds species were observed in experimental fields. They can be categorized under broad and grass weed species. A total of 18 weed species belonging to 10 families comprised of 11 broadleaf and 7 grasses (Table 2). Among grass weed species, *Avena fatua, Phalaris paradoxa, Oplismus hetilatus and setaria pumila* was the major one. On the other hand, *Guizotia scarba, Spergula Arvensis, Raphanus raphanustrum, Galium sporium, and Polygnom nepalensis* were the major broad leaf weed species observed in the trial fields across locations.

Table 2. Scientific names, family, life form and categories of weeds in experimental fields

Scientific name	Family	Life form(Category)
Achyranthes aspera	Acanthaceae	Annual(Broadleaved)
Avena fatua	Graminaea	Annual(Grass)
Caylusea abyssinica	Resedaceae	Annual(Broadleaved)
Commolina latifolia	Commelinaceae	Annual(Broadleaved)
Corrigoila capensis	Caryophyllaceae	Annual(Broadleaved)
Digitaria ternata	Graminaea	Annual(Grass)
Galinsoga Parviflora	Asteraceae	Annual(Broadleaved)
Galium sporium	Rubiaceae	Annual(broadleaved)
Guizotia scarba	Asteraceae	Annual(Broadleaved)
Oplismus hertilatus	Graminaea	Annual(Grass)
Phalaris paradoxa	Graminaea	Annual(Grass)
Poa Annua	Graminaea	Annual(Grass)
Polygonum nepalense.	Polygnonaceae	Annual(Broadleaved)
Rhaphanus raphanistrum	Brassicaceae	Annual(Broadleaved)
Setaria pumila	Graminaea	Annual(Grass)
Snodonia Polystachia	Graminaea	Annual(Grass)
Spergula arvensis	Caryophyllaceae	Annual(Broadleaved)
Stachys arvensis	Labiatae	Annual(Broadleaved)

3.2. Weed Density (m^{-2}) and Percentage Weed Reduction

Results of the experiment revealed that all weed management practices reduced weed density significantly as compared to weedy check (Table 2). But the level of reduction was vary based on the type of practices. This is in analogy with findings of Rekha *et al*., (2002) who reported that weed density was lower in all weeding practices compared to the un weeded control plot. Among the weed management practices the minimum total weed density (13.3m^{-2}) and (29.7 m^{-2}) was recorded in two times hand weeded plots followed by Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding (16.0m^{-2}) and (30.3m^{-2}) at Shambo and Gedo, respectively. This minimum numbers of weed density may be attributed to effectiveness' of management practices. The reason of low density of weed species in two times hand weeded plots might be the continuous removal of weeds through manual weeding which favor health crop growth and suppressed further establishment of weeds. This result is supported by the results of Singh and Pillai (1993). whereas, the maximum total weed density (49.5m^{-2}) and (102.0 m^{-2}) was observed weedy check plots at Shambo and Gedo, respectively. The maximum number of weeds could be due to the fact that un-treated plots could promoted the weed emergence and growth, and less competition and more time to explored the nutrients from the soil and crop plants by weeds.

From post-emergence herbicides, plots treated with Fenoxaprop-P-Ethyl 69 gm/lt alone shown the minimum number of grass weed species at both study locations and scored higher number of broad leaved weed species. In contrary, application of Dical 720 gm/lt SL alone at thirty days after sowing (30 DAS) scored the minimum numbers of broad leaf weed species. These variations of results might be attributed to the selective nature of those herbicides. This result was in line with the finding of Nano *et al.* (2012) who reported 2, 4-DEE to be ineffective in reducing the population of grassy weeds but effectively controlled broad leaved weed species. Thus, it can be a better option for highly broadleaved weed infested fields in the periods of labor shortage. (Nassar, 2008) also shown that Fenoxaprop-p-ethyl and clodinafop-propargyl are the two herbicides effective against grass weeds. These results are also in accordance with those of Salarzai *et al*. (1999) and Nati (1994) who concluded that herbicides significantly affected the weed population per unit area.

Combination of herbicides (Dical 720 gm/lt SL + Fenoxaprop-P-Ethyl 69 gm/lt) shown effective control over both broad and narrow leaved weed species. It might be due to the fact that integration of herbicides that are effective against target weed species can result in sufficient management. This result is in analogy with the findings of (Chaudhry *et al.,* 2008; Bostrom & Fogelfors, 2002; Khan & Rashid, 1994) that shown several combinations of herbicides can provide good control of broad and narrow leaved weeds and cause significant reduction in their density and increase yield attributes as compared to check plots. Percentage weed reductions of all the treatments were different (Table 3). The maximum percentage of weed reduction (72.9 and 70.8 %) was recorded from two times hand weeded plot followed by Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeded plots (66.0 and 70.2%) at Shambo and Gedo, respectively. Results had shown variation across location for weed density that could be mainly due environmental factors.

Table 3. Effect of weed management practices on weed density(m^{-2}) at study areas

	Weed Density (m^{-2}) at 80 DAS							
	Shambo				Gedo			
Treatments	**Broad (m^{-2})**	**Grass (m^{-2})**	**Total(m^{-2})**	**PWR (%)**	**Broad(m^{-2})**	**Grass(m^{-2})**	**Total(m^{-2})**	**PWR (%)**
Dical	9.7±3.1b	10.7±3.2ba	20.3±4.5bc	58.6 7.6b	12.7±3.6c	30.7±5.5a	43.3±6.6b	57.3±7.7b
Dical+Fenox	9.5±3.1b	7.8±2.8b	17.3±4.2bc	64.5±8.0ba	25.3±5b	12.7±3.5b	38.0±6.1cbd	62.8±7.9ba
Fenox	12.5±3.5b	7.1±2.6bc	19.5±4.4bc	60.5±7.8ba	26.0±5.1b	15.3±3.9b	41.3±6.4bc	59.3±7.7b
Fenox+HW(1x)	7.1±2.6b	9.7±3.1b	16.7±4.1bc	66.0±8.1ba	14.0±3.7c	16.3±3.9b	30.3±5.5d	70.2±8.3a
Dical+HW(1x)	10.5±3.2b	10.7±3.3ba	21.1±4.7b	57.4±7.6b	19.3±4.4bc	11.3±3.4b	30.7±5.6cd	69.9a±8.4
HW(2X)	10.2±3.1b	3.1±1.7c	13.3±3.7c	72.9±8.5a	17.0±4.1bc	12.7±3.5b	29.7±5.4d	70.8±8.4a
UN WD	35.3±5.9a	14.2±3.8a	49.5±7.0a	0C	73.3±8.6a	28.7±5.4a	102.0±10.1a	0c
LSD(0.05)	5.7	4.4	7.2	12.6	9.8	8	10.7	10.2
CV (%)	12.68	15.69	10.79	6.51	11.2	12.3	7.7	5.1
F-test	**	**	**	**	**	**	**	**

Note: - Means followed by the same letter within columns has statistically no difference.
*LSD= list signifance difference, CV (%) = Coefficient of variation, F-test= probability value, *,** = signifance difference* & highly *signifance difference*, respectively, PWR(%) = Percentage weed reduction, *UN WD = weedy check, Fenox = Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x) = Dical 720 gm/lt SL + hand weeding, Fenox+ Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times hand weeded, Fenox + HW(1x) = Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding*

3.3. Weed dry weight (g m^{-2}) and weed control efficiency (WCE %)

Results of the experiments regarding to weed dry weight (g m^{-2}) and weed control efficiency (WCE %) depicted that both of these parameters were significantly affected by weed management practices (Table 4). All treatments significantly reduced weed dry weight (g m^{-2}) as compared to weedy check. This is in analogy with the finding of Sharma *et al.* (1998) and Saini, (2000) who reported significant reduction in weed dry matter accumulation with weed control treatments. Statistically significance difference was observed among treatments for total weed dry weight (g m^{-2}) at both study areas. The maximum total weed dry weight (111) and (65.5g m^{-2}) was recorded from un-treated plots at Shambo and Gedo, respectively. This large dry weight might be attributed to a high weed density resulted from zero weed management which ultimately promote emergence, growth and development of weeds in these plots. Singh and Kumar (1999) also reported that the maximum weed dry weight was recorded in the un-weeded control which was significantly higher compared to other weed control practices. In contrary, the minimum total weed dry weight (20.3) and (17.8g m^{-2}) was observed in two times hand weeded plots at Shambo and Gedo, respectively. The lowest dry weight recorded was due to removal of most of the weed plants there which suppressed density of weeds and resulting into a lower competition between the crop and weeds for resources.

Application of Dical 720 gm/lt SL and Fenoxaprop-P-Ethyl 69 gm/lt alone and in integration form significantly reduced the total weed dry weight as compared with un-treated plots. The reduction in weed dry weight might be due to the inhibition effect of herbicide treatments on growth and development of weeds. These results are in general agreement with those recorded by Turk *et al* (2003); Nassar (2008) and EL-Metwally and Soudy (2009). Combination of these chemicals with one times hand weeding also resulted in significant reduction of weed dry weight. Treatments had shown different weed control efficacy. Twice hand weeding provided maximum weed control efficacy (81.7 and 72.4 %) followed by Dical 720 gm/lt SL + Fenoxaprop-P-Ethyl 69 gm/lt (77.8 and 68.6 %) treated plots at Shambo and Gedo, respectively. These results are in accordance with the findings of Shah and Koul (1990) and Thakur (1994), who observed higher WCE under twice hand weeding carried out at 20 and 40 days after sowing in maize crop.

Table 4. Effect of weed management practices on weed dry matter(g m $^{-2}$) at Shambo and Gedo

Weed Dry weight(g m $^{-2}$) at 80 days after sowing								
	Shambo				Gedo			
Treatments	Broad(g m $^{-2}$)	Grass(g m $^{-2}$)	Total(g m $^{-2}$)	WCE (%)	Broad(g m $^{-2}$)	Grass (g m $^{-2}$)	Total (g m $^{-2}$)	WCE(%)
Dical	22.0b±4.7bc	23.0±4.6a	43.7±6.5 b	60.7±7.7d	16.5±4.0bc	16.7±4.0a	33.1±5.7b	50.1±7.0c
Dical+Fenox	16.3±4.0cd	8.3±2.9b	24.7 ±+5.0 cde	77.8 ±8.8bac	10.7±3.2c	9.5±3.1b	20.2± 4.5cd	68.6±8.3ba
Fenox	26.0±5.1b	9.3±3b	35.3±5.9bcd	68.2± 8.2bad	21.7±4.6b	8.4±2.9b	30.1±5.5bc	53.9±7.3bc
Fenox+HW	14.0±3.6c	7.3±2.7b	21.3 ± 4.6 de	75.1±9.0ba	15.3±3.9bc	8±2.8b	23.3±4.8cbd	64.8±8.0ba c
Dical+HW	25 ± 5.0b	12.0±3.4bb	37.0 ±6.1bc	66.7±8.2 dc	12±3.5c	10.2±3.2b	22.2±4.7cd	65.8±8.1ba
HW(2X)	13.3 ± 3.6d	7.0±2.6b	20.3±4.5e	81.7±9.0a	9.8±3.1c	8.0±2.8b	17.8±4.2d	72.4±8.5a
UN WD	82a±13.03a	29.0 ± 5.4a	111±10.5a	0e	48.0±6.9a	17.5±4.2a	65.5±8.1a	
LSD	7.1	10.8	14.8	13.3	7.7	6.1	10.8	14.8
CV (%)	10.1	18.3	11.2	6.6	11.8	15.4	10.3	8.5
F-test	**	**	**	**	**	*	**	**

***Note: -** Means followed by the same letter within columns has statistically no difference.*
*LSD= list signifance difference, CV (%) = Coefficient of variation, F-test= probability value, *,** = signifance difference* & highly *signifance difference*, respectively, WCE(%) = *weed control efficacy , UN WD = weedy check, Fenox= Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x) = Dical 720 gm/lt SL +One times hand weeding, Fenox + Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times hand weeded, Fenox + HW(1x) = Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding*

3.4. Yield and yield related parameters of barley as affected by weed management options

Analysis of variance revealed that there was statistically significance difference observed among treatments regarding to yield and yield attributing parameters like plant height, number of tillers m $^{-2}$, spike length and thousand kernel weight (Table 5 & 6).

3.4.1. Number of tillers (m $^{-2}$)

Results of trials regarding to number of tillers depicted that all treatments were shown superiority over un-weeded (weedy check) across locations. Among the treatments studied, Maximum number of tillers were obtained from two times hand weeded (199.7 and 215.6 m $^{-2}$) while the minimum (154.7 and 183.4 m $^{-2}$) were observed in un-weeded plots at Shambo and Gedo, respectively. The combinations of treatments significantly increase the number of tillers as compared with other treatments except two times hand weeding. This maximum number of tillers was primarily due to the better crop growth as a result of less competition with weeds. This is in analogy with findings of Ijaz *et al.* (2008) who shown that better weed control increased the nutrients availability to the crop which ultimately increased the spike bearing tillers. Application of herbicides alone resulted in lower number of tillers, while doses of herbicides when supplemented with one hand weeding resulted in better tiller numbers.

3.4.2. Plant height (cm)

Among the treatments the highest plant height (115.3 and 116 cm) was measured from two times hand weeded plots followed by Dical 720 gm/lt SL + one times hand weeded at (40 DAS), having (109 and 115.4 cm) at Shambo and Gedo, respectively. The maximum plant height scored might be due to efficient weed control provided by these treatments. In contrary, the minimum plant height (100 and 103 cm) was scored from weedy check plot at Shambo and Gedo, respectively. This minimum plant height might be attributed to adverse crop affect caused by heavy weed competition with crop for resource which in turn suppressed crop growth. This result is in analogy with (Oerke, 2006; Ryan et al., 2009; Smith et al., 2010).

3.4.3. Panicle length (cm)

Analysis of variance revealed that panicle length was statistically significantly affected by weed management practices ($p \leq 0.05$) at Shambo, while no statistically significance difference was observed for panicle length at Gedo site (Table 5). But, numerical difference was observed. Plots treated with combination of Dical 720 gm/lt SL and Fenoxaprop-P-Ethyl 69 gm/lt scored the highest panicle length (7.2 and 6.9 cm) where the lowest (6.3 and 6.0 cm) was observed in un-weeded plot at Shambo and Gedo, respectively. The maximum highest panicle length might be accounted to favorable environment provided for health growth and development of crop which in turn create conducive environment for flowing and panicle formation.

3.4.4. Number of grain per spike

Number of grain per spike is one of the basic parameters in studying weed management practices to assess its impact on crop and weeds. Results showed that there was significance difference among treatments in case of number of grain per spike. All experimental treatments shown superiority over un weeded plots. The maximum number of grain per spike (48.5) was obtained from the plots treated with hand weeding + Fenoxaprop-P-Ethyl 69 gm/lt followed by two times hand weeding (46.9) at Shambo site, whereas maximum (51.1) grain per spike was found in Dical 720 gm/lt SL + Fenoxaprop-P-Ethyl 69 gm/lt followed by hand weeding + Fenoxaprop-P-Ethyl 69 gm/lt (50.9) at Gedo site. The minimum number of grain per spike (42.2 and 46.0) was obtained from un-weeded plots at Shambo and Gedo, respectively. Significantly higher number of grains might be the result of easily accessible growth factors (nutrient, moisture and light) for individual plant that retained more flowers and higher net assimilation rate in the absence of competition from weeds. Also the development of more and vigorous leaves under low weed infestation might have helped to improve the photosynthetic efficiency of the crop and supported higher number of grains. Similar result was reported by (Chaudhry et al., 2008; Bostrom & Fogelfors, 2002; Khan & Rashid, 1994). This lowest grains found in un-treated plots might be due to severe weed competition between the weeds and crop which prominently reduced the nutrient mobility towards grains and affected the grain development potential of the barley crop.

3.4.5. Grain yield as affected by weed management practices

Grain yield was affected significantly by weed management practices. The maximum grain yield (4312.5 and 4382.6 kg ha^{-1}) was recorded in two times hand weeded plot. This maximum yield might be due to effective weed management achieved by hand weeding. In contrary, the minimum yield (2525.7 and 2776.9 kg ha^{-1}) was recorded in weedy check at Shambo and Gedo, respectively. The minimum grain yield might be attributed to maximum infestation of weeds that can heavily compete for resource which adversely affected grain yield. This is in analogy with (Jarwar *et al.,* 2005) which suggests Weeds compete with crop plants for various resources such as water and nutrients, resulting in low yields. (Chaudhary *et al*., 2008; Dalley *et al.,* 2006). also reported that high weeds intensity and more competition time with crop plants cause more reduction in crop yield). This also indicates that weeding at proper time definitely enhances crop yields. Post-emergence application of Fenoxaprop-P-Ethyl 69 gm/lt alone showed the least (3532.2 and 3533.5 kg) grain yield as compared with any other treatments except un-treated one at Shambo and Gedo, respectively. Similarly, application of Dical 720 gm/lt SL alone shown maximum yield over weedy check. This superior yield might be due to reduction in weed infestation as influenced by herbicides treatment. This result is in analogy with findings of (Khan *et al*., 2003; Madafiglio *et al*., 2006). Which suggests Increase in grain yield of herbicides treated plots occurred due to reduced weed-crop competition but in weedy check weeds were using resources that negatively affect grain produce.

Combination of management practices provided better yield as compared with sole management practices. This yield performance might be due to effective weed control provided by integration of management options. This is in conformity of (Singh, 2014; Kewat, 2014). Integration of the two herbicides, Fenoxaprop-P-Ethyl 69 gm/lt at the rate of 1.25 L and Dical 720 gm/lt SL 1 L per hectare gave the maximum yield (4166.7 and 4303.5 kg) leaded by two times hand weeding at Shambo and Gedo, respectively. This is due to the fact that combination of herbicides having broad spectrum achieved effective management for almost all weed species which in turn leads to increase in grain yield. It is in analogy with the findings of (Chaudhry *et al.,* 2008; Bostrom & Fogelfors, 2002; Khan & Rashid, 1994) which shown combinations of herbicides can provide good control of broad and narrow leaved weeds and cause significant reduction in their density and increase yield attributes as compared to check. The combination of herbicides with hand weeding also showed a better yield as compared with herbicidal application alone and un-treated plot. This is due to the reason that the doses of herbicides supplemented with hand weeding were more effective than their sole applications. This supported the concept of combining weed control strategies.

3.4.6. Harvest Index as Influenced by Weed Management Practices

Harvest index of the crop was significantly affected by treatments. There was highly significance difference among weed management practices at both study sites (Table 5 & 6). The variation in harvest index under different treatments might be due to variation in the grain yield and yield related parameters. Two times hand weeding produced significantly maximum harvest index (50.7 and 54.4 %) followed by Fenoxaprop-P-Ethyl 69 gm/lt + one times hand weeding (47.3 and 53.0 %) at Shambo and Gedo, respectively. Whereas the minimum (22.0 and 27.6 %) was obtained from weedy check plots at those respective locations. In agreement with this result, Nano (2012) reported that twice hand weeding showed the highest harvest index (46%) than other treatments on the same variety.

Table 5. Effect of weed management practices on Yield related parameters of barley at Shambo

Treatments	Plant height(cm)	Panicle length(cm)	No. of grain spike-^{1}	TKW(gm)	No. tiller(m-^{2})	Yield ha^{-1}(Kg)	Harvest Index (%)
Dical	102.7bc	7.1a	43.8ba	31.7c	178.0ba	3766.7b	43.2ba
Dical+Fenox	108.0bac	7.1a	45.3ba	38.3ba	187.0ba	4166.7a	47.2ba
Fenox	105.3bc	6.9ba	45.2ba	36.7bac	182.7ba	3532.2b	40.2b
Fenox+HW(1x)	108.3bac	7.6a	48.5a	41.7a	184.3ba	4133.3a	44.2ba
Dical+HW(1x)	109.0ba	6.9ba	45.7ba	40.0a	195.0a	4116.7a	40.3b
HW(2X)	115.3a	7.2a	46.9ba	43.3a	199.7a	4312.5a	50.7a
UN WD	100.0c	6.3b	42.2b	30.0c	154.7b	2525.7c	22.0c
LSD(0.05)	8.9	0.71	5.97	7.56	35.372	249.97	9.42
CV (%)	4.7	5.7	7.39	11.367	10.86	3.704	12.876
F-test	*	**	*	**	*	**	**

Note: - *Means followed by the same letter within columns has statistically no difference.*
*LSD= list signifance difference, CV (%)= Coefficient of variation, F-test= probability value, *,** = signifance difference* & highly *signifance difference*, respectively, *UN WD = weedy check, Fenox = Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x) = Dical 720 gm/lt SL +One times hand weeding, Fenox + Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times weeded, Fenox + HW(1x) = Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding*

Table 6. Effect of weed management practices on Yield related parameters of barley at Gedo, Western Oromia

Treatments	Plant height(cm)	Panicle length(cm)	No. grain spike^{-1}	TKW	No. tiller(m^{-2})	Yield ha^{-1}(Kg)	Harvest Index (%)
Dical	107.9dc	6.7a	50.3a	43.3bac	202.2ba	4001.3b	51.5ba
Dical+Fenox	114.0bac	6.9a	51.1a	50.0a	206.6ba	4303.5ba	53.0ba
Fenox	109.1bdc	6.3a	49.8a	38.3dc	193.4ba	3533.5c	46.6c
Fenox+HW	110.9bac	6.7a	50.9a	46.7ba	200.0ba	4181.2ba	50.8bac
Dical+HW	115.4ba	6.6a	47.6a	41.7bdc	204.0ba	4269.8ba	46.4bc
HW(2X)	116.0a	6.8a	49.5a	48.3ba	215.6a	4382.6a	54.4a
UN WD	103.0d	6.0a	46.0a	35.0d	183.4b	2776.9d	27.6d
LSD(0.05)	6.69	0.91	6.88	7.04	14.33	313.16	6.92
Cv (%)	3.40	7.80	7.84	9.13	8.02	4.49	8.30
F-test	**	ns	ns	**	*	**	**

***Note: -** Means followed by the same letter within columns has statistically no difference.*
*LSD= list signifance difference, Cv (%)= Coefficient of variation, F-test= probability value, ns, * and ** = non significance, signifance difference* & highly *signifance difference*, respectively, *UN WD = weedy check, Fenox = Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x) = Dical 720 gm/lt SL + One times hand weeding, Fenox + Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times hand weeded, Fenox + HW(1x) = Fenoxaprop-P-Ethyl 69 gm/lt + One times hand weeding*

3.5. Partial budget analysis

Economic analysis of different weed control treatments revealed that weed control barley by different weed management methods gave different economic return as compared to hand weeding (Table 7&8). The maximum net benefit (20124.38 and 20547.08) was recorded from two times hand weeded plot at shambo and Gedo, respectively. Application of Dical 720 gm/lt SL herbicide alone at the rate of 1L ha^{-1} fetched the highest marginal rate of return (MRR %) (36.4162 and 35.91566) followed by integration of Dical 720 gm/lt SL with Fenoxaprop-P-Ethyl 69 gm/lt at the rate of 1L ha^{-1}with MRR (%) of (6.5375 and 4.080275) at both respective locations. Thus, it was concluded that use of Dical 720 gm/lt SL alone is more economical than hand weeding and any other treatments. Some treatments were dominated due to higher costs involved.

Table 7. Partial budget analysis for weed management practices at Shambo, Western Oromia.

Treatments	Yield(kg/ha)	AdY(kg/ha)	GI(Birr)	V.cost(Birr)	Tot.cost	N.Benefit (%)	MRR (%)
UN WD	2525.7	2273.13	15229.97	0	5000	10229.97	0
Dical	3766.7	3390.03	22713.2	200	5200	17513.2	36.4162
Fenox	3532.2	3178.98	21299.17	480	5480	15819.17	D
Dical + HW(1x)	4116.7	3705.03	24823.7	640	5640	19183.7	3.79659
Fenox+ Dical	4166.7	3750.03	25125.2	680	5680	19445.2	6.5375
HW(2x)	4312.5	3881.25	26004.38	880	5880	20124.38	3.39587
Fenox+ HW(1x)	4133.3	3719.97	24923.8	920	5920	19003.8	D

***Note:-** Yied(kg/ha)= Grain yield per hectare, Ady =Adjusted yield, GI(Birr)=Gross income by birr, Tot.cost = Total cost N.Benefit = Net benefit, MRR(%)= Marginal rate of return, UN WD= weedy check, Fenox = Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x)= Dical 720 gm/lt SL + One times hand weeding, Fenox + Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times hand weeded*

Table8. Partial budget analysis for weed management practices at Gedo, Western Oromia.

Treatments	Yield(kg/ha)	AdY(kg/ha)	GI(Birr)	V.cost(Birr)	Tot. cost	N.Benefit (%)	MRR (%)
UN WD	2776.9	2499.21	16744.71	0	5000	11744.71	0
Dical	4001.3	3601.17	24127.84	200	5200	18927.84	35.91566
Fenox	3533.5	3180.15	21307.01	480	5480	15827.01	D
Dical + HW(1x)	4269.8	3842.82	25746.89	640	5640	20106.89	2.67967
Fenox+ Dical	4303.5	3873.15	25950.11	680	5680	20270.11	4.080275
HW(2x)	4382.6	3944.34	26427.08	880	5880	20547.08	1.384865
Fenox+ HW(1x)	4181.2	3763.08	25212.64	920	5920	19292.64	D

***Note:-** Yied(kg/ha)= Grain yield per hectare, Ady =Adjusted yield, GI(Birr)=Gross income by birr, Tot.cost = Total cost N.Benefit = Net benefit, MRR(%)= Marginal rate of return, UN WD= weedy check, Fenox = Fenoxaprop-P-Ethyl 69 gm/lt, Dical + HW(1x)= Dical 720 gm/lt SL + One times hand weeding, Fenox + Dical= Fenoxaprop-P-Ethyl 69 gm/lt + Dical 720 gm/lt SL, HW(2x)= two times hand weeded*

4. CONCLUSIONS

Weeds in general and grass weed species in particular are the major constraint in barley production in western part of our country and its control is too important to increase barley production and productivity. From the result of this experiment, it can be concluded that integration of Fenoxaprop-P-Ethyl 69 gm/lt with Dical 720 gm/lt SL or one times hand weeding was quite effective to control major broad and grass weed species observed in barley fields. From economic analysis, the highest net returns obtained from two times hand weeded plots. Whereas the maximum rate of return was obtained from the plot sprayed with Dical 720 gm/lt SL alone followed by its integration with Fenoxaprop-P-Ethyl 69 gm/lt. Thus, Dical 720 gm/lt SL post-emergence herbicide is economically feasible.

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CONFLICT OF INTEREST
The authors declare that there are no conflicts of interest

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