

Evaluation of Integrated Management of Wild Radish (*Raphanus raphanistrum*) in Faba Bean in Waliso District of South West Shoa, Ethiopia

Shashitu Bedada Nigussie Hundesa Desalengn Gela Gectachew Bekele
EIAR, Ambo Agricultural Research Center. P. O. Box 37. Ambo, Ethiopia

Abstract

A field experiment was conducted from 2017 to 2018 to evaluate effective and economical integrated management package for the control of *Raphanus raphanistrum* in faba bean in Waliso District of South West Shoa, Ethiopia. The experimental design used was split plot design with two levels of plowing frequency assigned as main plot and eight weed management practice as sub plot in three replications. Data recorded on crop and weed related parameters. Results obtained indicated that the interaction effect of plowing frequency and combination of herbicides with hand weeding frequency significantly affected plant height, number of pods per plant, seeds per pod, crop biomass and grain yield of faba bean. The highest mean grain yield (1541 kg/ha) was obtained from the interaction effect of plowing three times with application of pendimethalin at 3 Lt ha⁻¹ supplemented with once hand weeding at 30-35 days after sowing. This is followed by plowing three times and application of S-Metolachlor at 1 litter ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 days after sowing that gave a mean grain yields of 1463kg/ha. The interaction effect of plowing frequency and combination of herbicides with hand weeding frequency also significantly affected the weed population, weed plant height and biomass. The lowest *R. raphanistrum* population, height and biomass was obtained from the interaction of three times plowing and application of S-metolachlor at 1 litter ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 days after sowing. Economic analysis showed that trice plowing combined with application of Pendimethalin at 3 Lt ha⁻¹ supplemented by once hand weeding at 30-35 days after sowing gave the highest Net benefit (23174 birr) followed by three times plowing combined with application S-Metolachlor at 1 Lt ha⁻¹ supplemented by twice hand weeding. Therefore, three times plowing and application of S-Metolachlor herbicide supplemented by twice hand weeding at 30-35 and 50-55 DAS or three times plowing and application of Pendimethalin herbicide at 3 Lt ha⁻¹ supplemented with one time hand weeding at 30-35 DAS is recommended for economic control of *R. raphanistrum* in faba bean production.

Keywords: *Raphanus raphanistrum*, s-metolachlor, pendimethalin

DOI: 10.7176/JBAH/10-5-02

Publication date: March 31st 2020

Introduction

Wild radish (*Raphanus raphanistrum*) is a major weed of winter crops in southern and eastern Australia, and is particularly troublesome in cereal and brassica crops. It is thought to be poisonous to livestock. Reproduction is only by seed, which spread shorter distances by wind, water, animals and human activities. Dispersal via contaminated agricultural produce is thought to be the most significant means of long range spread (Retter and Harden, 2005).

Several exotic weed species have long been introduced to Ethiopia. Among these, *R. raphanistrum* is now causing a serious impact on crop and rangelands in Ethiopia. So far, there was no concrete evidence on how *R. raphanistrum* introduced into Ethiopia. The weed is extremely expanding on highlands ecology of the country and devastating cereals, pulses, oil crops and rangelands. It became a serious weed of crop and rangelands in West Shewa, particularly in Welmera and Cheliya; South West Shewa (Waliso) and Horo Guduru district in east Wellega zone of Oromiya, region.

According to farmers around Chaliya district (Gedo), *R. raphanistrum* was introduced during the war between Ethiopia and Italy (1930-1935) through Italy armed forces. Farmers say that the weed was brought to Gedo through horse feed contaminated with *R. raphastirum* seed and that it was first observed in Fortino area. Its distribution and spread is more restricted to the normal upland /drained type of grazing area rather than water logged grazing area (Shugute, unpublished, 2015). It is locally known as "*Gomana Faranji*" (French cabbage) possibly indicating its introduction from abroad (Personal communication). The weed has substantial impact on the native biodiversity of rangelands and arable lands by canopy covering, being toxic to animals and causes severe human health problems by making allergic reactions on hands while making hand weeding in field crops. Therefore, it has become an increasing serious problem in major crops as well as faba bean in the study area.

Results of field experiment conducted during 1997 -1998 at Shambu testing site indicated that *Raphanus* alone incurred 28.9% grain yield loss in bread wheat relative to the weeded check and effective control of this weed was obtained using mecoprop, 2,4-D and the tank mixture of both herbicide, and ioxynil + bromoxynil

+mecoprop treated plots (Dhaba *et al.*, 2005).

Cultural, chemical and biological weed control activities can exert a strong selective influence on the weed population (Chancellor, 1985). Thus, knowledge of the weed community structure is an important component of weed management, and is essential in setting priorities for management and research. Chemicals nowadays are expensive and are not environmentally friendly. Thus, “best mix” approach is currently advocated as Integrated Pest Management (IPM) involves logical combination of different compatible tactics for the control of pests (Brader, 1979).

Wild radish is among the major weeds found in Wolliso district. However, there is limited information regarding its management and its effect on the productivity of major crops particularly faba bean. Therefore, this trial was initiated with the objective to enhance faba bean crop yield by reducing *R. raphanistrum* weed infestation level using appropriate weed management options and evaluate effective and economical management package.

Materials and Methods

Description of study area

The study was conducted in Waliso districts of South West Shoa Zone of Oromiya Regional State on the farmer’s field during the main cropping season of 2017 and 2018. Testing site was selected after field observation on the availability of naturally infested heavy and wide population of *R. raphanistrum* weeds at major Faba bean growing area.

Treatments and experimental design

The experiment was laid out as a split-plot design with three replications. The factors includes two plowing frequency (two times plowing and three times plowing) assigned as a main plot and eight weed management practices (S-metolachlor at 1 lt ha⁻¹ supplemented by one hand weeding at 30-35 days after sowing (DAS); S-metolachlor at 1 lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS; Pendimethalin at 3 lt ha⁻¹ supplemented by one hand weeding at 30-35 DAS; Pendimethalin at 3 lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS; twice hand weeding at 30-35 and 50-55 DAS; S-Metolachlor at 1 lt ha⁻¹; Pendimethalin at 3 lt ha⁻¹ and; weedy check were assigned as sub plot. The size of each sub plot was 5m x 4m (20 m²) with a distance of 1m between plots and 1.5 m between blocks were left to avoid spray drift from adjacent plots. Faba bean variety Walki was sown at 200 kg/ha with a spacing of 40 cm between rows and 5 cm between plants and DAP were applied at 100 kg/ha at sowing time.

Experimental procedures

Land was prepared with oxen plough to fine soil bed which supports easy contact of the seed with soil. All other agronomic practices required for the crop were applied according to recommendation given for the crop.

Method of application: The required quantity of the herbicide was calculated and measured into manual knapsack sprayer with a pre-determined water volume for each plot and each herbicide was applied separately one day after sowing under non windy condition.

Data collection

Data on yield and yield components of faba bean like number of pods per plant, number of seeds per pod, grain yield, biomass, plant height, and 1000 seed weight were recorded. Total number of pods in 10 randomly selected plants in each plot was counted at harvest and expressed as the number of pods plant⁻¹. From these pods, the seeds were counted to determine the number of seeds pod⁻¹. Thousand seeds were counted from each plot, and their weight was recorded. Above ground dry biomass weight was measured at physiological maturity from each plot. This was converted in to kg ha⁻¹. Grain yield (kg) was recorded from each net plot area.

In addition, data on *R. raphanistrum* weed height, density/count after herbicide application and biomass at harvest was collected. *R. raphanistrum* weeds present in the experimental fields of all plots were recorded after application by placing a quadrat of 0.25m X 0.25 m randomly at two spots. Its height was measured from 10 randomly selected weeds before crop harvesting. Biomass was also measured during crop harvest from all plots. Partial budget analysis procedure was employed for economic analysis of herbicide application and it was carried out for faba bean yield

Data analysis

The data collected were subjected to analysis of variance using SAS software. Means that showed a significant difference were separated by least significant difference at 0.05 probability level by SAS (SAS, 2004).

Economic analysis

The partial budget analysis as described by CIMMYT (1988) was conducted to determine the economic feasibility

of the weed management practice. Economic analysis was made using the prevailing market prices for inputs at planting and for the outputs at the time of crop harvest. It was calculated by taking in to account the additional input and labor cost involved and gross benefits obtained from weed management practices. Average yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could obtain from the same weed management practices as described by (CIMMYT, 1988). For economic evaluation, partial budget, value to cost ratio (VCR) and marginal analysis were used based on the local market price of the faba bean yield and herbicide cost, the cost of tillage and weeding were also taken from the farmers own practice.

Results and Discussion

Plant height

The result of mean separation from the two years data indicted in Table 1 showed that plant height was significantly influenced by the interaction effect of plowing frequency, application of herbicides and hand weeding. The highest mean plant height (112.91 cm) was obtained from the interaction effect of three times plowing + application of Pendimethalin at 3 lt ha⁻¹ followed by three times plowing + application of S-metolachlor at 1 lt ha⁻¹. However, the lowest mean plant height (58.94 cm and 62.23 cm) were obtained from twice plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS and twice plowing + application of Pendimethalin at 3 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS, respectively. This indicates that three times plowing is more effective in increasing plant height as compared to twice plowing, but plant height was not influenced by application of herbicide and hand weeding (Table 1).

Number of pods per plant

Analysis of variance revealed that there is a high significant difference among the treatments in number of pods per plant (Table 1). Combined effect of two years data indicates that the highest mean number of pods per plant (7.5 and 7.4) was recorded from three times plowing + twice hand weeding at 30-35 and 50-55 DAS and three times plowing + application of S-metolachlor at 1 litter ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS, respectively. This might be due to reduced weed competition for nutrient, moisture and light as result the crop get higher net assimilation rate thus retaining more flower. The development of more and vigorous leaves under low weed infestation might have also helped to improve the photosynthetic efficiency of crop and supported large number of pods (Hodgson and Blackman, 2005). However, the lowest mean number of pods per plant (5.3 and 5.6) was recorded from twice plowing + S-metolachlor at 1 lt ha⁻¹ and twice plowing + Pendimethalin at 3 lt ha⁻¹, respectively (Table 1). This result indicted that, three times plowing + twice hand weeding at 30-35 and 50-55 DAS are the most effective followed by three times plowing+ S-metolachlor 1 lt ha⁻¹+ twice hand weeding at 30-35 and 50-55 DAS in increasing number of pods per plant in faba bean. These results are in line with Hadi et al. (2006) who observed an increased number of pods plant⁻¹ where weed population was reduced by management techniques. Similarly, Pereira et al. (2015) and El-Metwally et al. (2008) sated that the number of pods produced per plant or maintained to final harvest depends on a number of environmental and management practices.

Number of seeds per pod

The interaction effect of different weed control options showed significant effect on number of seeds per pods of faba bean (Table 1). The highest mean number of seeds per pod (3.03) was obtained from the interaction effect of three times plowing + application of Pendimethalin 3 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS followed by three times plowing + application of Pendimethalin at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS which having (2.9) number of seeds per pod. These is might be due the reduced interference of weeds; the vigorous leaves might have helped to improve the photosynthetic efficiency of crop that support large number of seeds pod⁻¹ which can have positive contribution for increment of grain yield. However, the lowest mean number of seeds per pod(2.45) was recorded from twice plowing + twice hand weeding at 30-35 and 50-55 DAS, but non-significant different existed in twice plowing + S-metolachlor at 1 lt ha⁻¹, twice plowing + weedy check, three times plowing + S-metolachlor at 1 lt ha⁻¹ + once hand weeding at 30-35 DAS, three times plowing + twice hand weeding at 30-35 and 50-55 DAS, three times plowing + S-metolachlor at 1 lt ha⁻¹, three times plowing + Pendimethalin 3 lt ha⁻¹ and three times plowing + weedy check (Table 1).

Table1. Effect of integrated *R. raphanistrum* weed management on plant height, number of pods per plant, number of seed per pod and biomass of faba bean at Waliso district during 2017/2018.

Treatments	Plant height	No of pods per plant	No seeds /pod
Year 2017	118.265 ^a	7.6625 ^a	2.5375 ^b
Year 2018	52.740 ^b	4.9854 ^b	2.8833 ^a
LSD (0.05)	7.7315	0.5129	0.1184
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	76.12 ^{efg}	6.3 ^{abcd}	2.867 ^{abc}
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	58.94 ^g	5.92 ^{cd}	2.55 ^{cde}
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	73.18 ^{efg}	6.52 ^{abcd}	2.8 ^{abcd}
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	62.23 ^g	5.98 ^{bcd}	2.87 ^{abc}
Twice plowing+ twice hand weeding at 30-35 and 50-55 DAS	77.94 ^{defg}	6.07 ^{abcd}	2.45 ^e
Twice plowing+ S-metolachlor 1 lt ha ⁻¹	76.49 ^{efg}	5.33 ^d	2.533 ^{cde}
Twice plowing+ Pendimethalin 3 lt ha ⁻¹	93.44 ^{abcde}	5.6 ^d	2.87 ^{abc}
Twice plowing+ weedy check	65.16 ^{fg}	5.8 ^{cd}	2.6 ^{bcd}
Three times plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	80.73 ^{defg}	5.87 ^{cd}	2.533 ^{cde}
Three times plowing+ S-metolachlor 1 ltha ⁻¹ + twice hand weeding at 30-35 and 50-55 DAS	86.00 ^{cdef}	7.4 ^{ab}	2.8 ^{abcd}
Three times plowing+ Pendimethalin3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	104.14 ^{abc}	7.1 ^{abc}	2.90 ^{ab}
Three times plowing+ Pendimethalin 3 lt ha ⁻¹ + twice hand weeding at 3-35 and 50-55DAS	89.38 ^{bcd}	7.23 ^{abc}	3.03 ^a
Three times plowing+ twice hand weeding at 30-35 and 50-55 DAS	99.18 ^{abcd}	7.5 ^a	2.73 ^{abcde}
Three times plowing+ S-metolachlor 1 lt ha ⁻¹	108.68 ^{ab}	6.25 ^{abcd}	2.47 ^{de}
Three times plowing+ Pendimethalin3 lt ha ⁻¹	112.91 ^a	6.3 ^{abcd}	2.78 ^{abcde}
Three times plowing+ weedy check	103.53 ^{abc}	6.02 ^{bcd}	2.58 ^{bcd}
LSD (0.05)	21.868	1.4508	0.3348
CV (%)	22.16	19.88	10.70

Note: CV= Coefficient of Variation, LSD=Least significance difference, DAS=Days after sowing, lt =litter, Means followed by the same letter within a column are not significantly different at 0.05p

Crop Biomass

Result for crop biomass yield indicated that significant differences among treatments were observed (Table 2). The highest mean value of crop biomass (4241.7 kg/ha) was obtained from the interaction effect of three times plowing + application of Pendimethalin3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS, but as par with three times plowing + Pendimethalin at 3 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS, and three times plowing + S-metolachlor at 1 lt ha⁻¹ + twice hand weeding at 30-35 DAS. However, the lowest mean value of crop biomass yield (1883.3 kg/ha) was obtained from twice plowing + twice hand weeding at 30-35 and 50-55 DAS, but non significantly twice plowing+ S-metolachlor at 1 lt ha⁻¹, twice plowing+ S-metolachlor at 1 lt ha⁻¹+twice hand weeding at 30-35 and 50-55 DAS, trice plowing+ S-metolachlor at 1 litter ha⁻¹. Therefore, three times plowing + application of pendamithaline at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS followed by three times plowing + application of pendimethalin at 3 lt ha⁻¹ supplemented with twice hand weeding at 30-35 DAS are effective in increasing above ground biomass as compared to other treatments. The increased above ground biomass yield in these treatments might be due to utilization of resources more efficiently by the crop in the absence of the weed that resulted in higher final crop stand. Similar with present results, Alfonso *et al.* (2013) reported good suppression of weed growth by cultural and herbicidal control measures that lead to low competition by weeds for light, space and nutrients and in contrast the utilization of resources efficiently by the crop that lead to higher dry biomass production.

Grain Yield

Analysis of variance indicated that high significant difference among different treatments (Table2). The highest mean grain yield (1541.2 kg/ha) was obtained as a result of interaction effect of three times plowing + application of pendimethalin at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS followed by three times plowing

+ application of S-metolachlor at 1 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS having 1462.8 kg/ha grain yield. But non significantly three times plowing + Pendimethalin at 3 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS, three times plowing+ weedy check, twice plowing + S-metolachlor at 1 Lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS and three times plowing+ twice hand weeding at 30-35 and 50-55 DAS. However, the lowest mean grain yield (748.3 kg/ha) was, however, recorded under interaction of twice plowing + application of S-metolachlor at 1 Lt ha⁻¹ followed by twice plowing+ application of pendimethalin at 3 Lt ha⁻¹ (Table2). This result indicated that three times plowing + application of pendimethalin at 3 Lt ha⁻¹ supplemented by once hand weeding at 30-35 DAS and three times plowing + application of S-metolachlor at 1 Lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS were gave highest grain yield of faba bean as compared to other treatments. Similarly, research conducted at Holeta and Shamboo showed that repeated plowings before planting significantly increased grain yield of faba bean (Endale Asmare and Rezene Fessehaie, 1991; Tolera Abera and Daba Feyisa, 2004). Bellido *et al.* (2003) also reported pre-planting conventional tillage is productive than no tillage in three rainy years.

Thousand seed weight

High significant difference was observed among treatments on thousand seed weight (Table 2). Maximum mean thousand seeds weight (696.75 g) and (693.47g) were obtained from the interaction of three times plowing + application of Pendimethalin at 3 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 DAS and 50-55 DAS and twice plowing + weedy check, respectively, though most of means showed statistical parity. Whereas, the lowest value (650.27 g) was recorded from three times plowing + application S-metolachlor at 1 litter ha⁻¹ supplemented with twice hand weeding. This is because of the fact that as pods of faba bean per plant increases, seed size decreased to accommodate more pod clusters in a node.

Table 2. Effect of integrated *R. raphanistrum* weed management on grain yield and thousand seed weight of faba bean in Woliso district during 2017-2018

Treatments	Crop Biomass (Kg/ha)	Grain yield kg/ha	1000 seed weight(g)
Year 2017	3595.8 ^a	1333.27 ^a	665.919 ^b
Year 2018	2320.8 ^b	1025.35 ^b	682.854 ^a
LSD (0.05)	275.84	136.83	10.995
Twice plowing+ S-metolachlor 1 Lt ha ⁻¹ + once hand weeding at 30-35 DAS	2958.3 ^{cdef}	1379.3 ^{abc}	684.28 ^{abc}
Twice plowing+ S-metolachlor 1 Lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	2425.0 ^{efg}	982.2 ^{def}	662.03 ^{bcd}
Twice plowing+ Pendimethalin 3 Lt ha ⁻¹ + once hand weeding at 30-35 DAS	2791.7 ^{def}	1150.3 ^{bcde}	666.25 ^{abcd}
Twice plowing+ Pendimethalin 3 Lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	2775.0 ^{def}	1092.7 ^{bcdef}	665.83 ^{abcd}
Twice plowing+ twice hand weeding at 30-35 and 50-55 DAS	1883.3 ^g	1108.3 ^{bcdef}	678.50 ^{abcd}
Twice plowing+ S-metolachlor 1 Lt ha ⁻¹	2241.7 ^{fg}	748.3 ^f	656.32 ^{cd}
Twice plowing+ Pendimethalin 3 Lt ha ⁻¹	2725.0 ^{def}	795.5 ^{ef}	657.52 ^{cd}
Twice plowing+ weedy check	2750.0 ^{def}	1147.2 ^{bcde}	693.47 ^a
Three times plowing+ S-metolachlor 1 Lt ha ⁻¹ + once hand weeding at 30-35 DAS	3066.7 ^{cde}	1271.8 ^{abcd}	673.62 ^{abcd}
Three times plowing+ S-metolachlor 1 ltha ⁻¹ + twice hand weeding at 30-35 and 50-55 DAS	3625.0 ^{abc}	1462.8 ^{ab}	650.27 ^d
Three times plowing+ Pendimethalin3 Lt ha ⁻¹ + once hand weeding at 30-35 DAS	4241.7 ^a	1541.2 ^a	683.97 ^{abc}
Three times plowing+ Pendimethalin 3 Lt ha ⁻¹ + twice hand weeding at 3-35 and 50-55DAS	3908.3 ^{ab}	1384.8 ^{abc}	696.75 ^a
Three times plowing+ twice hand weeding at 30-35 and 50-55 DAS	2700.0 ^{def}	1311.0 ^{abcd}	686.38 ^{abc}
Three times plowing+ S-metolachlor 1 Lt ha ⁻¹	2658.3 ^{efg}	1098.2 ^{bcdef}	675.73 ^{abcd}
Three times plowing+ Pendimethalin3 Lt ha ⁻¹	3366.7 ^{bcd}	1064.7 ^{cdef}	666.43 ^{abcd}
Three times plowing+ weedy check	3216.7 ^{bcd}	1331.0 ^{abcd}	692.83 ^{ab}
LSD (0.05)	780.19	387.01	31.099
CV (%)	22.85	30.35	3.99

Note: CV= Coefficient of Variation, LSD=Least significance difference, DAS=Days after sowing, Lt =litter, Means followed by the same letter within a column are not significantly different at 0.05p

***R. raphanistrum* weed count, height and fresh biomass**

There was significant interaction effect of plowing frequency, application of herbicide and hand weeding on *R. raphanistrum* plant count, height and biomass in faba bean field (Table 3). The lowest (18.67 and 21.33 weed/m²) *R. raphanistrum* plant count was recorded from three times plowing + twice hand weeding at 30-35 and 50-55 DAS and three times plowing + application S-metolachlor at 1 Lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS, respectively. The highest (62.67 weeds/m²) weed count was recorded from twice plowing + application of S-metolachlor at 1 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS followed by twice plowing + application of S-metolachlor at 1 Lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS, but most of treatments showed statistical parity. Therefore, three times plowing + application of S-metolachlor at 1 litter ha⁻¹ and three times plowing + application S-metolachlor at 1 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55DAS were effective in reducing *R. raphanistrum* weed population as compared to other treatments.

There was significant interaction effect of plowing frequency, application of herbicide and hand weeding on *R. raphanistrum* weed height and weed biomass in faba bean (Table 3). The shortest (36.36cm) *R. Raphanistrum* height was recorded from twice plowing + application of Pendimethalin at 3 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS followed by three times plowing+ application of Pendimethalin at 3 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS and three times plowing+ application of S-metolachlor at 1 litter ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55DAS, respectively, but as par with twice plowing+ S-metolachlor at 1 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS. The tallest (126.1 cm and 124.9 cm) mean *R. raphanistrum* height was recorded from three times plowing + application of pendimethalin at 3 Lt ha⁻¹ and three times plowing + application of S-metolachlor at 1 litter ha⁻¹, respectively. But non- significantly with twice plowing + Pendimethalin at 3 Lt ha⁻¹. This indicted that *R. raphanistrum* height was highly influenced by application of Pendimethalin at 3 Lt ha⁻¹ and S-metolachlor at 1 Lt ha⁻¹ when supplemented by twice hand weeding at 30-35 and 50-55 DAS as compared to other treatments. This is because of the fact that *R. raphanistrum* can managed at different germination stage because of the integration of pre emergence herbicide and twice hand weeding at different time.

The lowest weed fresh biomass (150.0 kg/ha and 191.7 kg/ha) was recorded from three times plowing + application of S-metolachlor at 1 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS and three times plowing + application of Pendimethalin at 3 Lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS, respectively (Table 3). The highest (9008.5 kg/ha) fresh weed biomass was recorded from three times plowing + weedy check. Non-significant different was observed among all treatment which was supplemented by twice hand weeding. The higher weed fresh biomass in weedy check might be due to higher weed density that provided an opportunity for the weeds to compete vigorously for nutrients, space, light, and water and carbon dioxide. These results are in agreement with findings of Alfonso et al., (2013) and Das and Yaduraju, (1999) who reported maximum weed dry weight in weedy check treatments.

Table 3. Effect of integrated weed management on *R. raphanistrum* plant count, height and fresh biomass in Waliso district during 2017/2018

Treatments	<i>R. raphanistrum</i> weed count/m ²	<i>R. raphanistrum</i> height (cm)	<i>R. raphanistrum</i> fresh biomass (kg/ha)
Year 2017	27.833 ^b	106.835 ^a	2288.5 ^b
Year 2018	48.250 ^a	50.322 ^b	3311.5 ^a
LSD (0.05)	10.43	7.0516	571.83
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	53.33 ^{ab}	65.79 ^{de}	2125.0 ^{def}
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	62.67 ^a	42.29 ^{fgh}	266.7 ^{gh}
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	25.33 ^{bc}	65.77 ^{de}	1875.0 ^{defg}
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	48.00 ^{abc}	36.36 ^h	391.7 ^{gh}
Twice plowing+ twice hand weeding at 30-35 and 50-55 DAS	40.67 ^{abc}	58.01 ^{efg}	825.0 ^{fgh}
Twice plowing+ S-metolachlor 1 lt ha ⁻¹	28.67 ^{bc}	102.871 ^{bc}	4416.7 ^c
Twice plowing+ Pendimethalin 3 lt ha ⁻¹	28.00 ^{bc}	112.024 ^{ab}	3225.0 ^{cd}
Twice plowing+ weedy check	35.33 ^{abc}	85.21 ^{cd}	4458.3 ^c
Three times plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	36.00 ^{abc}	97.98 ^{bc}	2458.3 ^{de}
Three times plowing+ S-metolachlor 1 ltha ⁻¹ + twice hand weeding at 30-35 and 50-55 DAS	21.33 ^c	39.11 ^{gh}	150.0 ^h
Three times plowing+ Pendimethalin3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	46.00 ^{abc}	87.59 ^c	1300.0 ^{efgh}
Three times plowing+ Pendimethalin 3 lt ha ⁻¹ + twice hand weeding at 3-35 and 50-55DAS	28.67 ^{bc}	38.89 ^{gh}	191.7 ^h
Three times plowing+ twice hand weeding at 30-35 and 50-55 DAS	18.67 ^c	59.09 ^{ef}	366.7 ^{gh}
Three times plowing+ S-metolachlor 1 lt ha ⁻¹	38.67 ^{abc}	124.983 ^a	7491.7 ^{ab}
Three times plowing+ Pendimethalin3 lt ha ⁻¹	54.00 ^{ab}	126.133 ^a	6250.0 ^b
Three times plowing+ weedy check	43.33 ^{abc}	115.144 ^{ab}	9008.5 ^a
LSD (0.05)	29.502	19.945	1617.4
CV (%)	67.19	21.99	50.05

Note: CV= Coefficient of Variation, LSD=Least significance difference, DAS=Days after sowing, lt =litter, Means followed by the same letter within a column are not significantly different at 0.05p

R. Raphanistrum Management on Economic Feasibility of Faba Bean Production

Partial budget analysis for different treatments was indicted in table 4. The value to cost ratio for plowing frequency was 6.62 to 42.01 EB per unit investment. The highest marginal rate of return of 2942% was obtained from three times plowing with no hand weeding. *R. raphanistrum* management with three times plowing combined with application of Pendimethalin at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS gave net profit advantage of 23174 EB with marginal rate of return of 187 % followed by three times plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS and twice plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS gave net benefit of 22352 and 21208 EB per hectare with marginal rate of return of 527 and 29 %, respectively (Table 4). The economic analysis confirmed that *R. raphanistrum* weed management on faba bean was profitable with three times plowing + application of Pendimethalin at 3 lt ha⁻¹ herbicide supplemented with once hand weeding at 30-35 DAS or three times plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS for Waliso district.

Table 4. Effects of integrated *R. Raphanistrum* management on economic profitability of faba bean during 2017-2018 cropping season

Treatments	Grain yield kg/ha	Adjusted yield kg/ha	Gross field benefit (EB/ha)	Herbicide cost (EB/ha)	Plowing cost (EB/ha)	Weeding cost (EB ha ⁻¹)	TCV (EB/ha)	Net benefit EB	Value to cost ratio	MRR (%)
Twice plowing+ S-metolachlor 1 liter ha ⁻¹	748	673.2	12117.6	0	195	237	432	11686	27.05	
Twice plowing+ weedy check	1147	1032.3	18581.4	0	195	237	432	18149	42.01	
Thrice plowing + weedy check	1331	1197.9	21562.2	0	293	237	530	21032	39.68	2942
Twice plowing+ twice hand weeding at 30-35 and 50-55 DAS	1108	997.2	17949.6	0	195	356	551	17399	31.58	
three times plowing+ twice hand weeding at 30-35 and 50-55 DAS	1311	1179.9	21238.2	0	293	356	649	20589	31.72	
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	1379	1241.1	22339.8	700	195	237	1132	21208	18.73	29
three times plowing+ S-metolachlor 1 lt ha ⁻¹ + once hand weeding at 30-35 DAS	1272	1144.8	20606.4	700	293	237	1230	19376	15.75	
three time plowing+ S-metolachlor 1 lt ha ⁻¹	1098	988.2	17787.6	700	293	237	1230	16558	13.46	
Twice plowing+ S-metolachlor 1 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	982	883.8	15908.4	700	195	356	1251	14657	11.72	
Thrice plowing+ S-metolachlor 1 lt ha ⁻¹ + twice hand weeding at 30-35 and 50-55 DAS	1463	1316.7	23700.6	700	293	356	1349	22352	16.57	527
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	1150	1035	18630	1260	195	237	1692	16938	10.01	
Twice plowing+ Pendimethalin 3 lt ha ⁻¹	796	716.4	12895.2	1260	195	237	1692	11203	6.62	
three times plowing+ Pendimethalin 3 lt ha ⁻¹ + once hand weeding at 30-35 DAS	1541	1386.9	24964.2	1260	293	237	1790	23174	12.95	187
three times plowing+ Pendimethalin 3 lt ha ⁻¹	1065	958.5	17253	1260	293	237	1790	15463	8.64	
Twice plowing+ Pendimethalin 3 lt ha ⁻¹ + twice weeding at 30-35 and 50-55 DAS	1093	983.7	17706.6	1260	195	356	1811	15896	8.78	
Three times plowing+ Pendimethalin 3 lt ha ⁻¹ + twice hand weeding at 30-35 and 50-55 DAS	1385	1246.5	22437	1260	293	356	1909	20528	10.75	

Conclusion and Recommendation

The result of the present study showed that plowing frequency, application of pre emergence herbicide supplemented by hand weeding showed significant increase on yield and yield components of faba bean. The highest mean grain yield (1541.2 kg/ha) was obtained from the interaction of three times plowings + application of Pendimethalin at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS followed by thrice plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS with mean grain yields of (1462.8 kg/ha). Similarly, *R. raphanistrum* weed population, height and fresh biomass were significant due to the interaction effect of the treatments. The lowest *R. raphanistrum* weed population, height and fresh biomass were obtained from the interaction of three times plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS. Economic analysis also showed that three times plowing + application of Pendimethalin at 3 litter ha⁻¹ supplemented by once hand weeding at 30-35 DAS gave the highest 23174 EB Net benefit followed by trice plowing + application S-metolachlor at 1 lt ha⁻¹ supplemented by twice hand weeding at 30-35 and 50-55 DAS gave 22352 EB net benefit. Therefore, three times plowing + application of S-metolachlor at 1 lt ha⁻¹ supplemented with twice hand weeding at 30-35 and 50-55 DAS or three times plowing + application of Pendimethalin at 3 lt ha⁻¹ supplemented with once hand weeding at 30-35 DAS is be recommended for an effective and economical management method of *R.raphanistrum* and obtain the highest grain yield in Waliso district of South West Shoa Zone.

References

- Alfonso S, Frenda, Paolo R, Sergio S, Bendetto F, Gjuseppe D, Gaetano A, Dario G. (2013). The critical Period of Weed Control in Faba bean and Chickpea in Mediterranean areas. Weed Science Society of America, 61 (3): 452-459.
- Bellido, R.J.,L. Bellido, F.J. Bellido and J.E. Castillo.(2003). Faba bean (*Vicia faba* L.) response to tillage and soil residual nitrogen in a continuous rotation with wheat (*Triticum aestivum* L.) under rain-fed Mediterranean conditions. Agron. J.95: 1253-1261.
- Brader, L. (1979). Integrated pest control in the developing world. Annual Review of Entomology 24: 225-254
- CIMMYT Economics Program, International Maize, & Wheat Improvement Center (1988) from agronomic data to farmer recommendations: An economics training manual. CIMMYT.
- Das Tk, Yaduraju NT. (1999). Effect of weed competition on growth, nutrient uptake and yield of wheat as affected by irrigation and fertilizers. Journal of Agricultural Science, 133(1): 45-51.
- Dhaba Feyisa, Tolera Abera and Girma W/Tsadik. (2005). Estimated yield loss in bread wheat (*Triticum aestivum*) following control of *Raphanus raphanistrum* with herbicides and hand weeding. *Arem 2005 Volume 6: 79 -84*.
- El-Metwally IM, Abdelhamid MT. (2008). Weed competition on growth, nutrient uptake and yield of wheat as affected by irrigation and fertilizers. Journal of Agricultural Science, 133(1): 45-51.
- Endale Asmare and Rezene Fessehaie. (1991). Evaluation of tillage and weed control methods in faba bean field at Welmera. Nile Valley Regional Programme on Cool-Season Food Legumes. Annual Report 1989/90, Ethiopia. ICARDA/NVRP-DOC_011.
- Hadi H, Ghassemi-Golezani K, Khoei FR, Vaizadeh, M, Shakiba MR, (2006). Response of common bean (*Phaseolus vulgaris* L.) to different levels of shade. Journal of Agronomy, 5: 595-599.
- Hodgson GL, Blackman GE. (2005). An analysis of the influence of plant Density on the Growth of *Vicia faba*. Journal of Experimental Botany, 48: 147-165.
- Pereira GAM, Barcellos JR, Silva DV, Bragam RR, Teixeira M, Silva AA, Ribeiro JR. (2015). Application Height in Herbicides Efficiency in Bean Crops. *Planta Daninha*, 33(3) : 607-614.
- Retter, L. and Harden, G.J.(2007). *Raphanus raphanistrum* L. New South Wales Flora Online. Plant NET - The Plant Information Network System of Botanic Gardens Trust. <http://plantnet.rbgsyd.nsw.gov.au>. Royal Botanic Gardens and Domain Trust, Sydney, New South Wales.
- Tolera Abera and Daba Fayisa. (2004). Effect of ploughing frequency, seed rate and weeding frequency on agronomic parameters of faba bean on farmers fields at Shamboo, Ethiopia. In: Proceeding of the 11th CSSE Conference, 26-27 april 2004, Addis Ababa, Ethiopia