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Effect of Different Weed Management Practices on Growth, Yield and Yield Components of Faba Bean (*Vicia faba* L.) In Bale Highland Conditions, Southeastern Ethiopia

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Abstract: Weed is the major production constraints for faba bean production in Bale Highlands. Its management is quite important to increase the production and productivity of the crop. Due to such gaps, the experiment was conducted at two locations *viz.,* Sinana (on-station and on farmers field) during 2015 and 2016 "*Bona*" main cropping seasons to evaluate the effect of hoeing plus hand weeding frequencies on the yield of faba bean. The treatments were consisted of eleven weed management options i.e. weedy check, Hand weeding at 25-30 days after emergence (DAE) and then at 40-45 DAE, Hoeing at 7 DAE + hand weeding at 25-30 and then 40-45 DAE, Hoeing at 7 DAE + hand weeding at 25-30 DAE, Hoeing at 7 DAE + hand weeding at 40-45 DAE, Hoeing at 14 DAE + hand weeding at 25-30 DAE and then at 40-45 DAE, Hoeing at 14 DAE + hand weeding at 25-30 DAE, Hoeing at 14 DAE + hand weeding at 40-45 DAE, Hoeing at 21 DAE + hand weeding at 40-45 DAE, Hoeing at 28 DAE + hand weeding at 40-45 DAE, Weed removal at 50% pod setting stage. It was laid out in a randomized complete block design (RCBD) with three replications. Results indicated that faba bean plant was flowered and matured early when infested with weeds as compared to well weed controlled treatments at both sites.The growth and yield attributes of faba bean were significantly reduced when the crop was left unweeded. The result also showed that there was about 41% and 35% yield reduction occured due to total weed infestation of faba bean as compared to the recommended two times hand weeding at on-station and on-farm respectively. Hoeing at 7 DAE plus twice hand weeding gave a yield advantage of 51% and 17% as compared to weedy check and the recommended two times hand weeding at on-station. There was 51% and 41% yield penalty while farmers remove weed at 50% pod setting stage for the purpose of feeding their livestock as compared to hoeing at 7 DAE plus twice hand weeding and the recommended two times hand weeding at on-station. Similarly, there was a yield loss of 17% while weed removal at 50% pod setting stage as compared to the recommended two times hand weeding and hoeing at 28 DAE plus once hand weeding at 40-45 DAE at on-farm. Thus, it was concluded that the use of weed management options as of hoeing at 7 DAE plus hand weeding at 25-30 DAE was more economically profitable and has an acceptable marginal rate of return at both locations.

Key words: Faba bean · Hand weeding management · Hoeing · Weed

INTRODUCTION

Faba bean *(Vicia faba* L.) is a valuable crop plant worldwide. It is the leading most important pulse crop grown in the highland areas of Ethiopia. In Bale zone of Oromia regional state, the crop is widely cultivated by the state farms and small scale farmers. It can be used as an effective break crop in cereal rotations since it substantially improves soil fertility through biological nitrogen fixation. At the same time, it produces seeds with high protein content frequently exceeding 20-41% [1]. It has been considered as a meat extender or substitute and as a skim-milk substitute [2]. It also generates household income for the farming community. However, the yield of faba bean is generally low due to several biotic and abiotic yield limiting factors. Among them, poor weed management in addition to poor soil fertility, untimely sowing and the lack of improved varieties are the major ones [3].

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Faba bean is a very sensitive crop to the competition of both broad-leaf and grass weed species [4]. They also observed that the extent to which the yield is reduced by weeds depends not only on the weed species and density but also on the period for which the crop is exposed to weeds. Therefore, inadequate and untimely weed control operation is one of the crucial factors causing low yields of the crop. In the study area, weeds are a challenging problem to pulse crop producers. Since the herbicides for most pulses crops are not locally available or very limited access, most small scale farmers could not access to use the chemical for weed control. Due to such reasons, hand weeding is the common cultural practice to remove weed from pulse crop fields. However, most of the farmers in Bale highlands, where faba bean is widely grown, have been practicing differently at different growth stages of the crop in order to remove the weeds. Some of the farmers remove at the recommended time while others react after severe competition occurred. In the meantime, in addition to hand weeding, most farmers started hoeing to reduce weed pressure. On the other hand, some farmers do not remove the weed until pod setting since they maintain the weeds for animal feeds in areas where a shortage of animal feeds are the main challenges. These temporal variations of weed managements considerably varied the yield performances of the crop and as a result its production and productivity across locations and seasons is low in which the average yield under small holder farmers' is not more than 1.8t ha^{-1} as compared to its potential productivity (3.8t ha^{-1}) the recently released variety [5]. However, the right time of hoeing and hoeing in combination with hand weeding frequencies and their economic feasibility studies were lacking in the study area. Therefore, this study was designed to evaluate the effect of hoeing and hand weeding frequencies on growth, seed yield and yield components of faba bean and to recommend economically profitable cultural weed management options.

MATERIALS AND METHODS

Experimental Sites: The experiment was conducted on research field of Sinana Agricultural research center and Sinana on-farm in the highlands of Bale, South-eastern Ethiopia under rainfed conditions during the main cropping seasons of 2015 and 2016. Sinana is located at a distance of about 463 km from Addis Ababa at about 7°07'N longitude and 40°10'E latitude, at an altitude of about 2400 meters above sea level. The area is characterized by bimodal rainfall pattern which is locally

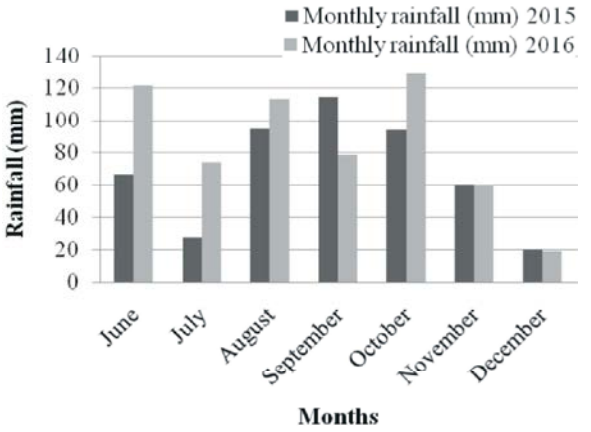

Fig. 1: Monthly rainfall during the experimental years (2015 and 2016 main cropping seasons) at Sinana, Source: Sinana Agricultural Research Center Meteorological Station.

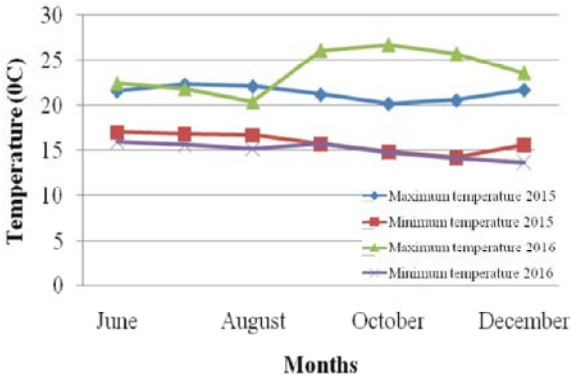

Fig. 2: Mean monthly maximum and minimum temperatures (°C) during the experimental years (2015 and 2016 main cropping season) at Sinana, Source: Sinana Agricultural Research Center Meteorological Station.

called "*Bona*" and "*Ganna*" based on the time of crop harvest. The seasonal annual rainfall of the area during the cropping seasons (2015 and 2016 main cropping season) was 475 mm and 594 mm, with an average minimum temperature of 15.81°C and 14.95°C and maximum temperature of 21.37°C and 23.84°C, respectively (Fig. 1 & 2). The soil of the area was characterized by Cambisol. The preceding crops planted in experimental sites were bread wheat which is the precursor of the current faba bean.

Experimental Treatments and Design: For this experiment, faba bean variety called 'Mosisa' was used as a test crop. It was released by Sinana agricultural research center in 1999/2000. The treatments consisted of eleven

weed management options: (1) Weedy check, (2) Hand weeding at 25-30 days after emergence (DAE) and 40-45 DAE, (3) Hoeing at 7 DAE, hand weeding at 25-30 DAE and 40-45 DAE, (4) Hoeing at 7 DAE and hand weeding at 25-30 DAE, (5) Hoeing at 7 DAE and hand weeding at 40-45 DAE, (6) Hoeing at 14 DAE, hand weeding at 25-30 DAE and 40-45 DAE, (7) Hoeing at 14 DAE and hand weeding at 25-30 DAE, (8) Hoeing at 14 DAE and hand weeding at 40-45 DAE, (9) Hoeing at 21 DAE and hand weeding at 40-45 DAE, (10) Hoeing at 28 DAE and hand weeding at 40-45 DAE, (11) Hand weeding or weed harvesting at 50% pod setting stage. The experiment was laid out in a randomized complete block design (RCBD) replicated thrice. Each plot consisted of 3 meters long 4 rows spaced 40 cm a part. The size of each plot was 3m x 1.6m ($4.8m^2$) and the adjacent blocks and plots were separated by 1m and 0.6m distances, respectively. The net central unit area of each plot consisted of 2 rows of sample measurements, leaving aside plants in the two outer rows and those at both ends of each of the rows to avoid border effects. The distance between plants was 10cm. The recommended seed rate of 125 kg ha^{-1} and 100 kg ha^{-1}NPS fertilizer was uniformly supplied for each treatment at planting.

Partial Budget Analysis: The partial budget analysis was done using [6] to identify the rewarding treatments. Actual yields from experimental plots were adjusted down ward by 10% to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment. This is due to optimum plant population density, timely labor availability and better management in weed control and better security under experimental conditions [6]. To find out the gross return the price of faba bean (sale price of 12.50 Birr kg^{-1}) prevailing in the local market at the time of harvest which is the average of one month was taken into account. Similarly, the variable costs that vary included the cost of labor for hoeing and hand weeding frequencies were; hoeing at 7, 14, 21 and 28 DAE was valued as 1800, 2100, 2400 and 2700 Birr ha^{-1} respectively. On the other hand, once hand weeding at 25-30 DAE and 40-45 DAE which followed hoeing was 1800 and 2100 Birr ha^{-1} respectively. The two times hand weeding followed hoeing and once hand weeding was 1500 Birr $ha^{-1}$and weed removal at 50% pod setting stage was 2700 Birr ha^{-1}. Two times hand weeding (at 25-30 and 40-45 DAE) without hoeing was 2400 and 2100 Birr ha^{-1} respectively.

Data Collection: Data were collected on days to flower, days to maturity, plant height, the number of pods $plant^{-1}$, the number of seeds pod^{-1}, aboveground biomass yield (kg ha^{-1}), seed yield (kg ha^{-1}) and 1000 seed weight in gram were recorded from each net plot. Thus, days to flower was determined by counting the number of days from the date of emergency to the period when 50% of the plants had flower based on visual observations. Days to maturity was determined by counting the number of days from the date of emergence to the period when 90% of the plants had reached the physiological maturity based on visual observations. Plant height (cm) was measured in meter from five randomly selected plants in each net plot area from the base to the tip (apical bud) of the main stem at physiological maturity. The number of pods $plant^{-1}$ was determined by counting the number of pods from each randomly selected non-border five plants and the average count was taken as the number of pods per $plant^{-1}$. The number of seeds pod^{-1} was determined by dividing the total number of seeds from five randomly selected non-border plants by the total number of pods from each selected five plants. Aboveground dry biomass yield (kg ha^{-1}) were determined as; at physiological maturity, plants from the central four rows of a net plot size 1.6m x3m ($4.8m^2$) were manually harvested close to ground surface using the sickle. Then the harvested plants were sun dried in open air and then weighed to determine the aboveground biomass yield per hectare. Seed yield (kg ha^{-1}) was measured after threshing the sun dried plants harvested from each net plot size $4.8m^2$ and the cleaned seed yield was weighted using an electronic balance and adjusted at 10.5% seed moister content. Finally, yield per plot was converted to per hectare basis. 1000 seed weight (g) was determined by counting 1000 seeds randomly sampled from seed lots of each treatment and weighed using an electronic balance.

Data Analysis: All the collected data were analyzed using [7]. The treatments were compared for their significance using calculated least significance difference (LSD) values at 5% level of probability.

RESULT AND DISCUSSIONS

This experiment was conducted for two years (2015/16 and 2016/17 cropping seasons) at two locations in Sinana district (at Sinana agricultural research center experimental station and on-farm). In 2015/16 cropping

season, the experiment was conducted at both locations and all the required field data were collected. Even though the experiment was repeated at the same locations in the second year (2016/17), the on-farm trial was totally failed due to frost damage occurred before the time of maturity stage. Therefore, the current result was summarized from the two years data of Sinana research station and one-year data from farmer's field.

Flowering and Maturity Date: Table 1 and 2 showed that weed management practices had a significant effect on flowering and maturity date at both locations. The result indicated that hoeing either at 7 DAE and then hand weeding at 25-30 and 40-45 DAE or hoeing at 7 DAE and then hand weeding at 25-30 DAE at on-station flowered late compared to other treatments. On the other hand, hoeing at 7 DAE and followed by hand weeding at 40-45 DAE and hoeing at 14 DAE and then hand weeding at 25-30 and then 40-45 DAE at on-farm flowered lately compared to the other treatments. While weedy check plots were flowered early at both locations. This may be due to resource competition caused narrow leaf which fix the lowest amount of nitrogen and less translocation of photosynthates from source to sink which resulted in late flower formation. Regarding maturity period at both locations, hoeing at 28 DAE with hand weeding at 40-45 DAE matured late as compared to weedy check and weed harvesting at 50% pod setting stage. This implies that the presence of weeds in the faba bean field might cause severe resource competition with the crop that may lead to forced maturity. Similar result was reported by [8], who reported that weedy check treatment was flower and matured early as compared to the intensive weed management treatments due to resource competitions in weedy check caused forced phonological growth of the crop.

Plant Height: Result of plant height presented in Tables 1 and 2 showed that weeding treatment had significant effect on plant height at Sinana on-station while non-significatn effect at on-farm. The highest in plant height (114.3 cm) at on-station was recorded when hoeing at 7 DAE and hand weeding at 40-45 DAE and followed by hoeing at 14 DAE and hand weeding at 40-45 DAE, respectively. The shortest plant height was recorded at weedy check, two times hand at 25-30 DAE and then 40-45 DAE and hoeing at 14 DAE plus two times hand weeding at 25-30 DAE and then 40-45 DAE. This may be early weed removal facilitates plants to have more resources for growth. These results agreed with [9, 10] they found that twice hand weeding significantly increased shoot length while unweeded treatment had decreased plant height. Similarly, [8, 11, 12] also reported the tallest plant was obtained in weed free treatment and under intensive weed management, while the smallest was observed at control treatment.

Number of Pods Plant^{-1}: Weed managemet practices significantly affected number of pods plant^{-1} at Sinana on-station while no significant effect at on-farm. The highest number of pods plant^{-1} (13.9) at on-station was obtaineed when hoeing at 7 DAE and hand weeding at 25-30 DAE and then 40-45 DAE though it was in par with most treatments. The minimum value was observed in weedy check and weed removal at 50% pod setting stage.

Table 1: Effect of weed management practices on faba bean growth, yield and yield components at Sinana research station during 2015 and 2016 main cropping season.

Treatments	DF	DM	PH (cm)	PPP	SPP	BY (kg ha^{-1})	SY (kg ha^{-1})	TSW (g)
Weedy check	55^{c}	127^{ab}	98.7^{c}	7.4^{c}	2.4	3993^{d}	1990.2^{d}	483^{bcd}
HW at 25-30 & 40-45 DAE	55^{c}	128^{a}	98.7^{c}	12.7^{ab}	2.3	7708^{abc}	3387.8^{abc}	488^{bcd}
Hoeing at 7 DAE+HW at 25-30 & 40-45 DAE	57^{a}	128^{a}	103.1^{abc}	13.9^{a}	2.1	9653^{a}	4068.8^{a}	476^{bcd}
Hoeing at 7 DAE + HW at 25-30 DAE	57^{a}	128^{a}	104.2^{abc}	11.7^{abc}	2.2	8125^{ab}	3768.8^{ab}	463^{d}
Hoeing at 7 DAE + HW at 40-45 DAE	56^{abc}	113^{b}	114.3^{a}	12.1^{ab}	2.6	7465^{abc}	3557.9^{abc}	505^{ab}
Hoeing at 14 DAE+HW at 25-30 & 40-45 DAE	56^{abc}	129^{a}	98.9^{c}	11.6^{abc}	2.4	6528c	2803.7^{bcd}	485^{bcd}
Hoeing at 14 DAE + HW at 25-30 DAE	56^{abc}	128^{a}	105.2^{abc}	12.9^{ab}	2.5	8021^{abc}	3517.1^{abc}	467^{cd}
Hoeing at 14 DAE + HW at 40-45 DAE	56^{abc}	128^{a}	111.7^{ab}	12^{ab}	2.3	5868^{cd}	2635.8^{cd}	500^{abc}
Hoeing at 21 DAE + HW at 40-45 DAE	55^{c}	128^{a}	100.9^{bc}	12.3^{ab}	2.5	6493^{bc}	2988.5^{a-d}	493^{a-d}
Hoeing at 28 DAE + HW at 40-45 DAE	55^{c}	130^{a}	101.2^{bc}	11.8^{abc}	2.4	7292^{bc}	3229.0^{abc}	527^{a}
Weed Removal at 50% Pod setting stage	55^{c}	127^{ab}	100.3^{bc}	9.2^{bc}	2.3	4167^{d}	1992.3^{d}	493^{a-d}
Mean	55.7	127	103.4	11.6	2.4	6846.6	3085.44	489.09
LSD (5%)	1.51	15.04	12.238	4.54	Ns	2252.4	1125.7	35.52
CV (%)	2.33	10.26	10.22	33.76	17.1	28.39	31.49	6.27

Means with the same letters are non significant, DF= Days to flowering, DM= Days to maturity, PH= Plant height, PPP= Pods per plants, BY= Biomass yield, SY =seed Yield, TSW= Thousand seed weight, CV= Coefficient of variation, LSD= Least significant difference.

Table 2: Effect of weed management practices on faba bean growth, yield and yield components at Sinana on-farm during 2015 main cropping season.

Treatments	DF	DM	PH (cm)	PPP	SPP	BY (kg/ha)	SY (kg/ha)	TSW (g)
Weedy check	63^{d}	132^{b}	132	13	2.3^{ab}	7431^{d}	2349^{b}	496
HW at 25-30 & 40-45 DAE	64^{cd}	134^{ab}	137	19	2.6^{ab}	10417^{abc}	3616^{a}	496
Hoeing at 7 DAE+HW at 25-30 & 40-45 DAE	64^{cd}	135^{ab}	131	14	2.6^{ab}	10764^{ab}	3577^{a}	484
Hoeing at 7 DAE + HW at 25-30 DAE	65^{ab}	134^{ab}	132	15	2.5^{ab}	10764^{ab}	3392^{a}	489
Hoeing at 7 DAE + HW at 40-45 DAE	66^{a}	135^{ab}	135	15	2.7^{ab}	9375^{bcd}	3262^{a}	493
Hoeing at 14 DAE+HW at 25-30 & 40-45 DAE	66^{a}	135^{ab}	134	17	2.7^{ab}	11667^{a}	3338^{a}	459
Hoeing at 14 DAE + HW at 25-30 DAE	64^{cd}	134^{ab}	135	18	2.2^{b}	10139^{abc}	3231^{a}	451
Hoeing at 14 DAE + HW at 40-45 DAE	65^{ab}	135^{ab}	135	17	2.4^{ab}	10972^{ab}	3422^{a}	493
Hoeing at 21 DAE + HW at 40-45 DAE	64^{cd}	134^{ab}	132	14	2.9^{a}	10347^{abc}	3212^{a}	465
Hoeing at 28 DAE + HW at 40-45 DAE	65^{ab}	136^{a}	133	20	2.4^{ab}	10139^{abc}	3621^{a}	498
Weed Removal at 50% Pod setting stage	65^{ab}	132^{b}	129	16	2.5^{ab}	8472^{cd}	2987^{ab}	474
Mean	64.6	134.2	133	16.2	2.5	10044.3	3273.4	482
LSD (5%)	1.66	3.70	ns	Ns	0.65	2047.9	706.51	ns
CV (%)	1.51	1.62	4.91	24.1	15.1	11.97	12.67	6.95

Means with the same letters are non significant, DF= Days to flowering, DM= Days to maturity, PH= Plant height, PPP= Pods per plants, BY= Biomass yield, SY =seed Yield, TSW= Thousand seed weight, CV= Coefficient of variation, LSD= Least significant difference.

This may be early weed removal facilitates plants to have more resources for growth and low abortion of flowers at the early crop growth stage due to less weed-crop completion for resources especially, for sunlight. These results are in comformity with the findings of [9, 10], they found that twice hand weeding increased number of pods plant^{-1} while unweeded treatment had low number of pods lant^{-1}.

Number of Seeds Pod^{-1}: Weed control methods showed significant effect on number of seeds pod^{-1} at Sinana on-farm. Whereas, it was non-significant at on-station. This difference might be ascribed the differences in environmental and soil conditions that prevailed at the two locations. The data from on-farm revealed that the highest number of seeds pod^{-1} (2.9) was recorded by hoeing at 21 DAE and hand weeding at 40-45 DAE though it was in par with most treatments. This might be due to low weed-crop competition at early stage and high competition at later stages. The lowest value was recorded when hoeing at 14 DAE and hand weeding at 25-30 DAE though it was in par with most of the treatment. This result was in line with [13, 14]. They also reported the highest number of seeds pod^{-1} under weed free treatment, while the lowest was obtained under weed infested treatment. Contradicting to the current result, [15] reported that number of seeds pod^{-1} was not affected by weed control measures since it was genetically controlled and part of plant character.

Biomass Yield: As indicated in Tables 1 and 2, various cultural weed management practices had significantly (P=0.05) influenced the biomass yield. The highest biomass yield (11667 and 9653 kg ha^{-1}) were obtained by hoeing at 7 DAE plus hand weeding at 25-30 and then at 40-45 DAE at on-station and hoeing at 14 DAE plus once hand weeding at 25-30 and then at 40-45 DAE, but statistically at par with most treatments at on-farm. The next highest biomass yield (10972 and 8125 kg ha^{-1}) were obtained when hoeing at 14 DAE plus hand weeding at 40-45 DAE and hoeing at 7 DAE plus hand weeding at 25-30 DAE were practiced while the lowest values were recorded under weedy check (7431 and 3993 kg ha^{-1}) followed by weed removal at pod setting stage (8472 and 4167 kg ha^{-1}) at on-farm and on-station respectively. Hoeing at an early growth stage (14 DAE) in combination with hand weeding at 25-30 and then at 40-45 DAE at on-farm and hoeing at 7 DAE in combination with hand weeding at 25-30 DAE and then at 40-45 DAE had shown significant biomass yield increase by 11% and 20% at on-farm and on-station, respectively as compared to hand weeding practices at 25-30 DAE and then 40-45 DAE (Table 1). This result implies that in addition to early established weed control, hoeing at early growth stage may improve soil aeration that could help for effective microbial activities, particularly for biological nitrogen fixation and hence N availability to the crop might be improved. Moreover, the higher biomass yield under intensive weed management practices might be due to the effect of weed control from the early establishment of the crop by hoeing and then hand weeding that significantly reduced the competition effect. In agreement with this result [14], reported the highest biomass yield were obtained at once hand weeding plus hoeing at 4 weeks after crop emergence which was non-significantly different from once hand weeding plus hoeing at 3 weeks after an emergence and complete weed free treatments. They further reason out that it might be due to a better

condition in soil rhizosphere which improved the competitive ability of the crop and favored more vegetative growth. Moreover, [16]; reported the increased biomass yield of the crop was highly governed by the length of weed free period.

Seed Yield: The difference in seed yield was observed to be highly significant due to different weed management practices at both locations. At Sinana expermental-station, the highest seed yield (4068.8 kg ha^{-1}) was obtained when hoeing at 7 DAE plus hand weeding at 25-30 and then at 40-45 DAE. The next highest seed yield (3768.8 kg ha^{-1}) was obtained when hoeing at 7 DAE plus hand weeding at 25-30 DAE were practiced. However, the lowest seed yield (1990.2 kg ha^{-1}) was obtained under weedy check and followed by weed harvesting at pod setting stage (1992.3 kg ha^{-1}). Hoeing at an early growth stage (7 DAE) in combination with hand weeding at 25-30 DAE and then at 40-45 DAE had showed significant seed yield increase by 17% compared to hand weeding practices at 25-30 DAE and then at 40-45 DAE (Table 1). This result implies that in addition to early established weed control, hoeing at an early growth stage may improve soil aeration that could help for effective microbial activities, particularly for biological N_2 fixation and hence N availability to the crop might be improved. However, hoeing at or after 14 DAE and even with two times hand weeding at 25-30 DAE and 40-45 DAE considerably reduced grain yield by not less than 31% as compared to hoeing at 7 DAE plus two times hand weeding (25-30 and 40-45 DAE). The yield reduction could be varied from 13-31% when hoeing at or after 14 DAE in combination with different hand weeding frequencies at different crop growth stage. This result clearly revealed that hoeing at an early stage is a determinant effect on the yield performance of the crop in Sinana and similar agro-ecological areas. These results are supported by those of [17, 18]. They found that garden cress and wheat yield were decreased as the weed infested duration increased due to decrease in the yield components like number of branches $plant^{-1}$ and number of seed $plant^{-1}$. Weed harvesting at pod setting stage significantly affected and more than 47% and 51% grain yield reduction were observed compared to hoeing at 7 DAE plus hand weeding at 25-30 DAE and hoeing at 7 DAE plus hand weeding at 25-30 DAE and then 40-45 DAE, respectively. This indicate that faba bean production without weeding until pod setting stage significantly affected yield performance. Although farmers use the weed as an animal feeds when the feed shortage is critical. Similar to this finding, [19, 20] reported that faba bean hand hoeing resulted in a good control of weed.

On the other hand, at Sinana on-farm, all treatment means, except weedy check, were statistically similar yield responses under various cultural weed management practices. Even though yield performance was not significantly different, a 17% numerical yield reduction could occur when weed harvesting at pod setting stage was practiced when compared with hoeing at 28 DAE and then once hand weeding at 40-45 DAE and two times hand weeding (25-30 DAE and 40-45 DAE). This result indicated that weed pressure at early crop establishment was low as compared to Sinana on-station. weed management practices at early stage, at Sinana on-station, resulted in positive yield response as compared to on-farm, which respond to late weed management like hoeing at 28 DAE and then at 40-45 DAE and two times hand weeding at 25-30 DAE and then 40-45 DAE. These two contrasting results might indicate that the variation might be due to the variation in moisture availability or rainfall distribution happened during the experimental season. Thus, during the experimental season at planting time, high amount of rainfall distribution was observed at Sinana on-station not for less than two weeks as compared to on-farm. However, enough moisture was observed at on-farm at crop maturity stage than on-station though, separate meteorological data was not available. Therefore, from Sinana on-farm data, it was observed that the highest seed yield was recorded when hoeing at 28 DAE plus once hand weeding at 40-45 DAE and two times hand weeding at 25-30 DAE and then at 40-45 DAE followed by hoeing at 7 DAE plus once hand weeding at 25-30 DAE and then 40-45 DAE. The result also showed yield reduction of about 35% was observed when faba bean was unweeded completely as compared to hoeing at 28 DAE and then once hand weeding at 40-45 DAE and two times hand weeding at 25-30 DAE and then at 40-45 DAE.

Thousand Seed Weight: Different weed management practices significantly affected 1000 seed weight at on-station while non-significant influence at on-farm. The data from on-station revealed that the highest 1000 seed weight was recorded when hoeing at 28 DAE and then once hand weeding at 40-45 DAE evenghough it was statistically in par with hoeing at 7, 14 and 21 DAE plus hand weeding at 40-45 DAE and weed removal at 50% pod setting stage. This might be due to ealy weed-crop competition was eliminated by hoeing and then the late comer weed competition was omitted by hand weeding. Similar findings were reported by [14, 21] where plants under complete weed free environment were free from weed competition that might have enhanced the

Table 3: Economic and Marginal Analysis of Weed Control Practices at Sinana Research Station, Highlands of Bale, during 2015 and 2016 Main Cropping Seasons.

Treatments	Yield (kg ha^{-1})	AdY (kg/ha)	GI (Birr)	VC (Birr)	NB (Birr)	*MRR* (%)
Weedy check	1990.2	1791.2	22389.75	0	22389.75	---
HW at 25-30 & 40-45 DAE	3387.8	3049.0	38112.75	4500	33612.75	D
Hoeing at 7 DAE+HW at 25-30 & 40-45 DAE	4068.8	3661.9	45774.00	5100	40674.00	125
Hoeing at 7 DAE + HW at 25-30 DAE	3768.8	3391.9	42399.00	3600	38799.00	456
Hoeing at 7 DAE + HW at 40-45 DAE	3557.9	3202.1	40026.38	3900	36126.38	D
Hoeing at 14 DAE+HW at 25-30 & 40-45 DAE	2803.7	2523.3	31541.63	5400	26141.63	D
Hoeing at 14 DAE + HW at 25-30 DAE	3517.1	3165.4	39567.38	3900	35667.38	D
Hoeing at 14 DAE + HW at 40-45 DAE	2635.8	2372.2	29652.75	4200	25452.75	D
Hoeing at 21 DAE + HW at 40-45 DAE	2988.5	2689.6	33620.63	4500	29120.63	D
Hoeing at 28 DAE + HW at 40-45 DAE	3229.0	2906.1	36326.25	4800	31526.25	D
Weed Removal at 50% Pod setting stage	1992.3	1793.1	22413.38	2700	20613.38	D

Table 4: Economic and Marginal Analysis of Weed Control Practices at Sinana On-farm, Highlands of Bale during, 2015 Main Cropping Season.

Treatments	GY (kg ha^{-1})	AGY(kg/ha)	GI(ETB)	VC (ETB)	NB (ETB)	MRR (%)
Weedy check	2349	2114.1	26426.3	0	26426	-
Weed Removal at 50% Pod setting stage	2987	2688.3	33603.8	2700	30904	166
Hoeing at 7 DAE + HW at 25-30 DAE	3392	3052.8	38160	3600	34560	406
Hoeing at 7 DAE + HW at 40-45 DAE	3262	2935.8	36697.5	3900	32798	D
Hoeing at 14 DAE + HW at 25-30 DAE	3231	2907.9	36348.8	3900	32449	D
Hoeing at 14 DAE + HW at 40-45 DAE	3422	3079.8	38497.5	4200	34298	D
HW at 25-30 & 40-45 DAE	3616	3254.4	40680	4500	36180	180
Hoeing at 21 DAE + HW at 40-45 DAE	3212	2890.8	36135	4500	31635	D
Hoeing at 28 DAE + HW at 40-45 DAE	3621	3258.9	40736.3	4800	35936	D
Hoeing at 7 DAE + HW at 25-30 & 40-45 DAE	3577	3219.3	40241.3	5100	35141	D
Hoeing at 14 DAE + HW at 25-30 & 40-45 DAE	3338	3004.2	37552.5	5400	32153	D

HW = Hand weeding, DAE = Days after emergency, AdY = Adjusted yield, GI = Gross income, VC = Variable cost, NB = Net benefit, MRR = Marginal rate of return, D = Dominated

availability of nutrients better translocation of photosynthates from source to sink resulting in higher accumulation of photosynthates in the seed. The lowest value was recorded when hoeing at 7 DAE and then once hand weeding at 25-30 DAE. The main reason for low seed weight might be due to the critical periods of weed competition in faba bean was begin from 30 DAE [11].

Partial Budget Analysis: Economic analysis of different weed management options revealed that weed control in faba bean by the use of hoeing plus hand weeding frequencies gave different economic return as compared to weedy check, weed removal at 50% pod setting stage and hand weeding frequency (Table 3 & 4). Thus, hoeing at 7 DAE plus two times hand weeding at 25-30 and then at 40-45 DAE and two times hand weeding at 25-30 and then 40-45 DAE gave the highest net benefit (40674.00 and 36180.00 birr) followed by hoeing at 7 DAE plus hand weeding at 25-30 DAE and hoeing at 28 DAE plus hand weeding at 40-45 DAE with net benefits of (38799.00 and 35936.25 birr) from on-station and on-farm, respectively. However, the maximum marginal rate of return (455.8 and 406.2%) was recorded for hoeing at 7 DAE plus hand weeding at 25-30 DAE at both locations and showed that it was economical for weed management option in faba bean production. Thus, it was concluded that the use of weed management options as of hoeing at 7 DAE plus hand weeding at 25-30 DAE was more economical at Sinana On-station while two times hand weeding (25-30 DAE and 40-45 DAE) is economically profitable and has an acceptable marginal rate of return.

CONCLUSION AND RECOMMENDATIONS

Weed pressure is the main driver factors that influence the production and productivity of faba bean. Even though integrated weed management approaches is the best option for effective and sustainable weed control, cultural practice is one of the best strategy for the control of weed, particularly in areas where access to post or pre-emergence herbicide is very limited. Among different cultural practices, hoeing and hand weeding are some of them. The result of this experiment, which focused on different cultural practices, revealed that hoeing at 7 DAE plus two times hand weeding (25-30 DAE and then at 40-45 DAE) at on-station two times hand weeding (25-30

DAE and 40-45 DAE) at Sinana On-farm performed an optimum yield advantage compared to other treatments and hence recommended for the end users. On the other hand, even though some farmers in the study areas practiced weed harvesting at pod setting stage for the purpose of animal feeds when the feed shortage is critical, significant yield losses were observed and hence not advisable for faba bean production.

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REFERENCES

1. Crepona, K., P. Marget, C. Peyronnet, B. Carrouea, P. Arese and G. Duc, 2010. Nutritional value of faba bean (*Vicia faba* L.) Seeds for feed and food:Field Crop Research. 115: 329-339.
2. Talal Thalji and Ghalib Shalaldeh. 2006. Effect of planting Date on Faba Bean (*Vicia faba* L.) Nodulation and Performance under Semiarid conditions.
3. Ghizaw, A. and A. Molla, 1994. Faba bean and field pea agronomy research. In: Telaye A., Bejiga G., Saxena M.C., Solh M.B. (eds.): Cool-season food legumes of Ethiopia. Proceedings of the 1stNational Cool-season Food Legumes Review Conference, 16-20 December, 1993, Addis Ababa, Ethiopia. ICARDA/IAR. ICARDA: Aleppo, Syria, 199-229.
4. Getachew Agegnehu and Rezene Fessehaie, 2006. Response of faba bean to phosphate fertilizer and weed control on Nitisols of Ethiopian Highlands. Ital. J. Agron. Riv. Agron., 2: 281-290.
5. Crop Variety Registration year book.2016. Issue Number. 18: June, 2016 Addis Ababa, Ethiopia.
6. CIMMYT (International Maize and Wheat Improvement Center). 1998. From Agronomic Data to Farmer Recommendations: Economics Training Manual Completely Revised Edition, Mexico.
7. SAS Institute Inc. 2009. SAS/Genetics ™ 9.1.3 Cary, NC, SA.
8. Kissi Wakweya D. and G. Reta Dargie, 2017. The Effect of Pre-emergence Herbicide (Dual gold) and Hand Weeding Frequencies on Faba Bean (*Vicia faba* L.) Growth, Yield and Yield Components in Bale Highlands, Southeastern Ethiopia. Scientific Journal of Pure and Applied Sceinces, 6(7): 589-596.
9. Ahmed M. El Naim, Mona A. Eldouma, Elshiekh A. Ibrahim, Moayad and M.B. Zaied, 2011. Influence of Plant Spacing and Weeds on Growth and Yield of Peanut (*Arachis hypogaea* L) in Rain-fed of Sudan. Journal of Advances in Life Sciences, 1(2): 45-48.
10. Bedry, K.A., 2007. Effect of weeding regimes on faba bean (*vicia faba* L.) yield in the Northern State of Sudan. University of Khartoum Journal of Agricultural Science, 15: 220-231.
11. Kavurmaci, Z., U. Karadavut, K. Kökten and A. Bakoðlu, 2010. Determining critical period of weed-crop competition in faba bean (*Vicia faba*). Int. J. Agric. Biol., 12: 318-320.
12. Achakzai, A.K.K., 2012. Effect of various levels of nitrogen fertilizer on some vegetative growth attributes of pea (*Pisum sativum* L.) cultivars. Pak. J. Bot., 44(2): 655-659.
13. Amaregouda, A., Jitendra Jadhav, M.B. Chetti and Nawalagatti, 2013. Effect of Weedicides on Physiological Parameters, Growth, Yield and Yield Components of Soybean (*Glycine max*. L) and Weed Growth. Journal of Agriculture and Allied Sciences, 2(4).
14. Getachew Mekonnen, J., J. Sharma, Lisanework Negatu and Tamado Tana, 2017. Effect of Planting Pattern and Weeding Frequency on Weed Infestation, Yield Components and Yield of Cowpea [*Vigna unguiculata* L.) WALP.] in Wollo, Northern Ethiopia. Journal of Agriculture, Forestry and Fisheries. Science Publishing Group. 6(4): 111-122.
15. Suliman Adam Ahmed Mohammed. 2013. Effect of Weed Control on Growth and Seed Production of Butterfly Pea (*Clitoria ternatea*) Under Rainfed Conditions at Zalingei Western Darfur State-Sudan. ARPN Journal of Science and Technology 3(5).
16. Mizan, A., J.J. Sharma and W. Gebremedhin, 2009. Estimation of Critical Period of Weed-Crop Competition and yield Loss in Sesame (*Sesamum indicum* L.). Ethiopian Journal of Weed Management, 3(1): 39-53.
17. Muhammad Shehzad, Asif Tanveer1, Muhammad Ayub, Khuram Mubeen, Naeem Sarwar, Muhammad Ibrahim and Imran Qadir. 2011. Effect of weed-crop competition on growth and yield of garden cress (*Lepidium sativum* L.). Journal of Medicinal Plants Research, 5(26): 6169-6172.

18. Ahmad, R. and A.S. Sheikh, 2003. Common weeds of wheat and their control. Pak. J. Water Resour., 7: 73-74.
19. SAAD EL-DIN, S.A., 2003. Efficiency of some weed control treatments on growth, yield and its components of broad bean (*Vicia faba* L.) and associated weeds. Egyptian Journal of Applied Science, 18(6B): 586-604.
20. Sharara, F.A.A., N.K. Messiha and S.A. Ahmed, 2005. Performance of some fababean cultivars and associated weeds to some weed control treatments. Egyptian Journal of Applied Science, 20(4): 101-105.
21. Al-Thahabi, S.A., J.Z. Yasin, B.E. Abu-Irmaileh, N.I. Haddad and M.C. Saxena, 1994. Effect of weed removal on productivity of chickpea and lentil in a Mediterranean environment. Journal of Agronomy and Crop Science, 5: 333-341.