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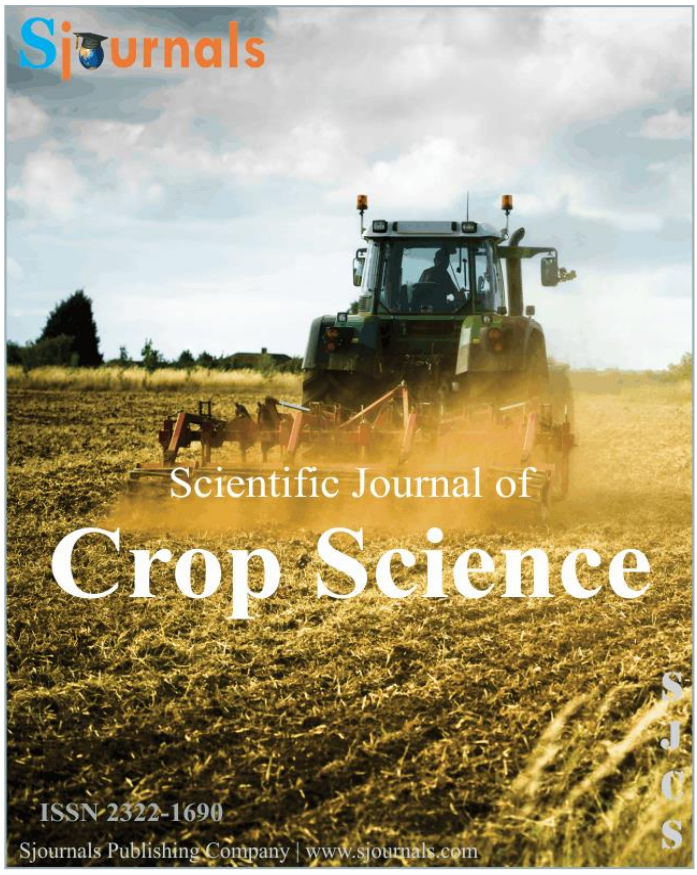

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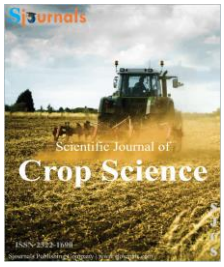

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Original article

Effect of time and frequency of hand weeding on growth, yield of Lentil (*Lens culinaris* L. Medic) in the highlands of Bale

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ABSTRACT

Weed is the major production constraints for lentil production in Bale highlands. Its management is quite important to increase the production and productivity of the crop. Therefore, this experiment was conducted at two locations at Sinana research station and Agarfa in 2017/18 and 2018/19 *'Bona'* cropping season to evaluate time and hand weeding frequency on lentil production. The experiment consisted of eleven hand weeding treatments i.e. weeding at 7, 7 and 14, 14, 14 and 21, 21, 21 and 28, 28, 28 and 35, 35 only, 21, 28 and 35 days after emergence including weedy check. It was laid out in randomized complete block design (RCBD) with three replications. A field layout was prepared and the treatments were assigned randomly to each plot within a block. The replications, blocks and experimental units were separated by 1.5 m, 1 m, and 1 m respectively. During the study period broad leaved weeds were dominant at Sinana while grass weeds were dominant at Agarfa. Yield and yield components were affected by the treatments. The maximum seed yield was obtained from plots weeded at 14 and 21 days after emergence at Sinana. On the other hand at Agarfa the maximum Seed yield was obtained from 21 and 28 days after emergence. However, to come up with conclusive recommendation, the experiment should be repeated over seasons and locations.

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1. Introduction

Grain legumes are the most important protein and mineral food crops in the world, especially in developing countries. Lentil is an important food legume crop in Ethiopia and is considered vital to food and nutritional security. For those who cannot afford animal products, lentil is a vital protein source, with a mean grain protein content of 23.25%. Additionally, lentil seed typically contains important macro and micronutrient (Ca, P, K, Fe, and Zn), vitamins, fiber, and carbohydrates for balanced nutrition (Bhatty, 1988). Furthermore, because of its high lysine and tryptophane content, its consumption with wheat or rice provides a balance in essential amino acids for human nutrition. Lentil straw is also a valued animal feed (Erskine et al., 1990). Its cultivation enriches soil nutrient status by adding nitrogen, carbon and organic matter which promotes sustainable cereal-based systems of crop production.

Lentil grows as an annual bushy leguminous plant, typically 20-45 cm tall; it produces many small purse shaped pods containing one to two seeds each. Lentil is well adapted to various soil types and also considered as drought-resistant crop. But it is susceptible to excessive water stress. It performs best on deep, sandy loam soils with high phosphorus and potassium content. It is widely grown in areas having an altitude range of 1,700-2,400 meters above sea level with annual rainfall ranging from 700-2,000 mm in Ethiopia. Lentil is mainly grown in the highlands of Ethiopia where rainfall is usually high in the regions of Amhara, Oromia, SNNP and Tigray. Two types of lentils are cultivated in the world: the macro-sperma, large seeded and the micro-sperma, small seeded. The large seeded lentils are generally late maturing compared to the small seeded ones. Of the two groups, the small seeded and early-set lentils are largely cultivated in Ethiopia.

Poor agronomic practices are among the major constraints limiting the production and productivity of this crop. Improving agronomic practices such as seedbed preparation, sowing date, seed rate, weed control and pest management will enhance the production and productivity of lentil. Among the crop management practices, weed management is of key importance. Lentil crop is poor competitor against weeds for light, water and nutrients due to small and weak canopy. Ahmad (1988) stated that first 02 to 06 weak after crop sowing is critical period for weed control. Whereas Ahlawat et al. (1981) reported that the most critical period of weed competition in lentil is first 4-8 weeks. During early stages of vegetative growth and in cool weather, lentil growth rates are slow and weeds can quickly overgrow the crop. If not adequately controlled, weed infestations can reduce yields by as much as 75 percent. Although the period of crop growth during which competition is most deleterious varies in different locations, competition from weeds is usually serious and requires some form of control in order to produce good seed yields. Wild oats, volunteer cereals, and other annual grasses are common and serious weeds in lentil crops.

Hand weeding is the most common weed control method used by small-scale farmers. It usually requires no capital outlay. This is a major advantage when cash is not readily available and labour is provided from the farmer's immediate family or through non-cash exchange. Most farmers in Ethiopia do not weed their fields at the right time and rather weeding is done at random time when labour is available. It is impossible to produce lentil economically without a well planned weed management. Therefore, this research was initiated with the objective of determination of time and frequency of hand weeding on lentil production.

2. Materials and methods

The research was carried out in the years 2017-2018 during bona season (July-December) at the experimental station of the Sinana Agricultural Research Center and Agarfa. Improved variety 'Asano' which was released by Sinana Agricultural Research Center was used for the experiment. The experiment consisted of five hand weeding at different growing stage of the crop including weedy check and laid out in randomized complete block design (RCBD) with three replications. A field layout was prepared and the treatments were assigned randomly to each plot within a block.

The replications, blocks and experimental units were separated by 1.5m, 1m, and 1m respectively. The treatments were accommodated in a gross plot size of 4.8m^2 (1.2m x 4m) containing six rows of lentil. Each plot consisted of 6 rows 20 cm apart and 4 m in length. The outer most rows on both sides of each plot and 0.25m length on each side of a row was served as a border. The remained net plots were used for data collection.

3. Results and discussion

This experiment was conducted for two years (2017/18 and 2018/19 cropping season) at two locations in Sinana Agricultural Research Center experimental station and Agarfa. In 2017/18 cropping season, the experiment was conducted at both locations but the experiment conducted at Sinana station was damaged due to chemical drift from Oromia Seed Enterprise (OSE). The experiment was repeated on both locations in the second year all the required field data was collected. Therefore, the current result was summarized from one year data of Sinana station and two years data from Agarfa.

3.1. Weed density

Normally, lentils are very sensitive to weed competition from the early growth stages up to start of flowering. Yield losses up to 50% can occur if lentils are left un-weeded. Different weed species under weed types of broad leaved, sedges and grass weeds were identified in the experimental field. The weed species found in experimental plots were identified and recorded. A quadrat with a 0.5 x 0.5m (0.25m^2) sampling area was used to sample weed species. The weeds falling within the quadrant were counted and each species sum value was expressed in number per meter square. Generally broad leaved weeds were dominant with relative density of 76.4% in frequently weeded plots. On the other hand, 78.3% was observed in weedy plot at Sinana station. The majority of weeds at Agarfa were grass weeds with relative density of 84% in frequently weeded plots while in weedy plot was 86.6%.

3.2. Effect of time and frequency of hand weeding on growth, yield of Lentil at Sinana

The results of analysis of variance revealed that days to flowering and maturity, seeds per pod, thousand seed weight and harvest index were not affected by time and frequency of hand weeding. On the other hand, plant height, tillers per plant, number of branches on main stem, number of pods per plant, and biological yield per hectare were significantly affected by time and frequency of hand weeding (Table 1). Seed yield of lentil also showed significant difference at Sinana. The highest seed yield (2633.5 kg ha^{-1}) was obtained from plots weeded at 14 and 21 days after emergence as compared to un weeded check which produced the least seed yield of all the treatments. The seed yield obtained at Sinana exceeded that obtained at Agarfa. This might be due to better growing conditions for the crop at Sinana than Agarfa and also there were higher weed density at Agarfa than at Sinana during overall experimental years. Therefore, further investigation has to be carried out on farmers' fields in order to further confirm the present results.

Table 1
Effect of time and frequency of hand weeding on growth, yield of Lentil at Sinana, 2018/19.

Treatments	DFL	DM	PHT	TPP	NBM	PPP	SPP	GYD	TSW	BYD	HI (%)
No Hand Weeding	62	134.8	47.3^{a}	3^{bc}	1.1^{d}	12.3^{ce}	1.7	1011.9^{c}	11.5	3472.2^{d}	32.7
HW at 7 DAE	60.7	132.8	37.8^{bc}	4.8^{a}	2.3^{abc}	15.6^{b-e}	1.0	2298.2^{ab}	11.8	7291.7^{abc}	37.5
HW at 7 and 14 DAE	60.8	135	37.7^{bc}	3.6^{ab}	2.4^{abc}	16.6^{a-e}	1.7	2381.7^{ab}	11.1	7638.9^{abc}	33.5
HW at 14 DAE	60.8	135.3	38.9^{bc}	4.2^{ab}	2.6^{abc}	16.3^{a-e}	1.3	2489.9^{a}	11.7	7986.1^{abc}	36.4
HW at 14 and 21 DAE	59.5	135.3	39.2^{bc}	3.6^{ab}	2.1^{abcd}	17.3^{a-c}	2.3	2633.5^{a}	11.9	6597.2^{a-d}	41.9
HW at 21 DAE	60.7	131.7	43.2^{ab}	2.7^{bc}	2^{bcd}	21.1^{a}	1.3	2344.6^{ab}	11.5	6250^{bcd}	41.2
HW at 21 and 28 DAE	60.7	132.8	37.7^{bc}	2.8^{bc}	2.3^{abc}	18.1^{ab}	1.3	2233.6^{ab}	11.7	7291.7^{abc}	30.6
HW at 28 DAE	61.8	135.0	35^{c}	3.3^{abc}	1.9^{bcd}	18.8^{ab}	1.3	2253.6^{ab}	11.5	5902.8^{bcd}	43
HW at 28 and 35 DAE	61.3	134.8	37.2^{bc}	2.7^{bc}	3.2^{a}	17.3^{a-d}	1.3	2603.8^{a}	11.9	10069.4^{a}	24.7
HW at 35 DAE	61.3	134.2	36.4^{c}	2.7^{bc}	2.7^{ab}	17.4^{ab}	1.3	2128.8^{b}	11.4	8333.3^{ab}	26.2
HW 21, 28 and 35 DAE	61	134.8	41.4^{abc}	1.8^{c}	1.4^{cd}	21.2^{a}	1.7	1221.6^{c}	11.8	4513.9^{cd}	29.3
$LSD_{0.05}$	ns	Ns	5.78	1.53	0.99	4.51	ns	477.8	ns	3083.76	ns
CV (%)	13.6	17.8	8.6	23.8	26.4	15.2	26.8	12.7	6.3	26.4	22.8

KEYS: DM=Days to maturity, PHT=Plant height, NTL=Number of tillers per plant, NBM=Number of branches on main stem, PPP=Pods per plant, SPPO=Seeds per pod, SPP=Seeds per plant, SYD=Seed yield (kg ha^{-1}), TSW=Thousand seed weight, BYD=Biological yield (kg ha^{-1}), HI=Harvest index LSD=least significant difference, CV=Coefficient of variation, HW=Hand weeding and DAE=Days after emergence.

3.3. Effect of time and frequency of hand weeding on growth, yield of Lentil at Agarfa

The results of analysis of variance revealed that tillers per plant, seeds per pod, thousand seed weight, and harvest index were not significantly ($P<0.05$) influenced by time and frequency of hand weeding. On the other

hand days to flowering and maturity, plant height, number of branches on main stem, pods per plant, biological yield were significantly influenced by time and frequency of hand weeding. Seed yield of lentil was also showed significant difference at Sinana. The highest seed yield (1846.6 kg ha^{-1}) was obtained from plots weeded at 21 and 28 days after emergence as compared to unweeded check which produced the least seed yield (419.1 kg ha^{-1}) of all the treatments. The seed yield at Agarfa was lower than obtained at Sinana. This might be due to higher weed population and then high competition of season-long weed interference from later emerging weeds as there was more rainfall during the crop season.

Table 2
Effect of time and frequency of hand weeding on growth, yield of Lentil at Agarfa, 2017/18 and 2018/19 (combined).

Treatments	DFL	DM	TPP	PHT	NBM	PPP	SPP	GYD	TSW	BYD	HI (%)
No Hand Weeding	62^{ab}	135^{ab}	0.5	41.1^{a}	1.3^{d}	11.85^{d}	1.5	419.1^{c}	22.7	1278^{b}	29.2
HW at 7 DAE	57.33^{c}	125^{c}	0.7	37.4^{ab}	2.2^{bcd}	21.1^{cd}	1.3	1053.7^{bc}	25.3	3074^{ab}	37.4
HW at 7 and 14 DAE	60^{abc}	131^{abc}	0.8	32.6^{b-d}	2.8^{abc}	40.97^{a}	1.4	1237.4^{ab}	24.9	2950^{ab}	35.1
HW at 14 DAE	59^{abc}	129^{abc}	0.8	31.1^{b-d}	4^{a}	34.15^{abc}	1.8	1440.9^{ab}	25.4	4063^{a}	39.2
HW at 14 and 21 DAE	59^{abc}	129^{abc}	0.6	31.6^{b-d}	3^{ab}	38.32^{ab}	1.3	1363.9^{ab}	24.6	4414^{a}	32.8
HW at 21 DAE	59.67^{a-c}	130.3^{abc}	0.5	30.2^{cd}	1.9^{bcd}	23.42^{cd}	1.2	980.5^{bc}	25.1	2658^{ab}	29.2
HW at 21 and 28 DAE	58^{bc}	127^{bc}	0.7	29.7^{cd}	2.8^{abc}	37.5^{ab}	1.8	1846.6^{a}	25.8	4404^{a}	47.8
HW at 28 DAE	57^{c}	125^{c}	0.5	30.4^{cd}	1.4^{cd}	25.7^{bc}	1.2	1006.2^{bc}	25.3	4662^{a}	28
HW at 28 and 35 DAE	57^{c}	125^{c}	0.5	29.3^{cd}	1.5^{cd}	32.52^{abc}	1.3	1193.7^{abc}	26.1	4041^{a}	32.1
HW at 35 DAE	63^{a}	137^{a}	0.8	36.1^{a-c}	1.7^{bcd}	22.2^{cd}	1.2	1073.1^{abc}	25.8	3560^{ab}	33.5
HW 21, 28 and 35 DAE	62^{ab}	135^{ab}	0.3	28.8^{d}	1.7^{bcd}	28.82^{abc}	1.2	1148.5^{abc}	24.7	5108^{a}	19.7
$LSD_{0.05}$	3.65	7.6	ns	6.16	1.28	11.67	ns	681.5	ns	2167.5	ns
CV (%)	4.6	4.3	28.7	16.3	30.5	24.6	28.4	30.5	18	31.2	33.6

KEYS: DM=Days to maturity, PHT=Plant height, NTL=Number of tillers per plant, NBM=Number of branches on main stem, PPP=Pods per plant, SPPO=Seeds per pod, SPP=Seeds per plant, SYD=Seed yield (kg ha^{-1}), TSW=Thousand seed weight, BYD=Biological yield (kg ha^{-1}), HI=Harvest index LSD=least significant difference, CV=Coefficient of variation, HW=Hand weeding and DAE=Days after emergence.

4. Conclusion

Lentils are very sensitive to weed competition from the early growth stages up to start of flowering due to small and weak canopy. Even though integrated weed management approaches is the best option for effective and sustainable weed control, hand weeding is one of the strategy for the control of weed, particularly in areas where access to post or pre emergence herbicide is very limited. The results of the present study showed that the grain yield of lentil was highly affected by weed. From the experiment which was conducted at Sinana highest seed yield (2633.5 kg ha^{-1}) was obtained from plots weeded at 14 and 21 days after emergence as compared to un-weeded field. On the other hand at Agarfa highest seed yield (1846.6 kg ha^{-1}) was obtained from field weeded at 21 and 28 days after emergence. Seed yield from both locations were influenced different time and hand weeding frequency. This might be due to differences in rainfall distribution and hence difference weed population during the crop season**.** Therefore from the results observed managing the weeds at 14 and 21 days after emergence at Sinana and 21 and 28 days after emergence at Agarfa and hence concluded, further study should be conducted over different varieties, locations and cropping seasons in order to confirm the results since the present results markedly differed from previous recommendations.

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