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Research Article

Determining Critical Weed Competition at Different Weed Free Periods in Linseed in Holeta District Central Ethiopia

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Abstract

A substantial proportion of linseed yield is lost due to weeds in the Holeta area of Central Ethiopia. The weeds infest the crop fields during the early growth stage and consume growth resources. To protect the crops from weeds, farmers manage their fields using cultural practices. However, there is a knowledge gap between farmers on critical weed removal time for the management of the weeds from the crop. Therefore, it is assumed that determining the weed-free period after the sowing of linseed to control the weeds is necessary. The experiment was designed to determine the suitable weed-free period for the control of weeds and increasing linseed production. The trial was treated with different weed-free periods before 20, 30, 40, 50, and 60 days of sowing; and after 20, 30, 40, 40, and 60 days of sowing, twice hand weeding, weed-free, and control. The treatments were organized in a Randomized Complete Block Design (RCBD) replicated three times. It was found that *Galinsogapulviflora* was the most dominant weed, contributing to 18% of the total weeds present in the fields. Plots treated with weed-free after 20 days of sowing produced superior results in terms of reduction of weed dry weight by 100%, increased number of bolls per plant by 3.08 folds, stand count by 245%, and grain yield by 11 folds as compared to untreated check respectively. Hence, making weed free of linseed after 20 days of sowing is recommended for the management of various weeds in linseed.

Introduction

Linseed is one of the important oil crops cultivated so far on small-scale farms in Ethiopia. It is the fourth oil seed crop preceded by Sesame, groundnut, and Noug in area of production with mean average annual production and productivity of 564, 86.64 tons, and 1.02 tons ha^{-1} respectively [1].

Linseed productivity can be strongly susceptible to the occurrence of weeds [2,3]. Numerous researchers have pointed out that linseed is a slowly grown species compared to oil seed crops [4]. The reduced competitive capability can be attributed to the growth structure of the crop and its early sluggish development. Many weed species can be found in linseed including *Setariaviridis* L., *Avenafatua* L., *Chenopodium album* L., *Circiumarvense* L., and *Amaranthusretroflexus* L. [5].

Seed yield reduction due to weeds in linseed Ethiopia was reported by different scholars, in Ethiopia 56% by Rezene [6], in the USA 53% [7], and also in India 15% - 50% [8]. In spite of many choices intended for chemical weed management, there is an insufficiency of recorded types of action for nontoxic in-crop use in linseed. This absence of a variety joined with herbicides categorized as a risk for the progress of herbicide resistance [9,10] causes an increase in herbicide-resistant weeds. Definitely, wild oats and green fox tails are well-known herbicide-resistant [11-13].

Hence, weed management options are a main and inevitable task for linseed production. Manual weeding is the fourth most extensively proficient traditional weed management practice in most crops all over the country, mostly due to the unaffordable prices of herbicides and terror of toxic residue joined with the absence of information for their use at the farmers' level. Consuming diverse herbicides is not the sole solution to an agreement with herbicide-resistant weeds [14]. Categorizing and exploiting original types can help to decrease the assortment burden on these resilient inhabitants.

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However, clarification of the way of finding exact critical weed-free periods is essential for weed management in linseed. At present, there is limited access to registered pre-emergence herbicides for the control of weeds in linseed. Likewise, repeated application of a single herbicide or herbicide with similar mechanisms of action or families of herbicides eventually led to the persistence of the herbicide, weed resistance, accumulation of harmful residues in the food chain, and hazardous effects on both people and animals. Therefore, assessment of novel research being how to manage different kinds of weeds is crucial. Although linseed is slow at its initial growth stage, competition against weed is poor. Weeds emerged earlier and consumed growth resources faster than the crop. Therefore, it is necessary to determine the actual period of weed removal time to overcome the consequent yield losses caused by weeds.

Determining the critical weed competition period from numerous fields of study can help to reduce the competitive pressures produced by weeds at the economic threshold level, but ultimately improve the competitive ability and productivity of linseed. Therefore, critical weed interference periods for linseed are due to various weed species being lacking in the study. Therefore, this study was planned to identify the appropriate weed-free period /s for the control of weeds and increasing linseed production.

Materials and methods

Description of the experimental site

Field study was carried out for two successive years from 2020-2021 during the main cropping season under rain-fed situations at Holeta Agricultural Research Center. Holeta is situated at an elevation of 2400 m.a.s.l and within the geographic matches of 90 00′N and 380 30′E (Figure 1). The area gates yearly rainfall of 1144 mm with lowest and highest temperatures of 6 °C and 22 °C respectively (EIAR, 2021). The soil of the trial sites is clay loam with a pH of 6.65, organic carbon (2.26%), available Phosphorus (14.17 mg kg1), total nitrogen (0.12%), and cation exchange capacity of 17 Cmol kg^{-1} [15]. The soil and climatic situations detected for the duration of the experimental period were favorable for the development of abundant weed species that strived with the crop plants.

Treatments and experimental design

The experimental field was treated with different weed-free periods i.e. weed - free before 20, 30, 40, 50, and 60 Days of Crop Emergence (DACE); weed - free after 20, 30, 40, 50, 60 days of crop emergence, including two times manual weeding, weed free and control that was replicated three times.

Crop management

The land was tilled two times with tractors followed by harrowing to create appropriate beds for planting. The popular Linseed variety, the *Jeldu-1* variety, was used as a check variety. Seeds were drilled in well-prepared furrows at 20 cm spaced among rows. The trial area was nourished with the recommended rate of 22 kg ha^{-1} of N and 60.5 kg ha^{-1} of P_2O_5 that were applied in the form of Urea (46% N) and NPS (19% N, 38% P2O5, 7% SO4), respectively. The remaining management practices were similarly functional to all plots as per the suggested practices.

Data collection

Weed species identification was performed using handbooks for weed documentation in Ethiopia [16]. The dry weeds collected from each quadrant were placed into paper bags independently and oven-dried at 65 °C for 48 hours and afterward, the dry weights were measured. Relative Density (RD) was calculated by dividing the entire quantity of each weed species in all the quadrants by the overall number of each weed species in all quadrants multiplied by 100.

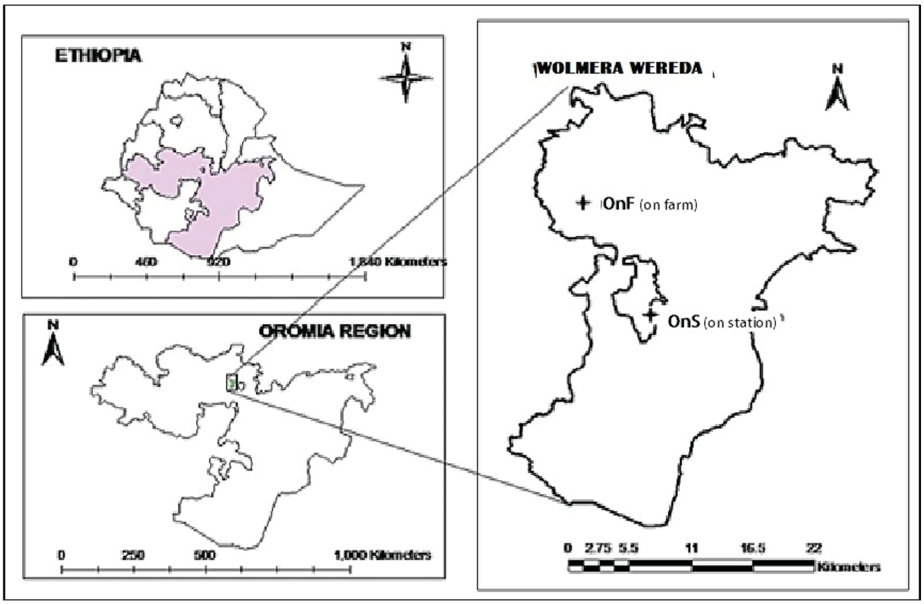

Figure 1: Map of Holeta Agricultural Research Center.

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Plant height was determined by sampling four plants per plot. A standing count was performed by calculating the plants in quadrates and calculated on an m^2 area basis. Bolls per plant were done by 4 plants per plot randomly. Thousand-grain weights were calculated from the main part of threshed products from the net plot area and their mass was noted. The seed yield was done after the split-up of the sun-dried plants gathered from each net plot and the yield was adjusted at 12.5% grain moisture content.

Data analysis

The average of individual data was tested by the routine test contingent on the Shapiro test (Pr < W) already analysis of variance using the generalized linear model technique of SAS (SAS 9.3 version). If the treatment effects were substantial, the average associated with using Fisher's LSD tests was at a 5% level of significance [17].

Results and discussion

Weed flora identification

The weed community in the trial sites comprised the majority of weeds, which were categorized into major families (Table 1). Of the total weed species present in the experimental sites, 86% were annual broadleaf and the rest were annual grass weeds. The highest relative weed density in the fields was *G. pulviflora* (22.91%), followed by *P. nepalense* (18.55%), whereas the lowest value was noted by *G. scabra* (0.98%) (Table 1). In general, weed species differ from habitat to habitat, period to period, and their propagation defines population number.

Weed dry weight

Weed dry weight was significantly ($p \leq 0.05$) influenced by the application of weed-free periods (Table 2). Application of weed-free periods decreased weed dry weight consistently and significantly. Hence, plots treated with weed-free periods after 20 DACE to weed-free periods 60 DACE decreased weed dry weight by 100% as compared to weedy check plots during 2020/21 and 2021/22 cropping seasons respectively, while other weed-free periods before 20,30,40,50 and 60 DACE decreased weed dry weight by 5.55, 5.5, 5.93,13, 16 folds as compared to weedy check in both years. The minimum weed dry weight is probably due to complete weed removal from plots, while the maximum weed dry weight at weed check is due to no removal of weeds. This is consistent with the findings of Haque, et al. [18] and Singh, et al. [19] who concluded that an increase in weed dry weight is probably weeds not being removed from plots.

Plant height

Plant height was significantly ($p \leq 0.05$) influenced by the application of different weed-free periods (Table 2). The application of weed-free periods increased plant height consistently and significantly. Hence, plots treated with weed-free periods before 20 DACE to weed-free periods 60 DACE increased plant height by 18%, 15%, 15%, 14%, and 7% as compared to weedy check plots during 2020/21 and 2021/22 cropping seasons respectively, while other weed-free periods after 20,30,40,50, 60 DACE, twice hand weeding and weed free increased plant height by 7%, 13%, 2%, 21%, 4%, 11%, 23% as compared to weedy check in both years. The tallest plant height is most likely due to restricted weed competition enabling the plants to produce taller plants, but the shortest plant height at weedy check is probably due to higher competition of weeds. The result clearly showed that the plant attained its maximum height where the competition was severe for light between crops as well as weeds but at lower competition, the plant could not invest larger resources to attain its maximum height. The tallest plant is found under low weed competition Gabiana, et al. [20] and Gavit[21].

Table 1: Common weed species, densities, and life forms in the linseed experimental fields in Holeta.

Scientific names	Families	Weed density m^{-2} before treatment	Relative Weed Density (%)	Life form/ category
*Arthraxonprinodes*L.	Poaceae	11.03	5.35	Annual (grass)
*Setariapumila*L.	Poaceae	15.12	7.34	Annual (grass)
*Phalarisparadoxa*L.	Poaceae	2.69	1.31	Annual (grass)
*Galinsogapulviflora*Cav.	Compositae	47.18	22.91	Annual (broad leaf)
*Corrigiolacapensis*Wild	Caryophylaceae	24.35	11.82	Annual (broad leaf)
Guizotiascabra(Vis) Chiov	Compositae	2.03	0.98	Annual (broad leaf)
*Oxalis corniculata*HBK	Oxalidaceae	14.00	6.79	Annual (broad leaf)
*Plantagolanceoleta*L.	Plantaginaceae	9.51	4.62	Annual (broad leaf)
*Polygonumnepalense*L.	Polygonaceae	38.20	18.55	Annual (broad leaf)
*Raphanusraphanistrum*L.	Brassicaceae	7.50	3.65	Annual (broad leaf)
*Spergulaarvensis*L.	Caryophylaceae	10.00	4.86	Annual (broad leaf)

Table 2: Effect of weed-free periods on weed dry weight and plant height in linseed during 2020/21 and 2021/22 cropping seasons.

Weed free periods	Weed dry weight (kg ha^{-1})		Plant height (cm)	
	2020/21	2021/22	2020/21	2021/22
Weed-free up to 20 DACE	123b	92.33c	94ab	82.5ef
Weed-free up to 30 DACE	115b	92.67c	92abc	85.41ef
Weed-free up to 40 DACE	104b	87c	91abc	90.41bcde
Weed-free up to 50 DACE	56c	43d	90abcd	87.08def
Weed-free up to 60 DACE	48c	34d	83cdef	95abcd
Weed-free after 20 DACE	0.0d	0.00e	83cdef	99.16ab
Weed-free after 30 DACE	0.0d	0.00e	89ef	96.66abc
Weed-free after 40 DACE	0.0d	0.00e	78def	90.83bcde
Weed-free after 50 DACE	0.0d	0.00e	97ab	89.16cde
Weed-free after 60 DACE	0.0d	0.00e	80def	91.66bcde
Hand weeding at 30 and 60 DACE	30cd	125b	87bcde	99.58ab
Weed-free	0d	0.00e	99a	101.66a
Weedy check	650a	603.33a	76f	77.91f
LSD (5%)	30.08	27.22	10.97	9.55
CV (%)	19.01	19	7.2	6.21

LSD: Least Significant Difference; CV: Coefficient of Variations; Means followed by the same letter in the lower case within columns are not significantly different from each other at a 5% level of significance

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Crop stand count

Crop stand count was significantly ($p \leq 0.05$) influenced by the use of different weed-free periods (Table 3). The application of weed-free periods increased the stand count consistently and significantly. Thus, plots treated with weed-free periods before 20 DACE to weed-free periods 60 DACE increased plant height by 182%, 201%, 219%, 234%, and 233% as compared to weedy check plots during 2020/21 and 2021/22 cropping seasons respectively, while other weed-free periods after 20,30,40,50, 60 DACE, twice hand weeding and weed free increased plant height by 245%, 227%, 222%, 220%, 223%, 205%, 239% over weedy check in both years respectively. Under low competition between weeds and crops for resources that enhanced productive tillers which contributed increase in stand count. Increased number of fertile productive tillers and relatively better weed control; which ultimately facilitated by more translocation of photosynthate towards reproductive growth due to lower weed-linseed competition.

The maximum stand count is possibly due to higher weed control enabling the plants to produce more tillers tiller, but the minimum number of stand counts at weedy check is probably due to severe competition of weeds [22,23].

Bolls per plant

Bolls per plant were significantly ($p \leq 0.05$) influenced by the application of different weed-free periods (Table 3). The application of weed-free periods increased bolls per plant consistently and significantly. Thus, plots treated with weed-free periods before 20 to 60 DACE increased bolls per plant by 1.36, 1.38, 1.38, 1.46, and 1.53 folds, while weed-free periods after 20 to 60 DACE increased bolls per plant by 3.08, 1.43, 1.35, 1.34, 1.25 folds respectively in both years. Moreover, plots treated with hand weeding twice and weed-free increased bolls per plant by 2.68-3.27 folds compared to weedy check plots during 2020/21 and 2021/22 respectively. The maximum bolls per plant are probably due to good weed management, which enables the crop's effective use of resources to produce more bolls, but the minimum number of bolls per plant at weedy check is possibly higher opposition of weeds. The number of bolls per plant increased with decreased weed competition. The poor grain filling due to the presence of weeds was reported to be due to reduced tillering, boll formation, stem weight, and height reduction in linseed. This is consistent with the findings of Mirza, et al. [24], who found that bolls per plant increased due to efficient utilization of resources that enable the crop to produce more branches and bolls.

Thousand seed weight

Thousand seed weights were significantly ($p \leq 0.05$) influenced by the application of different weed-free periods (Table 4). Therefore, plots treated with weed-free before 20 DACE to 60 DACE increased thousand grain weight by 0.26%, 4.2%, 0.13%, 3.9%, 0.00%, 3.9%, 0.13%, 4%, 0.26%, 4.3% in 2020/21 and 2021/22 years respectively while plots treated with weed-free after 20 DACE to 60 DACE increased thousand grain weight by 0.66%, 5%, 0.00%, 4.7%, 0.26%, 4.2%, 0.4%, 4%, 0.26%, 3.9% during 2020/21 and 2021/22 cropping seasons respectively as compared to weedy check plots. The maximum thousand-grain weight revealed effective weed management allows the plants to exploit extra growth resources while the minimum thousand kernel weight could be a higher struggle of weeds. The increased thousand grain weight could be related to lower dry weed biomass, better weed control efficiency, and minimum intra and inter-specific competition that enable the crop to utilize resources efficiently to produce vigor seeds but at weedy check treatments, the lowest number of thousand grain weight was due to the higher competition of plant growth resources that resulted in fewer vigor seeds.

This is consistent with the findings of Akbar, et al. [25] and Singh, et al. [26] who determined the possible cause for higher grain weight in plots wherever weed management

Table 3: Effect of weed-free periods on stand count and bolls per plant in linseed during 2020/21 and 2021/22 cropping seasons.

Weed free periods	Stand count (m^{-2})		Bolls per plant	
	2020/21	2021/22	2020/21	2021/22
Weed-free up to 20 DACE	423c	345.33b	3630b	3624b
Weed-free up to 30 DACE	442bc	393.33ab	3662b	3655b
Weed-free up to 40 DACE	460ab	401.33ab	3668b	3658.3b
Weed-free up to 50 DACE	475a	369.33b	3788b	3781.7b
Weed-free up to 60 DACE	474a	364b	3898b	3897.7b
Weed-free after 20 DACE	486a	473a	6565a	6268a
Weed-free after 30 DACE	468ab	386.67ab	3736b	3742.7b
Weed-free after 40 DACE	463ab	329.33b	3602b	3608b
Weed-free after 50 DACE	461ab	373.33b	3600b	3601.3b
Weed-free after 60 DACE	464ab	341.33b	3426b	3454b
Hand weeding at 30 and 60 DACE	446bc	469.33a	3875b	5662.7a
Weed –free	480a	342.67b	6565a	6563a
Weedy check	241d	314.6b	1537c	1535c
LSD (5%)	27.4	89.24	1683	1686.5
CV (%)	3.6	14.03	25.6	24.52

LSD: Least Significant Difference; CV: Coefficient of Variations; Means followed by the same letter in the lower case within columns are not significantly different from each other at a 5% level of significance

Table 4: Effect of weed-free periods on thousand grain weight and grain yield in linseed during 2020/21 and 2021/22 cropping seasons.

Weed free periods	Thousand grain weight (g)		Grain yield (kg ha^{-1})	
	2020/21	2021/22	2020/21	2021/22
Weed-free up to 20 DACE	5.06ab	4.8bc	473.6cd	405e
Weed-free up to 30 DACE	4.93ab	4.5cd	658.3bc	462de
Weed-free up to 40 DACE	4.8b	4.5cd	861.4ab	479de
Weed-free up to 50 DACE	4.93ab	4.6cd	970.5a	493de
Weed-free up to 60 DACE	5.06ab	4.9bc	876.9ab	538de
Weed-free after 20 DACE	5.46a	5.6a	970.8a	1442a
Weed-free after 30 DACE	4.8b	5.3ab	790.7ab	1063c
Weed-free after 40 DACE	5.06ab	4.8bc	657.7bc	556de
Weed-free after 50 DACE	5.2ab	4.6cd	687.4abc	547de
Weed-free after 60 DACE	5.06ab	4.5cd	422cd	538de
Hand weeding at 30 and 60 DACE	4.8b	4.5cd	815.8ab	588d
Weed –free	5.2ab	5.6a	931.5ab	1275b
Weedy check	4.8b	0.6e	119.2d	120f
LSD (5%)	0.55		286.76	6.19
CV (%)	6.61	7.4	23.44	0.65

LSD: Least Significant Difference; CV: Coefficient of Variations; Means followed by the same letter in the lower case within columns are not significantly different from each other at a 5% level of significance

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practice was voted due to lesser weed density which decreased the competition among crop plants and weeds for nutrients, light, moisture, and space involved in exploited consumption of resources by crop plants.

Grain yield

Grain yield was significantly ($p \leq 0.05$) influenced by the application of different weed-free periods (Table 4). The application of weed-free periods increased grain yield consistently and significantly. Therefore, plots treated with weed-free before 20 DACE to 60 DACE increased grain yield by 2.97, 2.37, 4.52, 6.05, 3, 7.14, 3.1, 6.35, 3.48, 7.14 folds in both years respectively while plots treated with weed-free after 20 DACE to 60 DACE increased grain yield by 11, 5.62, 7.85, 4.51, 3.63, 4.76, 3.55, 2.54, 3.48 folds during 2020/21 and 2021/22 cropping seasons respectively over weedy check plots. Plots received hand weeding twice increased grain yield by 5.84, 3.9, 6.81, and 9.6 folds as compared to weedy checks in the 2020/21 and 2021/22 cropping seasons respectively. The maximum grain yield for the crop was probably an efficient utilization of growth resources, but the lowest grain yield at the weedy check is possibly higher competition of weeds. The increased grain yield in the weed-free period can be attributed to reduced weeds, competition with the crop for plant growth factors, and optimal conditions for linseed to thrive and produce fertile crops, more seeds per plant, the mass of a thousand grains, and a larger amount of biomass production. This is consistent with the findings of Dordas [27] who reported that the maximum grain yield was obtained where minimum weed crop competition for nutrients and water, has existed. This is consistent with the discoveries of Khan (Khan, et al. [28], Singh and Singh [29] and Vinagradov, et al. [30] who pointed out the increased grain yield of the maize crop by controlling weeds with the application of herbicides.

Conclusion

Linseed yield radically decreased due to so many interrelated factors. Determination of the critical weed competition period significantly affects the production and productivity of linseed. The application of weed-free after 20 days of sowing the crop gave better performance than other weed-free periods because of the reduction of weed dry weight, weed control efficacy, stand count, thousand kernel weight, grain yield, and minimum yield loss. It was therefore summarized that making weed-free after 20 days of sowing is recommended for effective weed control in linseed. Determinations to avoid a decline in linseed yields as a result of infestation by weeds should focus on matching the early time of the crop with a period of low infestation by manipulating the sowing competitors, competitors of promising herbicides soon after planting or early vegetative growth of the competitors and avoiding growing linseed varieties that are poor competitor to the weeds.

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