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Effect of Different Time and Frequency of Weeding on Castor (*Ricinus Communis* L.) in Central Rift Valley of Ethiopia

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ABSTRACT

The intensity of weed-crop competition varies at different stages of the crop. Knowledge on critical weed-crop competition period is very important to identify the best time of controlling weeds. Field experiment was conducted on the critical weed-crop competition period in castor (*Ricinus communis L.*) at Melkassa Agricultural Research Center and Arsi Negelle during 2011 and 2012 cropping seasons. The objective of the study was to determine the critical weed-crop competition period and yield loss due to weeds in castor. The experiment was laid out in randomized complete block design using three replications. The treatment combination were six hand weeding (weeding at 30 days, 30 and 50 days, 50 days , 50 and 70 days, 70 days and 30, 50 and 70 days after sowing) at different growth stages of the crop and weedy check. *Ageratum conyzoides, Amaranthus hybridus, Galinsoga parviflora, Nicandra phaysalodes, Parthenium hysterophorus and Plantago lanceolata* were dominant among dicot weeds whereas *Digitaria ternata, Elusine indica, Eragrostis aspera and Setaria verticillata* were dominant among monocot weeds. Significant variation in density and dry weight was obtained among different treatments. The density and dry weight of weeds were higher in un-weeded plots. Seed yield of castor showed significant difference at $p \leq 0.5$ due to different treatments. The maximum seed yield was obtained from frequently weeded plots with a yield of 1850 and 2043 kg ha $^{-1}$ at Arsi Negele and Melkassa respectively. Uninterrupted weed growth caused a reduction of 86% at Melkassa and 89% at Arsi Negele in yield compared to frequently weeded plots. Because the growth of the castor leaf area is slow in the early phases of development, weeds are able to grow quickly and cover the soil. The critical weed-crop competition period was found to fall within the duration of 30 to 50 days after sowing. Two times hand weeding at 30 and 50 days after sowing is necessary to prevent a significant castor yield loss.

Keywords: Castor, competition, yield loss, weeding time, weeds.

INTRODUCTION

Castor (*Ricinus communis* L.) is a member of the Euphorbiaceae family that is found across all the tropical and semi-tropical regions of the world. Ethiopia is considered to be the most probable center of origin because of its high diversity [2]. Castor is one of the prospective sources of bio-diesel. It has a significant advantage compared to other oil seed crops because of its high oil content, nematocidal effects of the oil, high seed yield and superior quality of the oil/ diesel produced. It is also used in the manufacturing of all-purpose grease, hydraulic fluids, artificial leather, pharmaceuticals, soap, printing ink, special low temperature lubricants and flexible coating. In addition, the ability to be grown under drought and saline conditions and usually abandoned and where most other crops least adapt, is strategic opportunity which has to be exploited [1,5,6,16].. In recent years, the rising cost of fossil fuel and global climate change brought biodiesel back in the spotlight and this has raised the crop importance [3]. This potential will have a significant contribution in enhancing food security and meeting the growing energy demand in the country, thereby saving scarce foreign exchange that is used to import fossil fuels.

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However, competition from weeds is the most important of all biological factors that reduce castor yield in quantity and quality. These occur primarily because weeds use resources that would otherwise be available to the crop. The magnitude of yield loss is affected by many agronomic and environmental factors, but most importantly by the weed density, and time of emergence relative to the crop [20]. Weeds reduce crop yield and profits by competing with the crop for soil moisture and nutrients, light, CO2 and space. Weeds also harbor certain diseases and pests that attack castor and thus lead to indirect losses. According to [18]. Castor is a species of C3 photosynthetic plants with a metabolism characterized by a low photosynthetic efficiency, slow initial growth and a low ability to compete for resources with other species.

Maximum yields could not be obtained without controlling weeds. Developing a suitable integrated weed management system requires the precise study of weeds and their interference with crops. The critical weed crop competition period is a key component of an integrated weed management system. This period varied considerably with the nature and status of crop, weed flora composition, extent of weed infestation and the prevailing environment [9, 20,212]. Acquiring knowledge on critical weed-crop competition period is very important to identify the best time of controlling weeds and help the farmers to make the most efficient use of labor, resulting in an overall saving of time and cost of weed control [8, 12]. Despite the crop importance, no weed management research has been conducted in the past in Ethiopia. Hence, this study was aimed to determine the critical weed-crop competition period and yield loss incur due to weeds in castor.

MATERIALS AND METHODS

Experimental Site Description

A field experiment was conducted at Arsi Negele and Melkassa Agricultural Research Center during 2011 and 2012 rainy seasons. Arsi Negelle is situated at about 228 km South of Addis Ababa on the way to Shashamene. It is located at an elevation of 1960 m above sea level with latitude of 07° 24' N and longitude of 38° 09' E. The average annual rainfall in the area is 782 mm. which is erratic and uneven in distribution. The site has a mean maximum temperature of 25.2°C and mean minimum temperature of 12.4°C. The soil texture was clay loam with pH, bulk density, cation exchange capacity, total nitrogen and organic carbon of 6.5-7.5, 1.10, 20.48 – 22.23 Cmol kg $^{-1}$ soil, 0.112 % - 0.14 % and 1.27 % - 1.35 % respectively. Melkassa Agricultural Research Center is situated at about 107 km from Addis Ababa and 17 km from Adama on the way to Asella. It is geographically located at an elevation of 1550 m above sea level with latitude of 8°24' N and longitude of 39°21' E. The average annual rainfall in the area is 768 mm, which is erratic and uneven in distribution. The site has a mean maximum temperature of 28.5°C and mean minimum temperature of 12.6°C. Loam and clay loam soil textures are the dominant soils of the area [14].

Treatments and Experimental Design

The treatments consist of six hand weeding at different growing stage of the crop and weedy- check where no weeding was carried out. Treatment details are shown in Table 1. The experiment was set up in a randomized complete block design with three replications. The treatments were accommodated in a gross plot size of 28.8 m2 (4.8m x 6m) containing six rows of castor, while the net plot size was 19.2 m ^{2} (3.2m x6m) four rows of castor. Each plot and block were spaced 1.5 and 2.0 m apart respectively. Castor variety (Hiruy) seeds were sown at 80 cm inter-row and 60 cm intra- row spacing.

Data Collection and Analysis

Crop: Stand count, plant height, number of effective branch, length of inflorescence, 100 seed weight and final seed yield was collected. Stand counts were taken after thinning and at harvest by counting the whole plant in harvestable plot. Five sample plants were randomly selected from each plot. Plant height and length of inflorescence measured, number of effective branch counted and converted the value to single plant base. Hundred seeds were counted and their weight recorded out of the seeds harvested from each plot. Seed yield per hectare was calculated based on harvestable plot size.

Yield loss was determined using the formula:

$$YL = \frac{Y1 - Y2}{Y1} \times 100 \text{ [10].}$$

Where: YL = Yield loss (%), Y1 = Yield obtained from frequently weeded plot,

Y2 = Yield obtained from un-weeded plot.

Weed: Weed density and dry weight were collected. The weed species found in check plots were identified and recorded. The weed count was recorded species wise using 0.5 m × 0.5 m quadrat randomly in each plot. The weeds falling within the frames of the quadrat were counted and each species sum value was expressed in number m^{-2}. Weeds within the sample quadrats were cut from the ground level from each plot separately, dried under sun and their dry matter was measured. The dry weight was expressed in g m^{-2}. The weed count and density data were transformed using a square root transformation of actual data (i.e. SQRT [weed count/m^2 + 0.5]) to satisfy the assumptions of normality of distribution and homogeneous variances [13]. The adjustment constant of 0.5 was used for count data to compensate for the 0 values (i.e. when a weed species is absent from a given plot).

The Relative Weed Density (RWD) of each species was calculated with the help of the following formula:

$$RWD = \frac{NIW}{NTW} \times 100 \quad [4].$$

Where: RWD- Relative weed density, NIW- Number of individual weed species in quadrat, NTW- Number of total weed species in quadrat.

Collected data were subjected to the analysis of variance (ANOVA) using SAS Version 9.0 software [15]. Whenever treatment effects were significant, mean separation was made using the SNK test at five percent probability level.

Table1. *Description of treatments*

No.	Treatments
1	No weeding
2	Weeding at 30 days after sowing
3	Weeding at 30 and 50 days after sowing
4	Weeding at 50 days after sowing
5	Weeding at 50 and 70 days after sowing
6	Weeding at 70 days after sowing
7	Weeding at 30, 50 and 70 days after sowing

RESULTS AND DISCUSSION

Weed Community

Both dicot and monocot weeds were found in experimental fields are listed in Tables 2 and 3. The two year pooled data indicated that the relative density of dicot weeds (69-82%) was more than that of monocot weeds (18-31%). *Ageratum conyzoides, Amaranthus hybridus, Galinsoga parviflora, Nicandra phayaslodes, Parthenium hysterophorus, Plantago lanceolata* were dominant weeds among dicot weeds while *Digitaria ternata, Elusine indica, Eragrostis aspera and Setaria verticillata* were among monocots.

Table2. *Major weed species and relative weed density (%) recorded at Melkassa Agricultural Research Center, experimental field*

Melkassa				
Family	Scientific name	Common name	Class	RWD (%)
Amaranthaceae	*Amaranthus hybridus*	Smooth pigweed	Dicot	18.00
Cyperaceae	*Cyperus esculentus*	Yellow nutsedge	Mono-cot	4.00
Poaceae	*Eragrostis aspera*	Rough love grass	Mono-cot	12.00

Asteraceae	*Galinsoga parviflora*	Gallant solder	Dicot	13.00
Solanaceae	*Nicandra phayaslodes*	Apple of Peru	Dicot	11.00
Asteraceae	*Parthenium hysterophorus*	Parthenium weed	Dicot	21.00
Poaceae	*Setaria verticillata*	Bristly foxtail	Mono-cot	15.00
Asteraceae	*Xanthium abyssinicum*	Common cocklebur	Dicot	6.00

Table3.*Major weed species and relative weed density (%) recorded at Arsi Negele Agricultural Research Center, experimental field*

Arsi Negele				
Family	Scientific name	Common name	Class	RWD (%)
Asteraceae	*Ageratum conyzoides*	Goat weed	Dicot	16.00
Poaceae	*Digitaria ternata*	Crab grass	Mono-cot	5.00
Poaceae	*Elusine indica*	Goose grass	Mono-cot	13.00
Asteraceae	*Galinsoga parviflora*	Gallant solder	Dicot	25.00
Rubiaceae	*Galium spurium*	False cleavers	Dicot	12.00
Asteraceae	*Guizotia scabra*	Mech	Dicot	2.00
Solanaceae	*Nicandra phayaslodes*	Apple of Peru	Dicot	4.00
Plantaginaceae	*Plantago lanceolata*	Narrow leaf plantain	Dicot	21.00
Asteraceae	*Tagetes minuta*	Marigold	Dicot	2.00

Weed Density

Data pertaining to the effect of different weed crop competition periods on weed density showed that there were significant differences among all the treatments. Weeds density was significantly increased as the duration of weed crop association increased. Maximum number of weed (19-21 m^{-2}) was counted in weedy plots, where weeds were allowed to compete with crop for full growing season. On the other hand, minimum weed population (0.71 m^{-2}) was observed in frequently weeded plots (Table 4). Increase in weed population with prolonged competition period might be due to the extra time availed by weeds to germinate and continue their growth.

Weed Dry Weight

The data on above ground dry weight of weeds showed significant at $p \leq 0.05$ difference among the treatments. Full season weed crop competition period produced highest weed dry weight (29-36) which was significantly different from frequently weeded plots (Table 4). Increase in dry weight of weeds was due to increase in fresh weight of weeds as a result of prolonged weed growth. In general, as the duration for weed crop competition increased weed dry weight also increased. This result is in line with [14] who reported that there was an increase in weed population and biomass with an increase in weed-crop competition period.

Table4. *Effect of different time of hand weeding on weed density and dry weight at Arsi Negele and Melkassa*

	Arsi Negele		**Melkassa**	
Treatment	Weed density m^{-2*}	Weed biomass m^{-2*}	Weed density m^{-2*}	Weed biomass m^{-2*}
T1	21.00 ^{a}	36.00 ^{a}	19.24 ^{a}	29.40 ^{a}
T1	14.00 ^{b}	20.00 ^{b}	12.97 ^{b}	17.90 ^{b}
T3	9.00 ^{c}	10.00 ^{c}	7.50 ^{d}	8.33 ^{d}
T4	11.00 ^{d}	13.00 ^{d}	10.30 ^{c}	11.20 ^{c}
T5	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}
T6	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}
T7	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}	0.71 ^{e}
Mean	8.00	12.00	8.00	10.00
CV (%)	6.30	8.00	18.00	15.00

**transformed $\sqrt{x} + 0.5$*

Effect of Different Time of Hand Weeding on Seed Yield and Yield Component

Details of results obtained from Arsi Negele and Melkassa are presented in Tables 5 and 6. The results showed similar trend in both locations.

Stand Count: Crop stand was significantly reduced (21) in the weedy check as compared to other treatments. Frequently weeded plots gave significantly higher stand count (34-39) as compare to no weeding and late weeding. [19] reported that severe competition for growth resources in weedy check plots might have suppressed crop stands to such an extent that the crop plants could not survive.

Table5. *Effect of different time of hand weeding on yield and yield components of castor at Arsi Negele*

Treatment	Stand count	Height (cm)	Branch /plant	Inflorescence length (cm)	Hundred seed wt (gm)	Grain yield kg/ha	Yield loss (%)
T1	21.00[b]	99.00[d]	0.40 [c]	20.00 [d]	34.00 [c]	198.00 [c]	89.00
T1	31.00[a]	232.00[b]	2.93 [b]	41.00 [b]	49.00 [b]	1312.00 [b]	29.00
T3	32.00[a]	278.00[a]	3.73 [a]	50.00 [a]	53.00 [a]	1746.00 [a]	7.00
T4	30.00[a]	207.00[b]	2.20 [b]	35.00 [b]	46.00 [b]	1170.00 [b]	37.00
T5	31.00[a]	213.00[b]	2.67 [b]	36.00 [b]	47.00 [b]	1217.00 [b]	34.00
T6	23.00[b]	143.00[c]	0.60 [c]	26.00 [e]	35.00 [c]	289.00 [c]	84.00
T7	34.00[a]	290.00[a]	4.13 [a]	53.00 [a]	55.00 [a]	1850.00 [a]	0.00**
Mean	29.00	208.00	2.40	37.50	46.20	2134.50	
CV (%)	5.00	5.80	16.9	6.10	3.40	11.70	

***100% control or zero loss*

Plant Height: The plant in frequently weeded plots attained maximum height (290-377cm) which is significantly taller than other treatments except plots weeded at 30 and 50 days after sowing. The shorter crop plant height obtained from weedy treatment.

Table6. *Effect of different time of hand weeding treatments on yield and yield components of castor at Melkassa*

Treatment	Stand count	Height (cm)	Branch /Plant	Inflorescence length (cm)	100 seed wt (gm)	Grain yield (kg/ha)	Yield loss (%)
T1	21.00 [b]	159.00 [d]	0.60 [c]	22.40 [d]	37.00 [b]	279.00 [c]	86.00
T1	38.00[a]	332.00 [b]	3.20 [b]	43.00 [b]	52.00 [a]	1477.00[b]	27.00
T3	38.00 [a]	360.00 [a]	4.10 [a]	50.40 [a]	54.00 [a]	1955.00 [a]	4.00
T4	34.00 [a]	311.00 [b]	2.70 [b]	39.00 [b]	50.00 [a]	1376.00 [b]	33.0
T5	35.00 [a]	323.00 [b]	3.10 [b]	42.60 [b]	51.00 [a]	1452.00 [b]	29.00
T6	23.00 [b]	213.00 [c]	0.80 [c]	30.1 [c]	40.00 [b]	351.00 [c]	82.00
T7	39.00 [a]	377.00 [a]	4.70 [a]	52.00 [a]	56.00 [a]	2043.00[a]	0.00**
Mean	33.00	296.00	3.00	40.00	49.00	1276.00	
CV (%)	6.30	3.70	15.40	7.50	5.10	10.48	

***100% control or zero loss*

The shorter plant height (99-159) in weedy plot might be due to the negative impact of weeds on growth of castor plants. This result agrees with [7] who reported that the plant height in weed free plot is significantly taller than the one in weedy plot.

Branches per Plant: The maximum number (4.13-4.7) of branches plant^{-1} was recorded from frequently weeded plots which was statistically non-significant with branch number obtained from plots weeded at 30 and 50 days after sowing. The lowest branch plant^{-1} (0.4-0.6) was recorded from weedy plot.

Inflorescence Length: is very important yield component to be determined in the reproductive phase. Inflorescence length showed significant at $p \leq 0.05$ differences among treatments. Significantly longer (52-53 cm) inflorescence length was recorded from frequently weeded plots. Whereas shorter (20 - 22.4 cm) inflorescence length was obtained from weedy plot. This might be due to the significantly more weed density and weed dry weight that exerted severe competition with crop for growth factors [4].

Hundred Seed Weight: Seed weight reflects the capacity of a crop plant to transport its Photosynthetic assimilates to economically valuable parts. Duration of weed competition significantly influenced seed weight. The highest 100 seed weight (55-56 g) was achieved in frequently weeded treatment which was statistically non-significant with that recorded (53-54 g) in treatment weeded at 30 and 50 days after sowing. Weed competition up to full season resulted in lowest 100 seed weight

(34-37 g). It appears to be quite logical that weed free control crop made full utilization of the environmental resources. These results are in agreement with those of [17] who noted decrease in seed weight of maize with an increase in weed density. Similar findings were also reported on sesame by [12, 21].

Seed Yield: Seed yield is a function of the integrated effect of all the yield components. Seed yield of castor showed significant difference at $p \leq 0.05$ among treatments. The highest seed yield (1850-2043 kg ha^{-1}) was obtained from plots weeded at 30,50 and 70 days after sowing which was significantly higher than the yield obtained from other treatments except plots weeded at 30 and 50 days after sowing. The weedy-check treatment produced the least seed yield of 198 to 279 kg ha^{-1} which was not significantly different from late weeded treatment. This could be as a result of high weed competition for nutrients, water, space and sunshine with the castor plants as the weeds were not removed throughout the growth cycle of castor plant.

The result of the study indicated that plots that were weeded at 30 and 50 days after sowing gave good yields comparable to plots that were weeded at 30, 50 and 70 days after sowing. It was possible to get reasonable yield by weeding at 30 and 50 days after sowing rather than weeding frequently.

Growers assume that removing weed competition any time during the growing season solves the problem. However time of removal is as important as removal itself. Weeding without knowing the critical period is simply wastage of labor, time and money. For instance, weeding at 70 days after sowing (late weeding) has no much value to increase yield. When weeding is carried out late in the season, weeds are vigorous and well established. Thus, the weeds are hard to hand pull or hoe and takes more time as well as labor. Castor being a slow germinating plant but fast canopy forming crop. At late growing stage the canopy of the crop is able to suppress weeds which becomes etiolate as a result of the shading effect [16].

In general, weeding at 30 and 50 days after sowing plays significant role for the increment of yield in frequently weeded plots. Hence, critical weed-crop competition period or weeding time for castor is from 30 to 50 days after sowing. Two hand weeding between 30 and 50 days after sowing are enough for weed control in castor. This result is in conformity with that of [6]. Moreover, uninterrupted weed growth resulted in 86-89% reduction in yield as compared to frequently weeded treatment. Hence, yield loss incurred due to weed competition in castor was estimated to be 86 % - 89%. This result agrees with that mentioned by [18].

CONCLUSION

Castor is considered highly sensitive to weed competition. Weed competition affects castor plant adversely by reducing castor plant population, plant height, number of branches, length of inflorescence, and number of capsules per plant and seed yield and finally makes harvesting difficult. Weed competition is most serious at the early and mid-stages of crop establishment and being critical between 30-50 days after sowing of castor. The yield loss incurred due to weed competition was estimated to be 86- 89%. Therefore, in order to minimize this amount of loss twice hand weeding at the beginning and the end of critical period could be recommended for castor farmers particularly farmers that shares similar ecology, physicochemical soil properties and weed species with the locations where the trial was carried out.

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