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Appropriate Time for Weed Management for Finger millet(*Eleusin coracana Goartn)*

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Abstract
Field experiments were conducted in 2009 and 2010 at Adet and Finoteselam research stations to determine the critical period of weed competition in Finger millet (Eleusin coracana Goartn). Seventeen treatments where finger millet is kept weed free and left weedy for an interval of days after emergence (DAE) were tested in the experiment. The treatments were: weedy check, weed free check, weeding up to 20 DAE, weeding up to 25 DAE ,weeding up to 30 AE, weeding up to 35 DAE, weeding up to 40 DAE, weeding up to 45 DAE, weedy up to 20 DAE, weedy up to 25 DAE, weedy up to 30 DAE, weedy up to 35 DAE, weedy up to 40DAE,weedy up to 45 DAE, weeding at 20 and 25 DAE, weeding at 20, 25 and 35 DAE and weeding at to 20, 25, 35, 45 DAE. Crop-weed competitions were not the same across all stages of the crop. The competition became sever at early stage of growth than the late growth stage of the crop. Similarly, the critical period of weed competition lies at early growth stage between 20 days and 30 days after emergence of the crop. Therefore, to prevent yield loss due to weeds, the crop should be kept weed-free from 20 to 30 days after emergences; since an application of control measures before and after this period did not brought that much yield loss on finger millet. However, finger millet yield loss increased with increasing duration of weed interference, and decreased with increasing duration of weed free periods.
Keywords: critical ,loss, Competition

Introduction

In Ethiopia, finger millet is the 6th important crops after tef, wheat, maize, sorghum and barley. It comprises about 5 percent of the total land devoted to cereals. It is produced on 368,999.15 ha of land, from which 524, 191.1 tons are obtained at national level. It is mainly grown in North Gondar, West Gojam, some parts of Tigray and West Wollega. It is widely grown in the Amhara Region,it covers 164,321.16 ha of land and giving 2,495,09.2 ton in the region, which is 52.4 % of the total national production (CSA, 2012). The yields of finger millet are low in Ethiopia due to different production problems including: lack of improved varieties, little research emphasis given to the crop, non adoption of improved technologies, poor attitude to the crop, disease like blast which is the most serious disease, lack of appropriate weed control, lodging and moisture stress in dry areas, threshing and milling problem are some the most serious production constraints in Finger millet production in Ethiopia (Tsehaye and Kebebew, 2002; Degu et al., 2009; Andualem 2009; Molla, 2010).

Weeds pose one of the major constraints in the worldwide production of finger millet. Owing to initial slow growth of the finger millet favours weed growth, which causes more competition for sunlight, nutrient and water in early stages of growth lead in lowering productivity (Lall and Yadav, 1982). Weeds interference causes important yield losses worldwide with an average of 12.8% despite weed control applications and 29.2% in the case of no weed control (Burkill, 1985). Mechanical and chemical methods are two main weed control methods in Finger millet. Although controlling weeds with these two methods is effective, they have some disadvantages or side effects that increase production costs when applied intensively. Intensive mechanical weed control causes soil erosion and crop injuries and intensive use of herbicides are mostly associated with soil and water pollution and the selection of herbicide resistant weed biotypes (Fryer,1997).

To reduce the cost of finger millet production, intensive applications of weed control methods should be optimized (Fryer, 1997). Therefore, determining appropriate weed management practices is important for production to ensure optimum grain yield. Identifying the critical period for weed control (CPWC) in crops is one of the first steps in designing a successful integrated weed management (Evans, 2002). Therefore, the objectives of this study were to evaluate the effect of the timing of weed removal and the duration of weed interference on finger millet yield and to determine the optimum timing for weed control.

Material and Method

The experiment was conducted at Finoteselam and Adet research stations in 2009 and 2010 cropping seasons. The sites are located in humid agro climatic zone of the country where weather conditions are conducive for

reliable finger millet production. Finoteselam is located $10^0$42.7'N latitude and 37005.6'E longitude with an altitude of 2600 meters above sea level (m.a.s.l) while Adet is located 11016'N latitude and 37029'E longitude with an altitude of 2240 m.a.s.l. Seventeen treatments where finger millet is kept weed free and left weedy for an interval of days after emergence (DAE) were tasted in the experiment. The treatments were: weedy check, weed free check, weeding up to 20 DAE, weeding up to 25 DAE ,weeding up to 30 AE, weeding up to 35 DAE, weeding up to 40 DAE, weeding up to 45 DAE, weedy up to 20 DAE, weedy up to 25 DAE, weedy up to 30 DAE, weedy up to 35 DAE, weedy up to 40DAE,weedy up to 45 DAE, weeding at 20 and 25 DAE, weeding at 20, 25 and 35 DAE and weeding at to 20, 25, 35, 45 DAE. The design was RCBD with three replications of plot size 3m x 4m. Seed rate of 15 kg ha^{-1} was broadcast planted. Fertilizer rate of 100/50 kg ha^{-1} (DAP/UREA) were applied. Other agronomic activities were applied as per the farmer's experience. List of common weed species in the field, weed count per m^2, grain yield, and biological yield, plant height and effective tillers per m^2 were recorded accordingly. The data was analysis with stastical analysis software (SAS) version 12.0. Duncan's multiple range tests (DMRT) procedure was used for mean separation (SAS, 2002).

Yield loss assessment

The yield loss of the crop due to weed infestation was found with the manipulation of the yield obtained from maximum protected plot with the yield of lower treatments. Hence the Relative percent grain yield loss (L) was calculated using the formula:

YL% = [(Ybt- _ Ylt) X 100/Ybt];

Where Ybt is the yield from maximum protected plot and Ylt is the yield from lower treatments, yields of weedy check.

Result and Discussion

In this study 15 major weed species were recorded at adet and Finoteselam experimental fingermillet fields in 2009 and 2010. The highest weed population (101 weeds/m^2) was counted for Digitaria ternata ; while the lowest count (11 weeds /m^2) was for Caylusa abyssinica (table 1). The weed pressure was relatively stronger at Adet trial site and 2009 cropping season than Finoteselam trail site and 2010 cropping season. Weed growth, population density, and distributions in cereal fields vary from place to place depending upon soil and climatic factors and management practices (Abraham, 2008). Annual weeds dominated the trial. Generally, across the treatment grassy weeds dominated the weed flora while broad leaved weeds were the least occurring in the trial. Rezene (2001) also indicated that species of poacea are the most common in small grains including finger millet. Except grain yield and biological yield, other agronomic traits (plant height, tiller number and biomass yield) were not statistically significant both at Finoteselam and Adet (Table 2). Relatively greater crop growth performance was observed at Adet than Finoteselam due to better soil and climatic conditions for finger millet growth.As a result, an average grain yield of 22.7 q/ha and 18.1q/ha was result from Adet and Finoteselam respectively.

At Finote Selam, the highest biomass of 560 q/ha was produced from the weed free check; whereas the lowest biomass of 330 q/ha was obtained from the weedy check; and when weeding was done upto twenty days after emergency. Similarly, grain yield of 34.5 q/ha was highest for weed free check followed by grain yield of 31.8 q/ha and 31.6q/ha when weeding was performed four times at 20,25,35 and 45 days after emergency and weeding up to 30 days after emergency respectively. The lowest grain yield of 9.8 q/ha and 14.1q/ha was obtained from the weedy check and when weeding was not done until 45 days emergency. Grain yield reduction was highly sensitive to late weeding after 25 days after emergency; whereas grain yield increment was also apparent when weeding is done up to 30 days after emergency and the response ceased after wards (table2).This is due to sever weed competition during the early growth stage of fingermilet that can remarkably reduce grain yield if timely control measure is not taken.

At Adet, the weed free check gave the highest biomass yield of 502 q/ha and weedy check gave the least biomass of 310 q/ha. Generally, biomass yield was not consistently responded to the successive weeding periods. The result also reveals that grain yield of finger millet linearly responded to different weeding times; hence the maximum grain yield of 32.5 q/ha and 32.4 q/ha was harvested when finger millet is weed free for 40 and 45 days after emergency respectively; whereas the very minimal grain yield of 4.1 q/ha was recorded from weedy check.

As the combined result over locations indicates only grain yield was significantly influenced by the weeding treatments. The highest grain yield was obtained when the field was weed free up to 40 days after emergency (31.4 q/ha) ,weed free up to 45 days after emergency (31.4 q/ha) and when the weeds were completely controlled (30.2 q/ha). Lall (1983) also states that only grain yield was significantly affected due weed management practice.

Despite it is not statically significant, there was an indication that tallest plants (91.6 cm) were recorded from the weedy check and shorter plants (83.6 cm) from weed free check. This is probably due to tough

competition occurred for light on the weedy plot will result in tall and thin plants. Better productive tillers were obtained when the weed free periods increased successively due to reduced competition for space and dry matter accumulation that might be the reason for better grain yield; since there is also a good canopy closure to dominate weeds. These results are in conformity with the findings of Arunachalam et al. (1995) that indicated that reduced competition and increased availability of resources like nutrients, soil moisture and light paved way for higher leaf area per plant (leaf area index) and consequently increased the biomass of the crop.

This study quantified the magnitude of yield loss brought by delayed and untimely weeding of fingermillet.Those plots left weedy from 20 to 45 interval after the crop emerges caused yield loss ranged from 21%-68%.Totlaly unweeded plots gave 73% yield reduction while quitting weeding after 20 days up to 25 days after emergency caused a yield reduction as much as 41%. The finding agrees with the review made by Rezene (1986) and Hailu et al. (1991) of yield loss assessment in Ethiopia suggested that there is an average yield reduction of 36% due to weed competition in cereal crops.

The rate of yield increament and decrement was higher within the period 20- 30 days after emergence (DAE).However, dramatical reduction in yield were recorded when delayed weeding after 20 days of emergence (Figure 3). Weeding operations done earlier in 20-30 days after sowing affected the grain yields adversely and weed free conditions beyond 45 days after sowing did not give any additional advantage. This is due to the crop-weed competation became much true after 20 days after emergence.

The increases and decline line of grain yield meet at a point where substantial yield loss occurs (Figure 3). This intersection point is said to be critical period of weed competition (CPWC). It is determined by functional relationships between two separately measured competition components: crop yield as a function of the duration of weed interference to identify the beginning of CPWC and crop yield as a function of the duration of the weed-free period to identify the end of CPWC. At this crop growth stage weeds must be controlled to prevent yield losses.

The critical period of weed competition for finger millet lays between 20 days and 30 days after it has emerged (Figure 3). This suggests that Finger millet can tolerate weed interference up to 20 days after emergence and weed control measures can be postponed until this time. The crop should be kept weed-free from 20 to 30 DAE in order to prevent yield loss. Application of control methods before and after this period did not provide significant yield increase on finger millet. However, growers generally tend to keep fields weed-free as long as possible immediately after crop emergence to provide a long-term weed-free environment for finger millet (Lall et al., 1992). For this reason they may apply mechanical control and post-emergence herbicide repeated several times unnecessarily. Consequently, it could lead to cost ineffective finger millet production and also the chemicals may harm the environment. Therefore, adjusting the weed control timing to CPWC is an important way of reducing the production costs and potential hazards of weed control measures. According to the results of the CPWC, growers could improve timing of post emergence herbicide applications and hand weeding.

Moreover, within 10 days of critical weed competition interval finger millet has to be weeded at list two times one at the beginning and one at the end of this period. Beside the interval this also determines the earliest time to start weed control and the time to cease weed control. The result quit in conformity with the work by Lall and Yada (1982) that states the critical period of weed competition between the periods 25-45 after sowing for fingermillet.

There are stages when the interaction between weeds and crop became more sever and cause yield loss. The period is considered as a critical period of weed competition .Late and early stage weed control measures did not bring yield loss on the crop. Generally the experimental result raveled that competition of weeds with finger millet become sever between the 20^{th} and 30^{th} DAE. There for finger millet within these 10 days of interval finger millet should be kept weed free from 20^{th} up to the 30^{th} DAE in order to prevent yield loss. Application of control methods before and after this period did not provide significant yield increase on finger millet. Moreover, within the 10 days of critical weed competition interval finger millet has to be weeded at list two times one at 20^{th} DAE and one around the 30^{th} DAE i.e. at the beginning and end of at the the critical period of weed competition.

Table 1 Weed species count/m^2 at Adet and Finoteselam in 2009 and 2010

Weed species	Locations				Average
	Adet		Burie		
	2009	2010	2009	2010	
Galinsoga praviflora	65	41	53	49	**52.0**
Commenlia spps	57	35	62	45	**49.8**
Guizotta scarba	97	76	82	79	**83.5**
Digitaria ternata	111	89	102	103	**101.3**
Eleusine indica	41	35	31	29	**34.0**
Caylusa abyssinica	13	2	19	11	**11.3**
Polygonum nepalese	11	11	15	10	**11.8**
Phalaris paradoxa	21	37	20	14	**23.0**
Setaria pumila	32	19	21	18	**22.5**
Plantago laceolata	32	23	48	30	**33.3**
Oxygonum sinuatum	19	27	18	17	**20.3**
Medicago polymorpha	13	11	11	16	**12.8**
Bidens pachyloma	76	31	56	41	**51.0**
Cypress rotundus(spp.)	77	68	59	41	**61.3**
Oxalis corniculata	8	11	15	21	**13.8**
Sum	**682**	**526**	**621**	**534**	**682**
Average	**44.9**	**34.4**	**40.8**	**34.9**	

Table 1 the response of yield and yield components for weeding at Finote Selam

Treatments	Finote Selam over years			
	PH(cm)	ET (m^{-2})	BY (qha^{-1})	GY (qha^{-1})
Weedy check	94.5	48.0	330.0^{c}	9.8^{c}
weed free check	82.6	68.3	560.0^{a}	34.5^{a}
weeding up to 20 DAE	93.3	53.6	460.0^{ab}	20.8^{ab}
weeding up to 25 DAE	85.0	52.0	430.0^{ab}	27.9^{ab}
weeding up to 30 DAE	88.3	56.3	400.0^{ab}	31.6^{a}
weeding up to 35 DAE	85.3	57.0	360.0^{bc}	30.9^{a}
weeding up to 40 DAE	83.8	52.6	400.0^{ab}	30.3^{a}
weeding up to 45 DAE	86.0	62.3	460.0^{ab}	30.4^{a}
weedy up to 20 DAE	89.5	52.0	330.0^{ab}	27.7^{ab}
weedy up to 25 DAE	82.0	56.3	400.0^{ab}	21.2^{ab}
Weedy up to 30 DAE	84.2	55.0	400.0^{ab}	15.9^{c}
weedy up to 35DAE	78.7	52.0	430.0^{ab}	15.6^{c}
weedy up to 40 DAE	85.1	50.0	530.0^{a}	16.1^{c}
weedy up to 45 DAE	79.4	62.0	400.0^{ab}	14.1^{c}
weeding at 20 and 25 DAE	86.1	58.6	360.0^{bc}	24.9^{ab}
weeding at 20,25 and35 DAE	81.0	61.3	500.0^{a}	29.5^{a}
weeding at to 20,25,35,45 DAE	90.3	67.3	260.0^{c}	31.8^{a}
Mean	85.6	57.6	420	22.7
CV	8.56	14.9	29.2	23.8
P $_{0.01\ \&0.05}$	0.16	0.11	0.04	0.02

DAE=days after emergency, PH=plant height, ET=effective tillers, BY=biological yield, CV=coefficient of variation, P= probability

Table 3 the response of growth and yield parameters for weeding at Merawi

Treatments	Parameters			
	PH(cm)	ET (m^{-2})	BY (qha^{-1})	GY (qha^{-1})
Weedy check	89.4	41.0	489.0	4.1
weed free check	84.7	60.3	502.0^{a}	26.0^{ab}
weeding up to 20 DAE	87.3	59.7	390.0^{bc}	15.1^{bc}
weeding up to 25 DAE	83.5	60.7	437.0^{ab}	25.0^{ab}
weeding up to 30 DAE	85.3	59.1	478.0^{ab}	30.9^{a}
weeding up to 35 DAE	88.1	67.0	396.0^{bc}	31.3^{a}
weeding up to 40 DAE	85.4	58.6	387.0^{bc}	32.5^{a}
weeding up to 45 DAE	88.3	64.3	481.0^{ab}	32.4^{a}
weedy up to 20 DAE	86.4	57.0	310.0^{c}	20.1^{ab}
weedy up to 25 DAE	80.0	58.2	375.0^{bc}	17.2^{bc}
Weedy up to 30 DAE	87.7	57.3	398.0^{bc}	9.7^{c}
weedy up to 35DAE	81.2	58.7	411.0^{ab}	8.2^{c}
weedy up to 40 DAE	85.9	54.2	501.0^{a}	5.9^{c}
weedy up to 45 DAE	88.2	50.6	485.0^{ab}	5.2^{c}
weeding at 20 and 25 DAE	82.8	61.4	332.0^{c}	25.1^{ab}
weeding at 20,25 and35 DAE	80.4	56.3	349.0^{c}	30.2^{a}
weeding at to 20,25,35,45 DAE	82.8	57.8	333.0^{c}	33.9^{a}
Mean	85.1	58.1	414.9	18.1
CV	9.2	14.9	29.1	27.9
P $_{0.01\ \&0.05}$	0.3	0.2	0.03	0.01

DAE=days after emergency, PH=plant height, ET=effective tillers, BY=biological yield, CV=coefficient of variation, P= probability

Table 4 the response of yield and yield components for weeding combined over locations

Treatments	Parameters				Yeild loss (%)
	PH (cm)	ET (m^{-2})	BY (qha^{-1})	GY (qha^{-1})	
Weedy check	91.6	44.5	419.5	8.0^{c}	73.5
weed free check	83.6	64.3	531.0	30.2^{a}	0.0
weeding up to 20 DAE	90.3	56.6	425.0	17.9^{bc}	40.7
weeding up to 25 DAE	84.2	56.3	433.5	25.4^{ab}	15.9
weeding up to 30 DAE	86.8	57.7	439.0	29.7^{a}	1.7
weeding up to 35 DAE	86.7	62.0	378.0	30.3^{a}	-0.3
weeding up to 40 DAE	84.6	55.6	393.5	31.4^{a}	-4.0
weeding up to 45 DAE	87.1	63.3	470.5	31.4^{a}	-4.0
weedy up to 20 DAE	87.9	54.5	320.0	23.9^{bc}	20.9
weedy up to 25 DAE	81.0	57.2	387.5	19.2^{bc}	36.4
Weedy up to 30 DAE	85.9	56.1	399.0	12.8^{c}	57.6
weedy up to 35DAE	79.9	55.3	420.5	11.9^{c}	60.6
weedy up to 40 DAE	85.5	52.1	515.5	11.0^{c}	63.6
weedy up to 45 DAE	83.8	56.3	442.5	9.6^{c}	68.2
weeding at 20 and 25 DAE	84.4	60.0	346.0	13.6^{c}	55.0
weeding at 20,25 and35 DAE	80.7	58.8	424.5	22.4^{bc}	25.8
weeding at to 20,25,35,45 DAE	86.5	62.5	296.5	27.1^{ab}	10.3
Mean	85.3	57.8	417.5	21.5^{bc}	
CV	7.5	13.2	37.3	34.9	
P $_{0.01\ \&0.05}$	0.12	0.12	0.16	<.0.01	

DAE=days after emergency, PH=plant height, ET=effective tillers, BY=biological yield, CV=coefficient of variation, P= probability

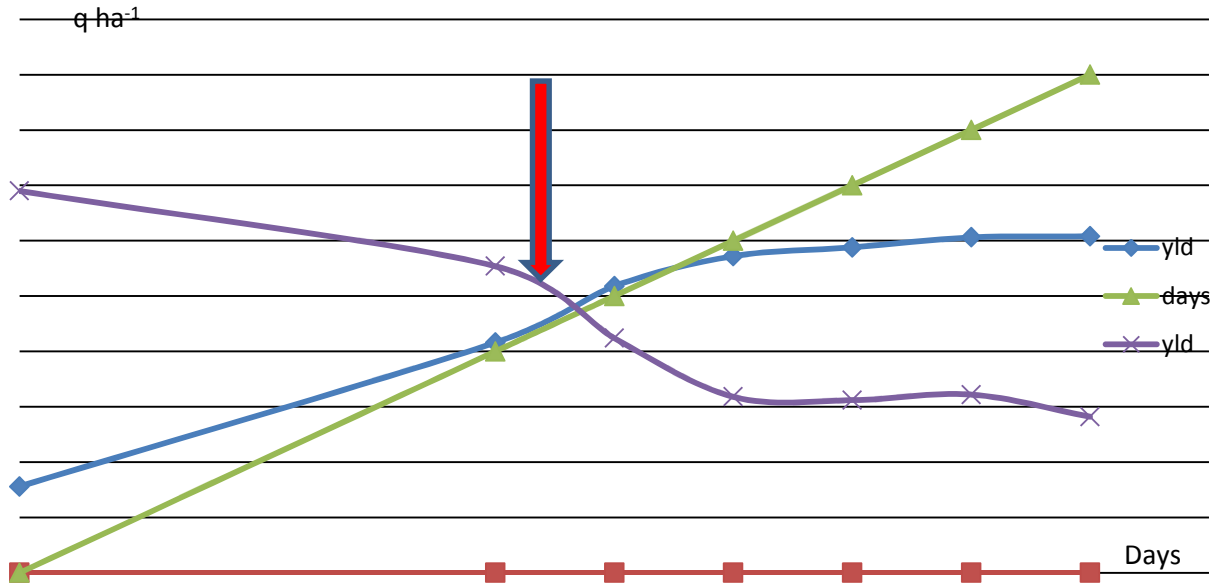

Figure 1 Critical period of weed competition of finger millet

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