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Critical Time of Weed Competition and Evaluation of Weed Management Techniques on Ginger (*Zengeber Officinale*) at Tepi in South West Ethiopia

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Abstract: *Ginger (Zengeber officinale) is one of the leading exported spice crop in Ethiopia. Weeds are a major constraint in ginger production. Ginger was found very poor competitor of weeds that as weeding was delayed tremendous yield loss was incurred. When weeding was totally ignored yield loss amounted to 100%. Understanding the critical period for weed competition and weed management techniques can be a tool for effective weed control and reducing the impacts of weeds. The experiment was conducted during 2010 to 2012 using randomized complete block design with three replications to determine the critical period and evaluation of weed management techniques at Tepi in south west Ethiopia. Timing of weed removal was based on the number of days after ginger planted. To determine critical time of weed competition, weeds allowed competing with ginger for 15, 30, 45, and 60 days after planting. In addition, season long weedy check and weed-free check were included as control. For weed management study five treatments (mulching at planting + weeding at 45, and 75 days; mulching at planting + weeding at 60 and 90 days; weeding at 30 + mulching + two hand weeding as needed; weeding at 30, 60 + mulching + one hand weeding as needed; weeding at 45, 75 + mulching + one hand weeding as needed) were applied which contain both hand weeding and mulching at different periods. All noxious and important weed species were abundantly grown in the experimental site and the surrounding, the important weeds were Poaceae and Asteraceae. Number of tiller, number of leaf per tiller, plant height, leaf width and length, rhizome width and length, number of fingers per rhizome and yield were affected significantly at p<0.001. Maximum yield loss (47%) was recorded when weeding applied at 60 days after planting (DAP) but minimum yield loss (9%) at 30 DAP. Yield advantage of 41% and 34% obtained when first hand weeding was applied at 30 and 45 DAP respectively as compared to 60 DAP. Sever ginger-weed competition was taken place between 30 and 60 days. Mulching of ginger after one or two hand weddings at 30 and 45 DAP found as good agronomic practice. plant height, leaf length, leaf width and weed biomass were do have a significant negative association with that of ginger yield where as number of ginger tiller per plant, number of leaf per tiller, rhizome length and width, number of fingers per rhizome, and stand count were found a positive significant association with yield. Hence, it would be wise to apply the first hand weeding between 30 and 45 DAP in order to avoid sever competition for maximum yield of the crop.*

Keywords: *critical, ginger, Tepi, weed.*

1. Introduction

Ginger (*Zengeber officinale*) is one of the leading exported spice crop in Ethiopia, for instance in 5 years (2005/06-2009/10), the country exported 47180 tons of dry ginger and generated $ 38.1 million and this accounted for the lion share of 71% of the total four major spices exported followed by turmeric (8.3%), and cumin (7.9%) and fenugreek, coriander and pepper taking the rest (Masresha Yimer, 2010).

However, the suitability of the agro ecology of south west Ethiopia for fast growth and diversity of weeds and susceptibility of ginger for weed competition make weed control difficult. Competition from weeds is the most important of all biological factors that reduce agricultural crop yield, this is due to weeds are the most competent for nutrient, water, and sun light. 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. As a general rule, an average weed infestation may be expected to reduce yields by 10 - 15% (Woolley *et al*., 1993).

Understanding the critical period for weed control (CPWC) can be a tool for effective weed control and reducing the impacts of weeds (Weaver and Tan, 1987). It is an integral part of integrated weed management (IWM) and can be considered the first step to design weed control strategy (Zimdahl, 2004). The CPWC is the period of crop life cycle during which weeds must be controlled to prevent unacceptable or economic yield loss **(**Evans et al, 1980 and Zimdahl *et al*., 2003)**.** The length of the critical period of weed control may vary depending on the acceptable yield loss first proposed in corn (Hall *et al*., 1992), and later in soybean and white bean (*Phaseolus vulgaris* L.) (Woolley *et al*., 1993).

The critical period of weed control for canola is around the 4-leaf stage, or 17-38 days after crop emergence (Martin et al., 2001). For pea varied between sites but began as early as 2 weeks after emergence (Harker *et al*., 2001). For a more competitive crop such as barley the timing of weed removal is not as clear cut (O'Donovan *et al*., 2005). For corn, the critical period depends on nitrogen availability, with the critical period becoming shorter with increased fertilizer rates. Critical period was determined as 7–49 days after seeding in off-season and 7–53 days in main season to achieve 95% of weed-free yield, and 23–40 days in off-season and 21–43 days in main season to achieve 90% of weed-free yield in aerobic rice (Anwar *et al*., 2012), leek should be kept weed free between 7 days and 85 days after transplanting to avoid yield losses in excess of 5% (Tursun *et al.,* 2007). Many findings suggested that critical time of weed competition vary from crop to crop and area to area. The present study seek to identify which time in the growth of ginger most susceptible for weed competition and result significant yield loss and determine weed management technique which is suitable, economical and effective.

2. MATERIALS AND METHODS

2.1. Experimental Site and Soil

The trial was conducted starting from 2010 to 2012 in Tepi National spices research center which is 611km away from Addis Ababa, and located at Latitude: 7^0 3' N Longitude: 35^0, 0'E with altitude of 1200 m. Maximum and minimum temperature are 30^0C and 15^0C respectively. Mean annual rain fall of the area is 1591mm; it is under hot to warm humid lowland agro ecology (EIAR, 2012). Soils of the area are very deep (>150cm) and have a color of dark brown (7.5YR3/2) when moist. The texture is clay with moderate medium sub angular blocky structure. The pH (H_2O) of surface soil is 7.7, decreasing to 5.8 in subsurface horizon. The organic matter content is medium to very high (2.47 to 7.02%) and the total nitrogen content is low to very high (0.09 to 0.73%); while available phosphorous is low to medium (0.97 to 7.36ppm). available micronutrients range between 1.1 to 6.92ppm for Fe, 51 to 111.7ppm for Mn, 1.96 to 5.16ppm for Zn and trace to 2.46ppm for Cu.

2.2. Plant Material

Ginger variety Yali was used for the study. This variety was selected because of it is widely grown in south west Ethiopia and it is highly affected by weed completion

2.3. Experimental Treatments and Design

The experimental design was a randomized complete block with three replications. To determine CPWC and evaluation of weed management technique. Timing of weed removal was based on the number of days after ginger planted. To determine CPWC, allowing the weeds to compete with ginger for 15, 30, 45, and 60 days after planting In addition, season long weedy check and weed-free check were included as control. For weed management study 5 treatment were applied which contain both hand weeding and mulching applying at different period (mulching at planting + weeding at 45, and 75 days; mulching at planting + weeding at 60 and 90 days; weeding at 30 + mulching + two hand weeding as needed; weeding at 30, 60 + mulching + one hand weeding as needed; weeding at 45, 75 + mulching + one hand weeding as needed. We were use vetiver (*Chrysopogon zizanioides*)) grass as a mulch material. Planting and other agronomic practice were done according to Girma *et al*., (2008) recommendation.

2.4. Data Collection

At each weed removal time, a 50cm × 50cm quadrate was randomly placed lengthwise at four spots in each plot for recording weed data. Weeds were clipped to ground level, identified and counted by species and List of the noxious and important weed species were summarized in a table. Fresh weight of individual weed species were measure and their correlation with other vegetative and yield related parameter were determined. From the crop, number of tiller per stand, number of leaf per tiller, leaf length, leaf width, rhizome length, rhizome width, number of finger per rhizome and fresh yield kilogram per plot were measured

2.5. Statistical Analysis

Statistical Analysis System (SAS 9.1) software was used to analyze the data. For each year, mean yield and measured vegetative parameter across the three blocks was calculated for each treatment. The yield data converted to percentage values (relative yield, RY) of the season long weed-free control in each treatment group. Person correlation coefficient were used to obtain the association of each parameter

3. RESULT AND DISCUSSION

All noxious and important weed species were abundantly growing in the experimental site and the surrounding. The classification as noxious and important was based on the species competitive ability and time and money spent for their control. The noxious species are highly competitive for essential growth requirements and are also too difficult to control once they are established in the field.

Table1. *List of the noxious and important weed species at Tepi*

Botanical name	Family	Growth nature	Eco-physiology definition	Economic importance
Cynodon spp	*Poacea*	Perennial	C4	Noxious
Cyperus spp	*Poacea*	Perennial	C4	Noxious
Digitaria spp	*Poacea*	Perennial	C4	Noxious
Gyzotia scabra	*Asteracea*	Annual	C3	Noxious
Bidens pilosa	*Compositea*	Annual	C3	Important
Commelina benghalensis	*Commelinacea*	Annual	C3	Noxious
Ageratum conyzoides	*Compositea*	Annual	C3	Important
Plantago lanceolata	*plantaginaceae*	Annual	C3	Important

There was a highly significant difference ($p<0.1$) between treatments (Table2). The result clearly demonstrated that ginger was very poor competitor of weeds that as weeding was delayed tremendous yield loss was incurred. When weeding was totally ignored yield loss amounted to 100%. From the result number of tiller, number of leaf per tiller, plant height, leaf width and length, rhizome width and length, number of fingers per rhizome and yield were affected significantly at $p<0.001$. from the treatment weeding starts at 15, 30, and 45 days after planting were found Significantly different to that of weeding starts at 60 days after planting, Maximum yield loss were obtained when weeding applied at 60 days after planting which is 46.57% and minimum yield loss were obtained when wedding applied at 30 days after planting which was 9.0%. the result reviled that yield advantage of 41.24% and 33.798% obtained when the first hand weeding was applied 30 and 45 days after planting when compared with the treatment where the first hand weeding was applied at 60 days after planting. This result clearly indicates that sever crop weed competition has taken place between 30 and 60 days. Hence, it would be wise to apply the first hand weeding between 30 and 45 days after planting in order to avoid the period where sever competition takes place for maximum yield of the crop.

From weed management treatment result, Mulching at planting followed by weeding at 45 and 75 days after planting; Mulching at planting followed by weeding at 60 and 90 days after planting and Weeding at 45 and 75 followed by mulching followed by one hand weeding as needed were significantly different to that of Weeding at 30 days followed by mulching followed by two hand weeding as needed and Weeding at 30 and60 days after planting followed by mulching followed by one hand weeding as needed.

The result also showed that mulching of ginger was found to be good agronomic practice especially when applied during planting and after one or two hand weddings applied at 30 and 45 days after planting. Mulching ginger at planting or after two hand weddings the frequency of hand weeding can be reduced and cost of weeding minimized. In addition to the advantage of mulching ginger for controlling weeds, mulching at planting has enhanced early germination and growth of ginger compared with un-mulched treatments. This might be attributed to the regulation of the mulch on soil moisture and temperature making suitable for early germination of the crop. Mulching at planting followed by two hand weeding at 45 and 75 days after planting and mulching at planting and followed by two hand weeding at 60 and 90 days gave similar yield with the clean weeding and the most frequently weeded treatment with 6 weeding frequencies. Since frequent weeding results high cost choosing the write treatment is important. Mulching apart from reducing the frequency of hand weeding also covers the soil and protects the rhizomes from sun light exposure which can seriously affect the quality of the crop. This finding has far reaching implication that farmers can mulch ginger at planting and can delay weeding ginger at busy times to do other farm activities without yield being affected.

Table2. *Mean of vegetative and yield data and their mean separation*

Treatment*	No.tiller/stand	Plant ht	No.leaf/tiller	Leaf W	Rhizome L	Rhizome W	No. fingers/rhizome	Yield kg/plot	%age Yield loss of clean weedig
T1	3.26^{A}	51.73^{BC}	4.146^{AB}	2.87^{AB}	11.73^{AB}	17.47^{A}	3.52^{A}	24^{ABC}	18.17
T2	3.14^{AB}	53.6A^{BC}	4.20^{AB}	2.72^{B}	10.93^{ABC}	14.27^{BCD}	3.51^{AB}	26.67^{AB}	9.07
T3	2.76^{AB}	53.47^{ABC}	4.177^{AB}	2.93^{AB}	10.87^{ABC}	15.2^{ABC}	3.18A^{BC}	23.67^{ABC}	19.39
T4	2.99^{AB}	52.27^{BC}	4.209^{A}	2.75^{AB}	10.73^{BC}	13.0^{DC}	2.97^{ABC}	15.67^{DEF}	46.57
T5	3.03^{AB}	55.6^{ABC}	4.145^{AB}	2.82^{AB}	11.47^{AB}	12.0^{D}	3.16^{ABC}	19.33^{CDE}	34.09
T6	3.089^{AB}	52.6^{BC}	4.107^{AB}	2.7^{B}	9.4^{C}	14.33^{BCD}	2.85^{BC}	20.67^{BCDE}	29.53
T7	2.451^{B}	59.33^{AB}	4.105^{AB}	3.0^{AB}	9.4^{C}	13.47^{DC}	2.74^{C}	11.33^{F}	61.37
T8	2.924^{AB}	48.33^{C}	3.886^{BC}	2.93^{AB}	10.93^{ABC}	12.73^{DC}	2.76^{C}	14.33^{EF}	51.14
T9	2.976^{AB}	52.6^{BC}	4.137^{AB}	3.067^{A}	10.33^{BC}	13.27^{DC}	2.89^{ABC}	21.67^{BCD}	26.12
T10	3.356^{A}	55.0^{ABC}	4.258^{A}	3.0^{AB}	12.67^{A}	16.133^{AB}	3.52^{AB}	29.33^{A}	0
T11	1.52^{C}	63.67^{A}	3.693^{C}	2.887^{AB}	4.47^{D}	5.0^{E}	1.77^{D}	2^{G}	93.18
CV %	15.3	11.8	4.5	6.97	10.5	10.5	13.097	20.3	
LSD 5%	0.7506	10.91	0.32	0.34	1.85	2.49	10.94	6.59	

**treatment description*

T1: weeding at 15,30,45,60,75,90,105,120,135,150,165 and 180 days after planting (12 weeding)

T2: weeding at 30, 60, 90,120, and 180 days after planting (6weeding)

T3: weeding at 45, 75, 105 and 135 and 165 days after planting (5weeding)

T4: weeding at 60, 90, and 120 and 150 days after planting (4weeding)

T5: mulching at planting + weeding at 45, and 75 days

T6: mulching at planting + weeding at 60 and 90 days

T7: weeding at 30 + mulching + two hand weeding as needed

T8: weeding at 30, 60 + mulching + one hand weeding as needed

T9: weeding at 45, 75 + mulching + one hand weeding as needed

T10: clean weeding (plots will be weed free all year round)

T11: un-weeded

Weed competition were found significantly affect vegetative, yield and yield related parameters. Plant height, leaf length, leaf width and weed biomass were a significant negative association to that of yield where as number of tiller per plant, number of leaf per tiller, Rhizome L and W, number of fingers per rhizome, and stand count were found a positive significant association with yield (table 3).

Table3. *Correlations result*

		Tiler/plant	Plant ht	Noleaf/tiller	Leaf L	Leaf W	Rhizome L	Rhizome W	Nofinger/rhizome	stand count	Yieldkg/plot	Weed biomass
Tiler/plant	Pearson Correlation	1	-.763**	.790**	-.379	.135	.919**	.845**	.864**	.892**	.882**	-.799**
	Sig. (2-tailed)		.006	.004	.250	.693	.000	.001	.001	.000	.000	.003
Plant ht	Pearson Correlation	-.763**	1	-.420	.093	.104	-.724*	-.666*	-.512	-.676*	-.580	.673*
	Sig. (2-tailed)	.006		.199	.786	.762	.012	.025	.107	.023	.061	.023
Noleaf/tiller	Pearson Correlation	.790**	-.420	1	-.461	-.057	.812**	.812**	.839**	.824**	.836**	-.870**
	Sig. (2-tailed)	.004	.199		.153	.869	.002	.002	.001	.002	.001	.001

Leaf l	Pearson Correlation	-.379	.093	-.461	1	.594	-.148	-.399	-.386	-.361	-.314	.296
	Sig. (2-tailed)	.250	.786	.153		.054	.664	.224	.241	.275	.347	.376
Leaf w	Pearson Correlation	-.135	.104	-.057	.594	1	.092	.066	-.101	-.167	-.016	-.149
	Sig. (2-tailed)	.693	.762	.869	.054		.787	.847	.768	.624	.964	.661
Rhizome l	Pearson Correlation	.919**	-.724*	.812**	-.148	.092	1	.872**	.880**	.853**	.839**	-.876**
	Sig. (2-tailed)	.000	.012	.002	.664	.787		.000	.000	.001	.001	.000
Rhizome w	Pearson Correlation	.845**	-.666*	.812**	-.399	.066	.872**	1	.846**	.831**	.851**	-.929**
	Sig. (2-tailed)	.001	.025	.002	.224	.847	.000		.001	.002	.001	.000
Nofinger/rhizome	Pearson Correlation	.864**	-.512	.839**	-.386	-.101	.880**	.846**	1	.933**	.921**	-.829**
	Sig. (2-tailed)	.001	.107	.001	.241	.768	.000	.001		.000	.000	.002
Stand count	Pearson Correlation	.892**	-.676*	.824**	-.361	-.167	.853**	.831**	.933**	1	.953**	-.841**
	Sig. (2-tailed)	.000	.023	.002	.275	.624	.001	.002	.000		.000	.001
Yield kg/plot	Pearson Correlation	.882**	-.580	.836**	-.314	-.016	.839**	.851**	.921**	.953**	1	-.836**
	Sig. (2-tailed)	.000	.061	.001	.347	.964	.001	.001	.000	.000		.001
Weed biomass	Pearson Correlation	-.799**	.673*	-.870**	.296	-.149	-.876**	-.929**	-.829**	-.841**	-.836**	1
	Sig. (2-tailed)	.003	.023	.001	.376	.661	.000	.000	.002	.001	.001	

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

4. Conclusion and Recommendation

30up to 45DAP of ginger were found the critical period for weed competition; Hand weeding and apply mulch in between 30and 45DAP were found good weed management practice; We recommend that ginger farmers must apply weed management practice during this critical period

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