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Effect of Weed Management Methods on the Growth and Yield of Ginger in Jimma, Ethiopia

Tadesse Eshetu and Melaku Addisu
Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center
P.O.Box 192, Jimma , Ethiopia

Abstract
A field experiment was carried out at Jimma Agricultural Research Center to determine the best weeding practice for ginger under Jimma condition. The experiment was carried out between 2010 and 2011 cropping seasons.Ginger was subjected to nine weeding regimes using randomized complete block design with three replications The treatments were: hand weeding at 30,60,90,120,150 & 180 days after planting, hand weeding at 45,75,105,135 &165 days after planting, hand weeding at 60,90,120,& 150 days after planting, mulching at planting followed by hand weeding at 45 and 75 days after planting, mulching at planting followed by hand weeding at 60 and 90 days after planting, hand weeding at 30 and60 days after planting followed by mulching once followed by one hand weeding as needed, hand weeding at 45 and 75 days after planting followed by mulching once followed by one hand weeding as needed, weed free and weedy controls. The result showed that the major weeds recorded were: Cynodon spp., Cyprus spp., Digitaria spp./ Commelina spp., Bidens pilosa, and Ageratum conyzoides. The result also reveled that ginger rhizome yield was highly significantly ($p<0.1$) affected by weeding regimes in both years that as hand weeding frequency increased ginger yield also increased. The result reveled that one early hand weeding applied between 30 and 45 days after planting was critical for high yield of ginger. When the first hand weeding was delayed up to 60 days from planting yield of ginger was reduced tremendously. However, the result showed that by mulching ginger at planting the first hand weeding can be delayed up to 60 days without yield being affected. Mulching ginger at planting followed by two hand weeding at 60 and 90 days gave similar yield compared with the weed free treatment where plots were kept free of any weed growth and the most frequently weeded treatment with six hand weeding frequencies. Similarly, hand weeding at 30 and 60 days followed by mulching once also gave comparable yield with the weed free treatment. In addition, the result also revealed that mulching at planting enhanced the fast germination and emergence of ginger compared with none mulched ginger. On the other hand, the result also showed that ginger was poor competitor of weed competition that ginger growth was affected as hand weeding was delayed beyond 30 days after planting. The highest weed biomass was recorded from the control treatment and when weeding was totally ignored yield reduction as a result of uncontrolled weed growth amounted 100 % under Jimma condition

Introduction

Ginger (Zingiber officinale Rose) is important spice crop which have been under cultivation since antiquity in Ethiopia. Ginger can be cultivated up to 2000 masl but the crop grows well in the hot humid and lowland areas of the southwest part of the country. Ginger is an important spice crop of the world .Its scientific name is *Zingiber officinale.* It is a valuable cash crop and plays an important role in aurvedic medicines in India .It has been used for cleaning body through perspiration, to calm down nausea, and to stimulate the appetite. Ginger tea is used as carminative and in the symptomatic treatment of colds. Ginger contains gingerol, an oleoresin that accounts for the characteristic aroma and therapeutic properties. Components of gingerol posses beneficial properties for the treatment of poor digestion, heart burn, vomiting and preventing motion sickness.

As the crop is slow germinating and growing yield loss as a result of weed competition is expected to be tremendous. The environmental condition of southwest Ethiopia is characterized by high temperature and high rainfall which is highly conducive for year round emergence and growth of highly competitive perennial and annual weed species such as *Cynodon spp., Cyprus spp., Digitaria spp./ Commelina spp., Bidens pilosa, Gyzotia scabra, and Ageratum conyzoides* (Tadesse et al,1998). In spite of the divers and highly competitive weed flora existing in the ginger growing areas, research information on ginger weed management is not available for Jimma area so far. Weeds cause reduction in crop yield and takes extra cost in the total labor use in crop production. Akobunda(1987) reported that weeds result in 65 % reduction in yield of root and tuber crops and takes 25% 0f total labor use in production. Weed competition has also been identified as a constraint to root and tuber production (Unamma,1984). At present farmers weed ginger late after the crop has been suffered weed competition or same times ginger fields may be left unwedded and as a result ginger yield obtained from farmers' fields has always been low.

The objective of the present study was therefore, to identify appropriate weed management methods for optimum growth and yield of ginger under Jimma condition.

Material and Methods

Experimental site description

The study was conducted on nitosols on naturally weed infested field at Jimma Agricultural Research Center (JARC) between 2010 to 2011. JARC is located 8 kilometers west of Jimma city at an altitude of 1753m. The monthly average minimum and maximum temperature over 20 years were 11.3^{0}C and 25.8^{0}C,respectively with monthly average relative humidity of 64% over 20 years. JARC receive mean annual rainfall of 1650mm.

Treatments

1. Hand weeding at 30,60,90,120,150 & 180 days after planting
2. Hand weeding at 45,75,105,135 &165 days after planting
3. Hand weeding at 60,90,120,& 150 days after planting
4. Mulching at planting followed by hand weeding at 45 and 75 days after planting
5. Mulching at planting followed by hand weeding at 60 and 90 days after planting
6. Hand weeding at 30 and60 days after planting followed by mulching once followed by one hand weeding as needed
7. Hand weeding at 45 and 75 days after planting followed by mulching once followed by one hand weeding as needed
8. Weed free control (plots will be kept free of any weed growth)
9. Weedy control (weeds will be allowed to grow with the crop throughout the growing period)

The design used was RCBD with three replications

Vetivar grass was used for mulching and the amount was 10 tone per hectare. Weed species were visually observed and recorded throughout the study period. Weed biomass was determined by harvesting all weeds on the plots shortly before harvest. For final measurement the weed biomass was sundried until the weeds were well dried. Stand count, rhizome weight, rhizome length, number of tillers per plant and yield was recorded at harvest.

Yield loss was calculated using the following formula (Panda, 2010)

$$YL = \frac{Y1 - Y2}{Y1} X100$$

Where YL= Yield loss, Y1 and Y2 represent yield of the weed free and other treatments, respectively

Weed control efficiency (WCE) was calculated using the following formula (Devasenapathy et al, 2008)

$$WCE = \frac{WDC - WDT}{WDC} X100$$

Where WDC= weed dry mass from the control plot (untreated), WDT= weed dry matter from treated plot

Growth parameters such as rhizome width, number of fingers per rhizome and rhizome Weight were recorded by selecting 5 rhizomes per treatment. In order to see the advantage of mulching at planting on early germination of ginger number of germinated ginger plants were counted at 10 days after planting by considering the whole plot.

Data analysis

All data were subjected to the analysis of variance (ANOVA) with the appropriate design as per Gomez and Gomez (1984) using SAS version 9.0 computer software program (SAS, 2002). Mean separation was performed when means were significant using Least Significant Difference (LSD) at 5 % and 1% level of probability

Results and Discussion

Weed Species and weed control

A total of 8 weed species belonging to 6 families were recorded. List of the major noxious and important weed species is presented in Table 1. 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 many spent for their control. The noxious species are highly competitive for essential growth requirements such as nutrients, moisture and light and are also too difficult to control once they are established in the field. The highest weed dry weight was recorded from the weedy check with 40 quintal/h a. followed by the treatment where the first hand weeding was delayed up to 60 days after planting ginger with 27.8 quintal/ha. and with 32.1% weed control efficiency. The noxious weed *Gyzotia scabra* germinated throughout the season and had the tendency of smothering the crop even towards the end of the growing season.

Table1. List of the noxious and important weed species at Jimma

Weed species (Botanical name)	Family	Life form	Ecophysiology 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

Effect on Ginger Germination (sprouting)

The result showed that ginger germination and emergence was highly influenced by mulching the crop at planting compared to non mulched ginger (Table 2). This might be because of the advantage of mulching in terms of moisture conservation and regulating the temperature required for fast germination of the crop compared with none mulched ginger. This result has far reaching implication that the crop can grow and develop fast to compete fast growing weeds compared with non mulched ginger which in most instances is smothered by fast and vigorously growing weed species especially during the early growing period of the crop. On the other hand, rapid germination of ginger can also escape insect attack and also can be saved from erosion from heavy rains in the field. Other research works done elsewhere also show that mulching ginger increased germination and growth of ginger plants in terms of height and number of tillers in the field and this was attributed due to the fact that mulching had changed the physical and chemical environment of the soil underneath resulting in increased availability of phosphorus and potassium (Maybe et al, 2007). This same researcher also reported that weed growth in mulched plots was much less compared with none mulched ginger.

Table 2. Influence of weed management methods on number of germinated plants of ginger 10 days after planting at Jimma

Treatment	2010	2011	Mean
Weeding at 30,60,90,120,150 & 180 days after planting	20	30	25.2
Weeding at 45,75,105,135 &165 days after planting	18.0	22	20.2
Weeding at 60,90,120,& 150 days after planting	14	19	16.7
Mulching at planting followed by weeding at 45 and 75 days after planting	115	99	107.7
Mulching at planting followed by weeding at 60 and 90 days after planting	116	91	103.8
Weeding at 30 and60 days after planting followed by mulching followed by one hand weeding needed	17	21	19.0
Weeding at 45 and 75 followed by mulching followed by one hand weeding as needed	16	8	12.7
Clean weeding	18	27	23.0
Weedy control	12	9	10.9
CV %	21	25	
LSD 5%	11.1	9.8	
LSD 1%	14.7	13.3	

Rhizome weight, Rhizome length and number of fingers per rhizome

There was a highly significant ($P<0.01$) difference growth of ginger in terms of rhizome length, rhizome weight and number of fingers per rhizome between treatments at Jimma (Table 3). As weeding intensity and frequency increased the rhizome length, rhizome weight and number of fingers per rhizome increased. The lowest rhizome length, rhizome weight and number of fingers per rhizome was recorded from the weedy control where the plots remained weedy throughout the growing period.

Table3. Effect of weed control methods on rhizome weight, rhizome length and number of tillers per rhizome at Jimma

Treatment	Rhizome weight (gm)			Rhizome length (cm)			Number of fingers/rhizome		
nu.	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
T1	12.1	13.7	12.9	17.4	6.2	11.8	14.6	14.7	14.7
T2	13.2	12.1	12.7	13.5	6.3	9.9	13.5	13.4	13.5
T3	11.9	12.7	12.3	11.1	6.3	8.7	13.6	12.5	8.7
T4	16.0	12.3	14.2	14.0	6.8	10.4	10.0	14.3	8.1
T5	13.3	12.1	12.7	14.8	6.9	10.9	18.1	12.4	10.2
T6	11.0	12.3	11.2	11.5	6.4	9.0	11.5	14.3	12.9
T7	15.4	12.0	13.7	13.4	6.3	9.9	14.8	12.7	13.8
T8	18.2	13.1	15.7	12.8	7.7	10.3	12.7	15.2	14.0
T9	2.0	1.5	1.8	3.4	2.5	2.7	1.6	2.1	1.9
CV%	31.1	10.8		20.4	20.6		13.5	17.4	
LSD 5%	4.9	1.5		1.1	1.5		2.0	2.6	
LSD !%	6.7	2.1		1.5	2.1		2.8	3.6	

Yield

There was a highly significant ($p<0.1$) fresh rhizome yield difference between treatments (Table4). Ginger responded well for hand weeding that as hand weeding frequency increased yield of ginger also increased. The result showed that when the first hand weeding was delayed from 30 days to 45 and 60 days yield loss amounted to 16 % and 42.3 %, respectively. This demonstrates that the crop suffers serious early weed competition leading to tremendous yield loss. This finding suggests that one early hand weeding applied between 30 and 45 days after ginger is planted is critical under Jimma condition in order to avoid early weed completion. However, the result of the present study showed that optimum ginger yield was consistently obtained in plots where ginger was mulched at planting and followed by two supplementary hand weddings at 60 and 90 days after planting. This is because of the fact that the mulch has suppressed early weed germination and growth satisfactorily creating good growing environment for the crop. This is evident by comparing the treatment where the first hand weeding was delayed up to 60 days without mulching and the treatment where mulching was applied at planting and the first hand weeding delayed up to 60 days producing 15.4 quintal additional yield advantage which is 36% increase. Hence, by mulching ginger at planting the first hand weeding can be delayed up to 45 and 60 days after planting without yield being affected. By mulching at planting farmers can save ample time and can do other farm activities especially at busy times as the expense of weeding ginger.

The result also revealed that the frequency of hand weeding in ginger can be reduced by mulching at planting followed by two hand weeding at 45 and 75 days or by mulching at planting followed by two hand weeding at 60 and 90 days after planting. Similarly, the frequency of hand weeding can also be reduced by applying two hand weeding at 30 and 60 days followed by mulching and followed by one hand weeding. For example, yield obtained from the most frequently weeded treatments the first treatment with 6 hand weeding frequencies and the clean weeding treatment (hand weeded 8 times)where the crop was kept weed free throughout the growing period was similar compared with treatments 4,5,7 and8 with mean yield of 45.9, 44.1,42.0 and 43.3 quintal /ha.,respectively. The present study has clearly demonstrated that application of mulch was equally effective either at planting followed by hand weeding at 60 and 90 days or hand weeding at 45 and 75 days or mulching after two hand weeding at 30 and 60 days or at45 and 75 days after planting. Ginger was so poor competitor of weeds that when weeding was totally ignored as a result of uncontrolled weed growth yield reduction amounted 100%.

The clean weeding treatment gave 96.3 % weed control efficiency compared with T4 and T5 with 63.8 % and 75 %, weed control efficiency ,respectively. However, interestingly in terms of rhizome yield the clean weeding treatment with 49 .7 quintal per hectare mean yield gave statistically similar yield compared with T4 and T5 with 45.9 and 44.1 quintal per hectare, respectively. This is due to the various advantages of mulching such as moisture conservation, nutrient addition from the decomposed mulch and also covering the top soil from erosion which is not a reality in no mulch treatments. This circumstance has created good growing environment for enhanced and robust growth of the crop for mulched turmeric compared with non mulched turmeric. Due to vigorous growth of the crop especially at early establishment period the crop can withstand weed competition although weed growth is high.

The present study has also showed the advantage of mulching ginger that the rhizome of mulched ginger plants was not exposed for direct sunlight which might seriously affect the quality of the crop as this was evident in none mulched ginger (data not shown). In addition the soil of the mulched ginger was covered and protected from soil erosion from heavy rains as this was evident from non mulched plots (data not shown).

Conclusion and recommendation

The present study has clearly demonstrated that ginger responded well for hand weeding that as weeding frequency increased yield of ginger also increased. As ginger is inherently low germinating and slow growing crop it suffers serious weed competition especially during early establishment period. The present study has demonstrated that mulching at planting enhance fast germination and growth of ginger which can result in robust growth for withstanding early competition from fast germinating and growing weed species. The result showed that one early hand weeding at 30 days after planting was critical for high yield of ginger. If the first hand weeding is delayed up to 45 and 60 days yield was reduced tremendously. The present study also revealed that mulching ginger at planting and supplemented with two hand weeding at 60 and 90 and at 45 and 75 days after planting resulted in satisfactory weed control and comparable yield was obtained with the most frequently weeded treatment and the clean weeding. Similarly, Mulching ginger after two hand weeding applied at 30 and 60 days and also at 45 and 75 days after planting gave high and comparable yield compared with the clean weeding treatment. In general the present study has clearly demonstrated that mulching was found to be good agronomic practice for weed control and increasing ginger yield when applied at planting or when applied after two hand weeding at 30 and 60 days or after 45 and 75 days after planting. Hence, mulching ginger at planting followed by two hand weeding at 60 and 90 days after planting or hand weeding ginger at 30 and 60 days followed by mulching is recommended for good weed control, good crop growth and high yield of ginger under Jimma condition.

Table 4.Yield of ginger as affected by weed management methods at Jimma

Treatment	Weed dry weight Q/ha	Weed control efficiency	%yield loss	Yield Q/ha. 2010	2011	Mean
Hand weeding at 30,60,90,120,150 & 180 days after planting	9.6	76.5	3.0	52.9	43.5	48.2
Hand weeding at 45,75,105,135 &165 days after planting	9.8	76.1	16.0	51.1	31.5	41.3
Hand weeding at 60,90,120,& 150 and 180 days after planting	27.8	32.1	42.3	40.9	16.5	28.7
Mulching at planting followed by hand weeding at 45 and 75 days after planting	15.1	63.8	7.6	58.2	33.5	45.9
Mulching at planting followed by hand weeding at 60 and 90 days after planting	10.0	75.0	11.3	46.7	41.5	44.1
Hand weeding at 30 and60 days after planting followed by mulching followed by one hand weeding as needed	10.9	72.8	15.5	44.0	40.0	42.0
Hand weeding at 45 and 75 followed by mulching followed by one hand weeding as needed	10.7	73.4	12.9	51.6	35.0	43.3
Clean weeding	1.5	96.3	-	60.9	38.5	50.0
Weedy control	40.0	0.0	100.0	0.0	0.0	0.0
CV %	22.0			19.5	16.7	
LSD 5%				10.3	8.8	
LSD 1%				17.2	16.9	

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