Peruvian Journal of Agronomy
http://revistas.lamolina.edu.pe/index.php/jpagronomy/index

RESEARCH ARTICLE
https://doi.org/10.21704/pja.v8i1.2102

Received for publication: 12 February 2024
Accepted for publication: 12 March 2024
Published: 29 April 2024
ISSN: 2616-4477

Influence of Different Period of Weed interference on growth and yield of mango ginger (*Curcuma amada* Roxb.)

Influencia de diferentes periodos de interferencia de malezas en el crecimiento y rendimiento del cultivo de cúrcuma (*Curcuma amada* Roxb.)

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Abstract

Field trials were conducted in the early and late wet cropping seasons of 2017 at Institute of Agricultural Research and Training, Ikenne Station to evaluate the critical period of weed interference in mango ginger. Twelve weed inference periods were evaluated and laid out in a randomized complete block design with three replications. Data were collected on growth parameters, yield, weed cover score and weed dry matter production. Results showed that keeping mango ginger free of weed for at least 8 WAP (weeks after planting) resulted in better crop growth than when left weed infested for 8 WAP and beyond. Mango ginger yield increased significantly with increase in weed free period from 4 weeks to 12 weeks, beyond which there was no significant yield increase. In early and late cropping seasons respectively, there was 18.7 % and 15.6 % yield loss when mango ginger was left weed infested for the first 4 weeks, while there was further 36.1 % and 39.1 % yield loss with additional weed infestation for another 4 weeks till 8 WAP. Therefore, first 8 weeks of production of mango ginger is crucial and should be kept weed free as this period is critical in the production of the crop.

Keyword*: Rhizome, Season of planting, Weed, Yield*

Resumen

Se realizaron ensayos de campo en las temporadas húmedas temprana y tardía del cultivo de cúrcuma el 2017 en el Instituto de Investigación y Capacitación Agrícola, Estación Ikenne para evaluar el período crítico de interferencia de malezas en el cultivo de cúrcuma. Se evaluaron doce periodos de interferencia de malezas y se dispusieron en un diseño de bloques completos al azar con tres repeticiones. Se midieron parámetros de crecimiento, rendimiento, cobertura de malezas y producción de materia seca de malezas. Los resultados mostraron que mantener el cultivo de cúrcuma libre de malezas durante al menos 8 WAP (semanas después de la siembra) resultó en un mejor crecimiento del cultivo que cuando se dejó infestado de malezas durante 8 WAP y más. El rendimiento del cultivo aumentó significativamente con el incremento del periodo libre de malas hierbas de 4 a 12 semanas, más allá del cual no hubo un aumento significativo del rendimiento. En cosechas tempranas y tardías hubo una pérdida de rendimiento de 18.7 % y 15.6 % respectivamente, cuando el cultivo de cúrcuma se dejó infestado de malezas durante las primeras 4 semanas, mientras que hubo una pérdida de rendimiento adicional de 36.1 % y 39.1 % con infestación adicional de malezas durante otras 4 semanas hasta 8 WAP. Por lo tanto, las primeras 8 semanas de producción de cúrcuma son cruciales y deben

How to cite this article:
Oke, H., Osunleti, S., & Tijani-Eniola, H. (2024). Influence of Different Period of Weed interference on growth and yield of mango ginger (*Curcuma amada* Roxb.). *Peruvian Journal of Agronomy, 8*(1), 19-29. https://doi.org/10.21704/pja.v8i1.2102

mantenerse libres de malezas ya que este período es crítico en la producción del cultivo.

Palabra clave: *Rizoma, Temporada de cultivo, Malezas, Rendimiento*

Introduction

Mango ginger (*Curcuma amada* Roxb.), a plant that belongs to ginger family, Zingiberaceae and have close similarity to turmeric. Mango ginger emanated from East India and can be found undomesticated in Konkan, Madras and Bengal (Chandarana et al., 2005). The economic part of mango ginger (rhizomes) resemble that of ginger but its aroma and taste is like that of raw mango (Alapati et al., 1989). It is a spice crop of much value in the globe. Being a cash crop with a difference, it also plays a major role as a result of its tender mango-like flavour and aroma, highly valued in culinary and salad making and pickles in southern and northern India (Sasikumar, 2005; Nayak, 2002; Tepe et al., 2006).

The rhizome has a combination of tastes, starting from being bitter, turning to a sweet and later sour aromatic sensation, used as a carminative, appetizer, digestive, diuretic, laxative, expectorant and antipyretic and useful in the treatment of dyspepsia, anorexia, flatulence, wounds, cough, bronchitis, skin diseases, ulcers, constipation, sprains and inflammations (Hussain & Virmani, 1992; Warrier et al., 1994). In Nigeria, mango ginger is an emerging crop used as a spice for cooking meat, flavour in the production of local drink called kunnu and as additive in production of juice drinks.

Mango ginger rhizome has other pharmacological significance for a variety of ailments for example, it is effective on skin allergies, reduces blood cholesterol, used for healing wounds, cuts, itching, sprains and skin diseases (Jatoi et al., 2007). It is also rich in essential oils (Nunes, 1989) which are highly valued as major sources of foreign exchange in the international markets because of its diverse uses.

The growth of ginger is characterized with initial slow growth, making it highly sensitive to weed interference, mostly at early stage of the of crop life cycle. Hence, rhizome yield loss from its competition with weed is expected to be high. Weed compete with crop for space, soil nutrients and moisture. Weed competition with crop, has been observed to be a major constraints to cultivation of root and tuber crops (Unamma, 1984). Uncontrolled weed infestation in ginger had been reported in India to be between 30 % and 45 % (Kerala Agricultural University [KAU], 2006). Similarly in mango ginger, Osunleti (2021, 2021a) and Osunleti et al. (2023) reported 85.1 % to 92.9 % rhizome yield reduction when weeds were permitted to grow freely with the crop. The present study hypothesized that, higher weed free period, will result in higher crop yield. Therefore, there is need to determine the period when the crop is most sensitive to weed infestation so as to prevent yield loss.

Materials and methods

The field trials were carried out in early and late wet cropping seasons of 2017 at Institute of Agricultural Research and Training, Ikenne Station, Ogun State. Ikenne is located on 06° 51'N, 03°42'E and altitude 94 m above sea level. Ikenne is in the humid forest agro-ecological zone of Western Nigeria. The rainfall in Ikenne is heavy and intense, with annual mean rainfall of 1 571 mm falling mostly from April to October. Ikenne has a mean temperature of 27.1 °C (Table 1) and the soil is an Ultisol soil order (Table 2).

The experimental design in both seasons, was a Randomized complete block design with three replicates. The treatments have two sets of weed interference period. In the first set, mango ginger plots were kept weed-free, initially for 4, 8, 12, 16 or 20 weeks after planting (WAP) and allowed to be subsequently infested until final harvest. In the second set, the plots were left weed-infested initially for the corresponding periods, before being kept weed free by hoe-weeding until harvest. There were weedy check plots and plots kept weed-free all through the life cycle as control treatments.

In each season, field was ploughed and then harrowed at two weeks interval to ensure a well pulverized soil. Afterwards, stumps and weed debris were removed, field layout was done, after which beds of 3 × 2 m were manually made

Table 1. Weather data for Ikenne during the experimental period

	Rainfall		Temperature (°C)		
Months	Number of Wet Days	Total (mm)	Minimum	Maximum	Relative Humidity (%)
January	1	15.1	21	33	75
February	2	13.5	23	34	73
March	6	83	24	34	77
April	10	119	23	33	83
May	11	141.3	22	32	88
June	15	172.1	23	29	88
July	13	152.4	23	29	86
August	7	115.1	22	29	85
September	8	147.6	22	29	88
October	8	85.6	22	29	84
November	2	24.3	23	32	80
December	1	18.4	22	32	78

Table 2. Physical and chemical properties of the soils at the experimental site

Soil Composition	
pH (H_20) 1:2	5.8
Available P (mg/kg)	6
Org. Carbon (g/kg)	9.4
Total N (g/kg)	0.9
Exchangeable acidity (cmol/kg)	0.4
Exchangeable cations (cmol/kg)	
Ca	1.6
Mg	1.9
K	0.3
Na	0.2
Extractable Micronutrients (mg/kg)	
Mn	215
Fe	136
Cu	2
Zn	2
Bulk Density (g/cm^3)	1.7
Particle size (g/kg)	
Sand	776
Silt	84
Clay	140
Textural class (USDA)	Loamy sand

with hoe. Mango ginger rhizomes, 25 g to 30 g with at least 2 eyes were then sown at 0.30 m × 0.20 m per stand to give total plant density of 133 333 plants for hectare. The mango ginger rhizomes were gotten from the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Prior to weeding operation, weed cover score was done, which was a visual rating of weeds, using a scale of 1- 5 (1 represent no weed and 5 represent total weed cover). Hoe weeding was done according to the treatment requirement using hand hoe. Before every weeding, weed samples were taken from two quadrats (each quadrat size was 0.5 m x 0.5 m). The weed samples collected were separated into sedges, broadleaves and grasses, and weighed. Samples collected from each of the plot were cumulated and added to determine total weed weight per treatment. Graph was also made on percent weed accumulation, which is the weed weight on various treatment, relative to the maximum. Data on mango ginger height, number of tillers, crop vigour score, rhizome yield, rhizome length, number of rhizomes, weed dry matter production and weed cover score were also taken. Data collected on growth and yield of mango ginger were subjected to Analysis of Variance (ANOVA) according to the procedures of GENSTAT. Significant means were separated using Duncan's Multiple Range Test at 5 % level probability.

Results and discussion

Growth Parameters

Period of weed interference significantly affect crop vigour all through the periods in both seasons. At 8 WAP in both seasons, plots kept weed free for 8 weeks and beyond produced significantly higher crop vigour score than leaving plots weed infested for 8 WAP and beyond. In both seasons at 12 WAP, plots weed free for 12 WAP and beyond resulted in significant higher crop vigour score than leaving the crops in the midst of weeds for 8 weeks and beyond. Also at 12 WAP, initial infestation of weeds for 4 WAP resulted in significantly higher crop vigour score than plots weed free initially for 4 and 8 WAP (Table 3). At 16 and 20 WAP in both seasons, weed

free situation for 12 WAP and beyond as well as initial weed infestation for 4 WAP produced significantly higher crop vigour score than when crops were left in the midst of weeds for 8 weeks and beyond, and those kept weed free initially for 4 and 8 WAP (Table 3).

Period of weed interference significantly affect plant height all through the periods in both seasons (Table 4). At 8 WAP in both seasons, the tallest plants were recorded on the plots kept weed free all through the crop life cycle. Generally at 8 WAP, taller plants were recorded on the plots kept weed free for different periods than those weed infested for 8 WAP and more. At 12, 16 and 20 WAP, plots kept weed free for 8 WAP and more resulted in taller plants than weed infestation for 8 WAP and beyond. At 16 and 20 WAP, plots weed infested for only 4 WAP produced in taller plants than plots kept weed free for 4 and 8 WAP (Table 4).

Period of weed interference significantly affect number of tillers throughout the period of observation in both season. Throughout the period of observation, the highest number of tillers was observed on the plots weeded throughout (Table 5). At 12, 16 and 20 WAP in both seasons, plot

Table 3. Effect of period of weed interference on crop vigour score

	Crop Vigour Score							
	8 WAP		12 WAP		16 WAP		20 WAP	
Treatments	Early	Late	Early	Late	Early	Late	Early	Late
Period of Weed Interference								
Weed Infested 4WAS	3.8b	3.7ab	4.5b	4.8a	4.7b	5.0a	5.0a	5.0a
Weed Infested 8WAS	1.0d	1.0d	2.0d	2.0c	2.0d	2.0c	1.0c	1.3c
Weed Infested 12WAS	1.0d	1.0d	1.0e	1.0d	1.0e	1.0d	1.0c	1.0d
Weed Infested 16WAS	1.0d	1.0d	1.0e	1.0d	1.0e	1.0d	1.0c	1.0d
Weed Infested 20WAS	1.0d	1.0d	1.0e	1.0d	1.0e	1.0d	1.0c	1.0d
Weedy Check	1.0d	1.0d	1.0e	1.0d	1.0e	1.0d	1.0c	1.0d
Weed Free 4WAS	2.0c	2.0c	1.0e	1.0d	1.0e	1.0d	1.0c	1.0d
Weed Free 8WAS	4.0a	3.8ab	4.0c	4.0b	4.0c	3.8b	3.2b	3.0b
Weed Free 12WAS	4.0a	4.0a	5.0a	4.8a	5.0a	5.0a	5.0a	5.0a
Weed Free 16WAS	4.0a	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a
Weed Free 20WAS	4.0a	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a
Weed Free Throughout	4.0a	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a
SEM (±)	0.0481	0.1036	0.1443	0.0649	0.0962	0.0481	0.0481	0.0962

Different letters indicate significance for p <0.05

Table 4. Effect of period of weed interference on plant height

	Plant Height (cm)							
	8 WAP		12 WAP		16 WAP		20 WAP	
Treatments	Early	Late	Early	Late	Early	Late	Early	Late
Period of Weed Interference								
Weed Infested 4WAS	34.7b	35.7e	44.8c	48.4b	55.3b	58.0b	61.7cd	67.7b
Weed Infested 8WAS	25.1d	26.8g	30.6f	33.6e	36.8d	37.3d	39.4f	43.5e
Weed Infested 12WAS	26.2d	27.2fg	28.2g	32.5e	33.4e	38.1d	36.5g	42.0e
Weed Infested 16WAS	25.8d	27.8f	28.3g	33.5e	32.6ef	37.8d	34.2h	42.7e
Weed Infested 20WAS	26.6d	26.6g	27.6g	32.2e	31.8f	38.4d	32.9i	43.0d
Weedy Check	25.2d	25.7h	26.3h	28.7f	27.4g	32.3e	27.9j	34.2e
Weed Free 4WAS	29.4c	27.3fg	34.7e	31.5e	36.9d	33.3e	38.4f	36.5e
Weed Free 8WAS	35.3b	39.7b	41.3d	44.2d	47.8c	53.7c	52.2e	60.4c
Weed Free 12WAS	35.0b	38.6c	46.3b	49.3b	55.9b	58.6b	61.3d	68.8b
Weed Free 16WAS	35.2b	37.6d	46.5b	48.6b	56.9a	59.1b	62.4bc	68.5b
Weed Free 20WAS	35.3b	36.5e	46.3b	46.2c	55.7b	58.0b	62.9b	68.0b
Weed Free Throughout	38.3a	42.5a	47.5a	52.4a	57.5a	64.2a	65.6a	72.2a
SEM(±)	0.740	0.2636	0.2346	0.647	0.2950	0.908	0.3417	1.033

Different letters indicate significance for p <0.05

weed free for 16 WAP and beyond produced in significantly higher number of tillers than keeping plot weed free for lesser period and weed infestation for 4 WAP and more. At 16 and 20 WAP in both seasons, similar number of tillers were recorded on plots weed free for 8 and 12 WAP and those left weed infested for only 4 Weeks, while keeping plots free of weeds for only 4 WAP had significantly lower tillers (Table 5). Generally, no tiller was observed when mango ginger was left weed infested for 12 WAP and beyond (Table 5).

The higher crop vigour on the weed free plots compared to the weed infested plots could be ascribed to the weed free period the crop enjoyed (Figure 1 and 2). The weed free period the crop enjoyed make both soil nutrients and environmental resources accessible for only the crop thereby resulting in good crop vigour. Also, early weed removal on the plots weed infested for only 4 weeks resulted in better crop vigour compared to plots weed infested for more than 4 weeks. This suggests that, mango ginger is highly vulnerable to weed infestation and weed should be removed early enough. This report

Tabla 5. Effect of period of weed interference on number of tillers

	Number of Tillers					
	12 WAP		16 WAP		20 WAP	
Treatments	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Period of Weed Interference						
Weed Infested 4WAS	2.0c	2.0c	3.0d	3.0c	4.0d	4.0c
Weed Infested 8WAS	1.0d	1.0e	2.0e	2.0d	2.0e	2.0d
Weed Infested 12WAS	0.0e	0.0e	0.0g	0.0f	0.0g	0.0f
Weed Infested 16WAS	0.0e	0.0e	0.0g	0.0f	0.0g	0.0f
Weed Infested 20WAS	0.0e	0.0e	0.0g	0.0f	0.0g	0.0f
Weedy Check	0.0e	0.0e	0.0g	0.0f	0.0g	0.0f
Weed Free 4WAS	1.0d	1.0d	1.0f	1.0e	1.0f	1.0e
Weed Free 8WAS	2.0c	2.0c	3.3d	3.0c	4.0d	4.0c
Weed Free 12WAS	2.3bc	2.3bc	3.3d	3.3c	4.3d	4.0c
Weed Free 16WAS	2.7ab	2.7ab	4.0c	4.0b	5.0c	4.7b
Weed Free 20WAS	2.7ab	2.7ab	4.7b	4.7a	5.7b	5.0ab
Weed Free Throughout	3.0a	3.0a	5.3a	5.0a	6.3a	5.3a
SEM(±)	0.1716	0.1716	0.1989	1.330	0.1641	0.1330

Different letters indicate significance for p <0.05

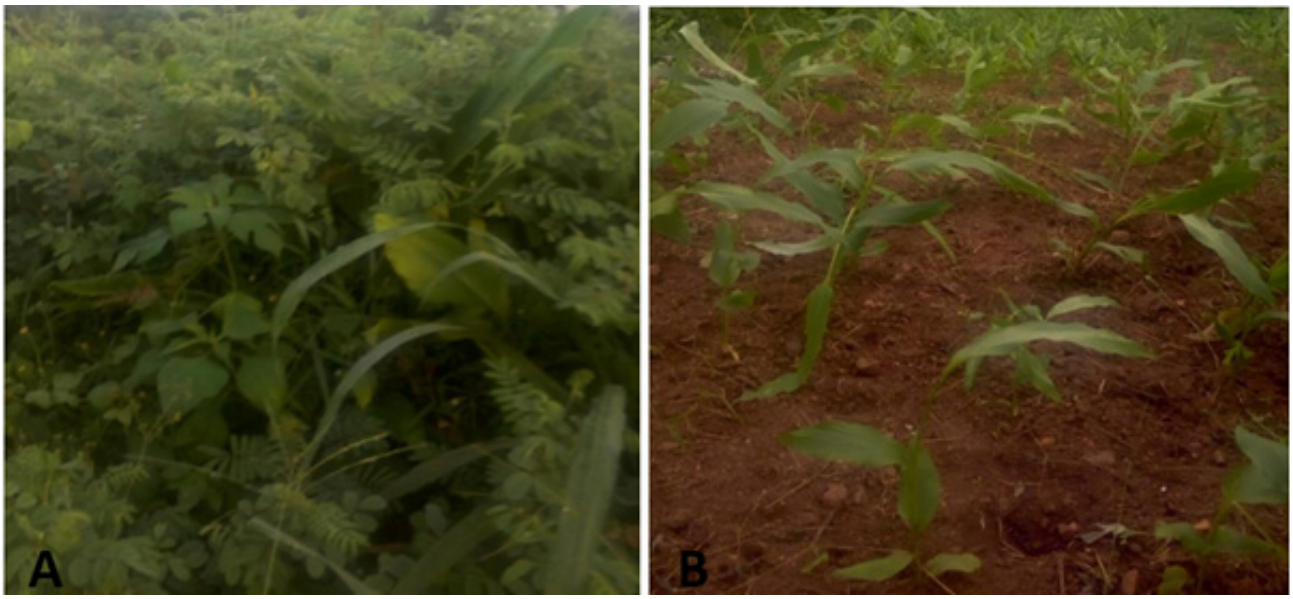

Figure 1: Plot kept weed infested for 16 WAP A) before weed removal B) after weed removal

Figure 2. Plot kept weed free for 16 WAP

agrees with the initial report of Salawudeen (2017) who reported higher crop vigour with increased in weed free period. Weed compete with crop for light, nutrients, water and most times serves as host for insect pest and as a results reducing the vigour of the crop because of reduced environmental resources (Osunleti et al., 2021). It is evident from the results of this study that uncontrolled weed infestation retards the crop of mango ginger. Taller plants were found on the weed free plots while shorter plants were found on the weed infested plots. This shows that crop suffers from both initial and subsequent weed infestation. Osunleti et al., 2023 had earlier reported that uncontrolled weed infestation retards the growth of mango ginger. The highest number of tiller recorded on the plots kept weed free all through could be ascribed to continuous weed free situation throughout on the plots. The continuous weed free situation gives no room for any form of competition between crop and weed, thereby allowing the crop to fully maximize the soil nutrients. This results corroborates the reports of Salawudeen (2017), who also reported increase in number of tiller as a results of increase in weed free periods.

Yield and Yield Components

Period of weed interference significantly affect yield and yield components in both seasons (Table 6). In this study, keeping plots weed free throughout as well as leaving it weed infested for a whole season resulted in the highest and lowest fresh rhizome yield. In both seasons, there was significant decrease in fresh rhizome yield with increase in duration of weed infestation from 4 WAS to 12 WAS after which there was no significant reduction between 12 WAS and 20 WAS. Conversely, there was significant increase in fresh rhizome yield with increase in weed free period from 4 WAS to 12 WAS after which no significant increase was noticed until keeping plots weed free throughout (Table 6). In both seasons, the longest and the shortest rhizome was recorded on plots kept weed free throughout and plot left weed infested all through the season, respectively. Plots weed free for 12 WAS and beyond in both seasons resulted in longer rhizome length than weed infestation for various durations. Weed infestation for only four weeks resulted in longer rhizomes than keeping plots weed free for 4 and 8 weeks. In both years, plots weed free for 8 WAS and beyond resulted in significantly higher number of rhizome than weed infestation for 8 weeks and more. Weed free situation for only 4 WAS resulted in similar number of rhizome with weed infestation for 8 weeks and more (Table 6). Figures 3 and 4 display percentage yield reduction as affected by period of weed infestation in early and late wet seasons, respectively. There was reduction in percent rhizome yield reduction with increase in weed free duration, while there was increase in percentage rhizome yield reduction with increase in weed infestation period. In both season, there was 85 % yield reduction with when mango ginger was kept weed free for only 3 weeks, while there was 14 % to 16 % reduction in yield with 12 weeks weed free situation (Figures 3

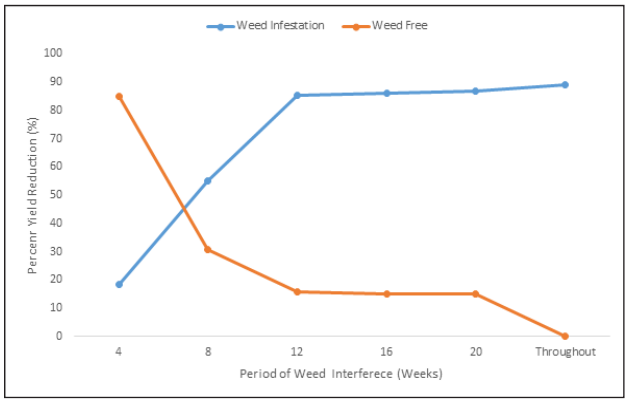

Figure 3. Effect of period of weed infestation and removal on percent yield in the early season

Table 6. Effect of period of weed interference on yield and yield components

	Fresh Rhizome Yield (t/ha)		Rhizome Length (cm)		Number of Rhizomes	
Treatments	Early	Late	Early	Late	Early	Late
Period of Weed Interference						
Weed Infested 4WAS	17.8c	17.9c	10.3d	10.1d	10.0b	9.3b
Weed Infested 8WAS	9.9e	9.6e	5.3f	5.1f	5.0d	5.7c
Weed Infested 12WAS	3.2fg	3.1f	4.9fg	4.8fg	4.7d	4.7cd
Weed Infested 16WAS	3.1fg	3.0f	4.7g	4.6g	4.7d	4.7cd
Weed Infested 20WAS	2.8g	2.8f	4.7g	4.6g	4.3de	4.3d
Weedy Check	2.4h	2.4g	3.2h	3.0h	3.7e	3.7d
Weed Free 4WAS	3.3f	3.0f	5.1fg	5.0f	4.7d	4.7cd
Weed Free 8WAS	15.2d	15.0d	8.0e	8.0e	9.0c	9.3b
Weed Free 12WAS	18.4b	18.2b	10.9c	10.6c	10.7b	9.7b
Weed Free 16WAS	18.6b	18.3b	11.4b	10.6c	10.3b	9.7b
Weed Free 20WAS	18.6b	18.4b	11.8b	10.9b	10.7b	9.7b
Weed Free Throughout	21.9a	21.2a	12.4a	11.9a	13.0a	12.2a
SEM(±)	0.1211	0.0747	0.1465	0.1039	0.2828	0.361

Different letters indicate significance for p <0.05

and 4). Also in both season, there was 15 % to 18 % rhizome yield reduction with when mango ginger was left weed infested for 3 weeks, while there was 85 % reduction in yield with 12 weeks weed infestation period (Figures 3 and 4).

In both seasons, the highest rhizome yield, count and the longest rhizome was recorded on the plots kept weed free all through crop life cycle. There was 42.7 increase in rhizome yield when mango ginger was kept weed free throughout the season compared to when the crop was kept weed free for the first eight weeks. This show the importance of keeping the crop weed free for a long period being a long seasoned crop. In both seasons, initial weed infestation for the first four weeks of production resulted in 17.1 % reduction in rhizome yield, while with further weed infestation for another 4 weeks resulted in 37.6 % yield reduction. It indicates that mango ginger should not be left weed infested beyond 4 weeks being a slow growing crop initially, and highly susceptible crop. These results are similar to the results of Osunleti et al. (2021) who reported 50 % yield reduction when weeding stops at 12 Weeks after planting and suggest longer weed free period in mango ginger being a long seasoned crop. The result also corroborate the reports of Kifelew & Getachew (2017) who earlier report significant yield reduction in ginger when plots were weeded up to 90 days after planting and allow subsequent weed interference. Many researchers among which are Habetewold et al. (2015) and Osunleti et al. (2022) also reported yield losses to the tune of 84 % when weeds are allowed to grow freely in ginger and mango ginger, respectively.

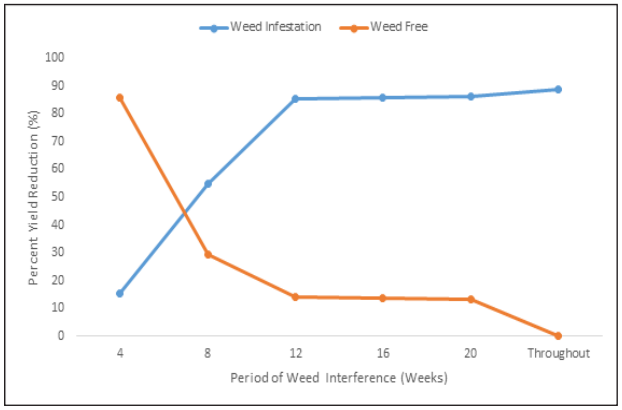

Figure 4. Effect of period of weed infestation and removal on percent yield reduction in the late season

Weed Dry Matter Production and Weed Cover Score

Period of weed interference had significant effect on weed cover score in both seasons (Table 7). At 8 WAP in both seasons, weed infestation for 8 WAS and more resulted in significantly higher weed cover score than weed free situation for various periods. At 12 WAP, weed free situation for only 4 weeks resulted in significantly higher weed cover score than weed infestation for 4 and 8 WAS, and weed free for 8 WAS and more. Also at 12 WAS weed infestation for 4 and 8 WAS

resulted in significantly higher weed cover score than weed infestation for 12 WAS and more. At 16 WAP, weed infestation between 4 and 12 WAS resulted in significantly lower weed cover score than plots weed infested for 16 WAS and more. Weed free situations for 12 WAS and more resulted in significantly higher weed cover score than weed infestation for 16 WAS and more and weed free situations for 4 and 8 weeks. At 20 WAP in both seasons, weed infestation between 4 and 16 WAS, and weed free for 12 WAS and more resulted in significantly lower weed cover score than plots left weed infested for 20 WAS and more as well as weed free for 4 and 8 WAS (Table 7). Period of weed interference significantly affect weed dry matter production in both seasons (Table 8). Generally, weed dry matter production increased significantly with increase in length of weed infestation in both seasons. Weed free situation for 4 WAS resulted in significantly higher weed dry matter production than plots left weed infested for 4 to 20 WAS (Table 8). Weed free situation for 16 WAS and more resulted in significantly lower weed dry matter production than plots weed infested for different periods (Table 8). Figures 5 and 6 show weed growth as affected by period of weed infestation and removal in both seasons.

Table 7. Effect of period of weed interference on weed cover score

	Weed Cover Score							
	8 WAP		12 WAP		16 WAP		20 WAP	
Treatments Period of Weed Interference	Early	Late	Early	Late	Early	Late	Early	Late
Weed Infested 4WAS	1.0d	1.0c	1.0d	1.0d	1.0d	1.2c	1.0c	1.2c
Weed Infested 8WAS	3.8b	5.0a	1.0d	1.0d	1.0d	1.0c	1.0c	1.0c
Weed Infested 12WAS	4.0a	5.0a	5.0a	5.0a	1.0d	1.0c	1.0c	1.0c
Weed Infested 16WAS	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	1.0c	1.0c
Weed Infested 20WAS	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a
Weedy Check	4.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a	5.0a
Weed Free 4WAS	2.0c	2.8b	4.7b	4.8b	4.8b	5.0a	5.0a	5.0a
Weed Free 8WAS	1.0d	1.0c	2.0c	2.0c	2.0c	2.2b	3.2b	2.5b
Weed Free 12WAS	1.0d	1.0c	1.0d	1.0d	1.0d	1.0c	1.0c	1.0c
Weed Free 16WAS	1.0d	1.0c	1.0d	1.0d	1.0d	1.0c	1.0c	1.0c
Weed Free 20WAS	1.0d	1.0c	1.0d	1.0d	1.0d	1.0c	1.0c	1.0c
Weed Free Throughout	1.0d	1.0c	1.0d	1.0d	1.0d	1.0c	1.0c	1.0c
SEM(±)	0.0481	0.0481	0.0962	0.0481	0.0481	0.0649	0.0481	0.0929

Different letters indicate significance for p <0.05

Table 8. Effect of period of weed interference on weed dry matter production

	Weed Dry Matter Production (kg/ha)							
	Broadleaves		Grasses		Sedges		Total	
Treatments Period of Weed Interference	Early	Late	Early	Late	Early	Late	Early	Late
Weed Infested 4WAS	306.4h	356.7h	47.5h	43.5g	6.1fg	11.2h	360.6h	411.5
Weed Infested 8WAS	469.3f	437.2f	64.0f	49.9f	9.7e	12.2g	543.3e	499.5fh
Weed Infested 12WAS	661.5e	525.5e	107.0e	62.5e	14.5d	16.4e	783.8e	604.5e
Weed Infested 16WAS	886.3d	630.1d	163.3d	77.3d	17.3c	20.0d	1067.4d	727.5d
Weed Infested 20WAS	1160.6c	768.7b	197.9c	103.8b	20.5b	23.5c	1379.6c	896.1b
Weedy Check	1582.9a	986.0a	268.1a	136.5a	26.0a	36.7a	1877.8a	1159.2a
Weed Free 4WAS	1242.7b	675.9c	210.7b	95.7c	20.2b	25.8b	1473.7b	797.6c
Weed Free 8WAS	326.5g	392.0g	52.2g	50.5f	6.3f	13.1f	385.5g	455.7g
Weed Free 12WAS	291.7k	335.3j	45.5j	41.4h	5.7h	10.6i	343.1k	387.5j
Weed Free 16WAS	295.0j	337.9j	46.2i	41.8h	5.8gh	10.7i	347.0j	390.5ij
Weed Free 20WAS	297.5i	341.3i	46.6i	42.2h	5.8gh	10.8i	350.4i	394.5i
Weed Free Throughout	251.8l	285.0k	39.1k	33.7j	5.1i	8.6j	296.0l	327.3k
SEM(±)	0.385	0.962	0.1925	0.385	0.0962	0.0962	0.674	1.443

Different letters indicate significance for p <0.05

With initial weed infestation, there was increase in weed dry matter as period increase in both season. Conversely, there was reduction in weed weight with increase in weed free situation. Reduction in weed cover score and weed weight observed on the weed free periods compared with the weed infested periods could be ascribed to constant removal of weeds on the weed free plots. Uninterrupted weed growth on the weedy check plots directly translated to the high weed dry matter recorded on the plots. This results corroborates the earlier report by Channappagoudar et al. (2013), who reported higher dry weed weight per unit area of land on the untreated plots in turmeric. Also, higher weed biomass had been reported with increasing duration of weed interference period (Korav et al., 2018).

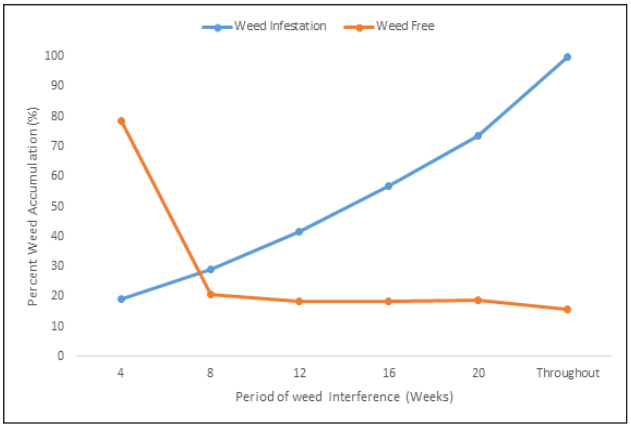

Figure 5. Effect of period of weed infestation and removal on weed accumulation in early season

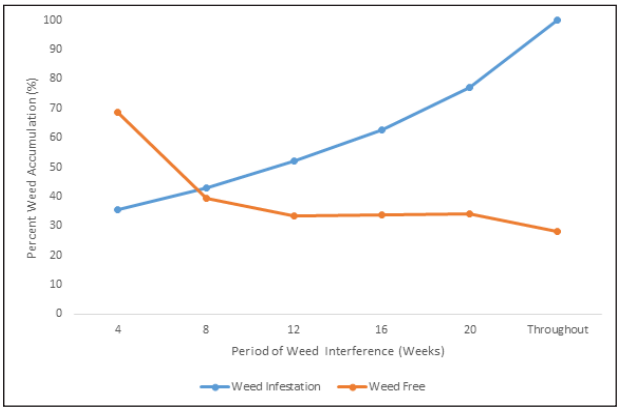

Figure 6. Effect of period of weed infestation and removal on weed accumulation in late season

Conclusion

The study revealed that growth and yield of mango ginger increased as duration of weed free increases and decreased with increase in weed infestation period. Period between 4 and 8 weeks after planting becomes so critical that the crop respond so well to weed infestation with great yield loss and weed free period with great yield accumulation. Therefore, mango ginger should be kept weed free for the first 8 weeks to avoid over 50 % yield loss. Uncontrolled weed infestation in this study resulted into 88.9 % yield loss.

Conflicts of Interest

The authors declare no competing interests.

Authors Contribution

H.A.O: data collection, revision of the manuscript. S.O.O: data analysis and interpretation of the data, drafting of the paper. H.T-E: conception, design and work supervision.

Funding Declaration

No external funding was received for this research.

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