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RESPONSE OF MANGO GINGER (*Curcuma amada* Roxb.) TO TILLAGE AND PLANT DENSITY IN IBADAN, SOUTH WEST NIGERIA

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ABSTRACT

Mango Ginger is a rhizomatous spice crop valued for its medicinal properties and mango-like flavour, but its growth and yield can be hampered by weed infestation. Deleterious effects of weeds on crop productivity could be minimized by the use of cultural practices. Therefore, influence of tillage and plant population density on fresh rhizome yield of mango ginger in Southwestern Nigeria were investigated in early and late wet seasons, in 2016. Treatments were laid out in split plot arrangement in a randomized complete block design with three replications. Main plot treatments were two levels of tillage operations viz: till and no till. The sub-plot treatments consisted of five planting populations viz: 66,667 plants/ha, 83,333 plants/ha, 111,111 plants/ha, 133,333 plants/ha and 166,667 plants/ha. Data collected on weed, growth and yield of mango ginger were analyzed using ANOVA, and treatment means were separated using the least significant difference at $p \leq 0.05$. Tillage and plant populations had significant effects on both the weed biomass and rhizome yield. Higher weed biomass were recorded in the no till plots compared to the till plots, while higher mango ginger yield was recorded from the tilled plots compared to the no tilled plots. In this study, weed biomass decreased with increase in plant population. Planting mango ginger at 133,333 plants/ha resulted in the highest rhizome yield, while planting mango ginger at 83,333 and 66,667 plants/ha resulted in the lower yields. Mango ginger could be planted at 133,333 plants/ha on a tilled soil.

Keywords: Mango ginger, till, weed biomass, rhizome, plants

INTRODUCTION

Mango ginger (*Curcuma amada* Roxb.) is a plant belonging to the ginger family, Zingiberaceae (Vishnupriya *et al.*, 2012) and it is closely related to turmeric (*Curcuma longa* L.) Chatterjee *et al.* (2012). It originated from East India and occurs in the wild parts of Bengal, Konkan and Madras Chandarana *et al,* 2005). The rhizomes of mango ginger are comparable to that of ginger (*Zingiber officinale* Rosc.) but have a raw mango smell and savour (Priyanka and Bhoomika 2012). Samant (2012) described the height as a perpendicular distance from the soil and its base to the highest point reached with all parts in their natural position.' Mango ginger has the ability to compete for light and plant height strongly correlates with their life span, seed mass and time to maturity Moles *et al.* (2009).

Mango ginger rhizome has other pharmacological importance for array of sicknesses 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 vital oils which are extremely treasured as main sources of foreign exchange earnings in the global markets because of its various uses. 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 is an important spice crop grown for its rhizome. Its peculiar raw mango-like aroma and flavor is highly valued in salad, pickles and culinary preparations. The main use of mango ginger rhizome is in the manufacture of pickles and culinary preparations. The aqueous and organic solvent extracts of mango ginger are antibacterial against *Escherichia coli, Bacillus subtilis,* and *Staphylococcus aureus* (Chandarana, *et al.*, 2005).

Despite the widespread value of mango ginger, its productivity is still low because of factors such as poor soil fertility, lack of improved varieties, and poor agronomic practices (Hailemichael and Tesfaye 2008; MoARD 2007).

Tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring and overturning. It is used principally to reduce soil erosion because the top soil is protected, reduce soil compaction, conserves soil water through the mulch, for preparation of seedbed, improve the soil condition with the increased organic matter content and to control weeds. In the rating of crop production factors, soil tillage contributes up to 20 %. (Khurshid *et al.,* 2006). In compressed soil enhanced by planted fallows in southwestern Nigeria, tillage improves soil volumetric density notably more than zero tillage (Salako, 2003). Such reduction in the apparent density of the soil promotes root penetration, air infilteration and growth for tuber and root crops in ridge tillage, cereals, mound tillage, and deep tillage in various agroecological regions. (Salako *et al.*, 2001).

Plant spacing is an important factor in crop production, as it influences interplant competition. Bahadur et al. (2000) observed significant differences in growth and yield of turmeric when spacing was varied. Osunleti et al. (2023) observed increase in the yield of mango ginger with increase in plant population.

Osunleti et al. (2021, 2023) reported that mango ginger was such a poor weed competitor with significant yield loss as a result of delayed weeding. It has been reported that uncontrolled weed infestation for 12 and 16 weeks after planting reduced fresh rhizome yield of mango ginger by 71.1 and 74.2%, respectively (Olurotimi, 2014). The reduction in rhizome yield of mango ginger ranged between 48 and 85% and is a function of the extent of competitiveness of crop and weed as well as the growth. Osunleti *et al.* (2021a) reported 91.9 to 92.1% reduction in mango ginger when weeds were completely ignored. Previous work by Tadesse and Melaku (2012) also reported that uncontrolled weed infestation throughout the growing period of ginger, a related crop to mango ginger resulted in 100% yield loss.

Therefore, the present research work was embarked upon to investigate the response of mango ginger to tillage practices and plant population density in Ibadan Southwestern Nigeria.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Department of Agronomy Research field, Parry road, University of Ibadan, Ibadan Oyo State during the 2016 early (April) and late (July) wet seasons (07^0 27' N, 03^0 53' E). The experimental field for the research work in Ibadan was a site where pepper, sweet potato and okra were previously grown in 2014 and 2015. The predominant weed types identified at the experimental site were broad leaves viz: *Tithonia diversifolia, Euphorbia hirta, Oldenlandia corymbosa, Portulaca oleracea, Mimosa pudica, Aspilla africana, Ageratum conyzoides, Centrosema pubescens, Amaranthus spinosus, Boerhavia diffusa, Talinum fruticosum, Spigelia anthelmia, Sida acuta, Mitracarpus villosus* and *Gomphrena celosioides.* Grasses were: *Megathysus maximus, Pennisetum pedicillare, Eleusine indica* and *Brachiaria deflexa.* Sedges were: *Cyperus esculentus, Cyperus rotundus* and *Mariscus umbellatus* (Table 1). The result of the soil analysis showed that the soil pH was 6.2 (slightly acidic), Total N was 1.3g/kg while the textural class was sandy loam. (Table 2). The highest rainfall was recorded in the month of September (170mm) while the lowest was recorded in the month of January (8mm). The rainfall distribution, mean temperature and relative humidity during the experiment are as shown in Table 3.

Table 1: Weed species and levels of occurrence at the experimental site

Weed Species	Level of infestation
Broadleaves	
Ageratum conyzoides L.	+++
Boerhavia diffusa L.	++
Chromolaena odorata R.M. (L.) King & Robinson	++
Euphorbia hirta L.	++
Euphorbia heterophylla L.	+++
*Mitracarpus villosus (*Sw)	+
Oldenlandia corymbosa L.	+
Phyllanthus amarus Schum & Thonn.	+
Sida acuta Burm.f.	++
Talinum fruticosum (Jacq.) Wild	++
Tithonia diversifolia (Hemsl.*)* Gray	+++
Tridax Procumbens (L.)	+++
Grasses	
Brachiaria decumbens (Trin.) Griseb.	+
Digitaria horizontalis Wild.	+
Eleusine indica Graertn	+
Imperata cylindrica (L.) P. Beauv.	+
Megathyrsus maximus Jacq.	+
Sedges	
Cyperus esculentus L.	+
Cyperus rotundus L.	+

+++ = High infestation (60-90 % occurrence) ++ = Moderate infestation (30-59 % occurrence) + = Low infestation (1-29 % occurrence)

Table 2: Physico-chemical properties of the soils at the experimental site

	2016
pH (H_20) 1:1	6.2
Available P (mg/kg)	7
Org. Carbon (g/kg)	13.3
Total N (g/kg)	1.3
Exchangeable acidity (cmol/kg)	0.1
Exchangeable cations (cmol/kg)	
Ca	1.4
Mg	2.4
K	0.4
Na	0.4
Extractable Micronutrients (mg/kg)	
Mn	264
Fe	310
Cu	1
Zn	1
Bulk Density (g/cm3)	1.42
Particle size (g/kg)	
Sand	780
Slit	126
Clay	94
Textural class (USDA)	Sandy

Table 3: Rainfall distribution, mean temperature and relative humidity during the experimental period

Months	Rainfall (mm)	Mean Temperature (^0C)	Relative Humidity (%)
Jan	8	27	76
Feb	23	28	71
Mar	76	29	75
April	125	28	78
May	145	27	83
June	163	26	86
July	132	25	88
Aug	74	24	87
Sep	170	26	86
Oct	152	26	84
Nov	43	27	81
Dec	10	27	79

Source: International Institute of Tropical Agriculture

Treatments and Experimental design

The trial in both seasons were laid out in a split-plot arrangement in a randomized complete block design in three replicates. In both seasons, the main plot treatments were two levels of tillage, viz: till and no till. Five plant population densities assigned to the sub-plots were: 166,667 plants/ha (where rhizomes were planted at 0.30m x 0.20m), 133,333 (where rhizomes were planted at 0.30m x 0.25m), 111,111 (where rhizomes were planted at 0.3m x 0.30m), 83,333 (where rhizomes were planted at 0.30m x 0.40m) and 66,667 (where rhizomes were planted at 0.30m x 0.50m) plants/ha. The no-till seedbed was achieved by application of glyphosate, a broad spectrum systemic and non-selective foliar herbicide at the rate of 1.1 kg active ingredient per hectare. Tilled seedbed was by ploughing followed by harrowing.

Cultural practices

Mango ginger rhizomes (50-80 g/piece) with obvious sproutable buds were planted in each season. Hoe-weeding was carried out at 4, 8, 12, 16, 20 weeks after planting (WAP). Weeding operations were preceded by data collection on the weed density by counting the broad leaves, grasses and sedges from a quadrat of 50 cm x 50 cm size. Weed samples collected were separated into broad leaves, grasses and sedges. Organomineral fertilizer (Grade B) was uniformly applied at 75 kg N, 50 kg P_20_5 and 50 kg K_2O per hectare to the experimental sites according to Oyedokun (2014). The composition of the Organomineral applied is contained in Table 4). There were 30 plots in the experiment and the size of each plot was 2 m x 3 m, while the size of the experimental site was 270 m^2.

Table 4: Proximate analysis of organomineral fertilizer Grade B

Nutrient element	Concentration Grade B
N (g/kg)	10.2
P (g/kg)	7.6
K (g/kg)	20.9
C (g/kg)	319.4
Mg	2.4
Ca (g/kg)	23.4
Na (g/kg)	2.9
Fe (mg/kg)	8,915.40
Zn (mg/kg)	1.9
Mn (mg/kg)	106.7
Cu (mg/kg)	16.9

Source: Aleshinloye Fertilizer Company, Ibadan, Nigeria

Data collection

Weeds were sampled from two quadrats of 0.5 m x 0.5 m size placed in the middle central rows before any weeding was done. The weeds were sampled by cutting them at the ground level in each quadrat. Total weed density was determined by counting all the weeds in each quadrat, whereas cumulative weed dry matter was done by oven drying the weeds collected from the quadrats at 70^0C until constant weight was attained. Mango ginger height was measured using measuring tape. Mango ginger was harvested manually eight months after planting. Fresh rhizome yield from each plot was harvested counted and weighed. Average length of the harvested rhizome was also taken.

Data analysis

The data collected in both seasons were pooled together and subjected to descriptive statistics, analysis of variance at 5% level of significance. Treatment means were separated using Duncan's Multiple Range Test.

RESULTS

Weed Parameters

Influence of tillage and plant population density on cumulative weed dry matter production of broad leaves, grasses and sedges (kg/ha) in mango ginger plots

Tillage had significant impact on the cumulative biomass production of broad leaves, grasses and sedges in the study location. Plots with tilled seedbed had significantly lower cumulative weed biomass of broad leaves, grasses and sedges than plots with no -till seedbed. Population density significantly influenced cumulative weed dry matter of broad leaves, grasses and sedges in Ibadan. Plant population density of 166,667 plants per hectare produced the lowest cumulative weed dry matter of the various weed types while plant population density of 66,667 plants per hectare resulted in the highest cumulative weed dry matter of broad leaves, grasses and sedges (Table 5).

Influence of tillage and plant population density on cumulative weed density of broad leaves, grasses and sedges ('000/ha) on mango ginger plots

The influence of tillage on cumulative weed density of broad leaves, grasses and sedges in was significant. Plots with tilled seedbed resulted in significantly lower cumulative weed density of broad leaves, grasses and sedges than those with no tilled seedbed.

Plant population density also significantly influenced the cumulative weed density of the various types of weed. Plant population densities of 166,667 plants per hectare had lowest cumulative weed density of broad leaves, grasses and sedges in the two locations in both tilled and no-till plots. Uncontrolled weed infestation all through the growing period of the crop resulted in the highest cumulative weed density. (Table 6)

Table 5: Influence of tillage and plant population density on cumulative weed dry matter production of broad leaves, grasses and sedges (kg/ha) in mango ginger plots in Ibadan

Treatment	Broadleaves	Grasses	Sedges
Tillage (T)			
No Till	3208.1 a	526.9 a	215.9 a
Tilled	1834.3 b	312.7 b	131.8 b
S.E.± (df)	0.96 (1)	0.73 (1)	0.32 (1)
Population (P)			
166,667	2172 e	343.3 e	150.0 e
133,333	2305 d	365.9 d	156.5 d
111,111	2549 c	426.4 c	177.7 c
83,333	2700 b	459.0 b	184.5 b
66,667	2880 a	504.2 a	200.7 a
S.E.± (df)	0.25 (4)	0.14 (4)	0.09 (4)
Interaction			
T × P	*	**	*

Means with same letter (s) in a column are not significantly different at 5 % level of probability by Duncan's Multiple Range Test, WAP: Weeks after planting T: Tillage, P: Population density CWDM: Cumulative weed dry matter

Table 6: Influence of tillage and plant population density on cumulative weed density of broad leaves, grasses and sedges in mango ginger plots in Ibadan

Treatment	Broadleaves (x000/ha)	Grasses (x000/ha)	Sedges (x000/ha)
Tillage (T)			
No Till	2655 a	475 a	169 a
Tilled	1539 b	275 b	101 b
S.E.± (df)	0.22 (1)	0.69 (1)	0.15 (1)
Population (P)			
166,667	1913 e	341 e	118
133,333	1999 d	357 d	126
111,111	2092 c	374 c	136
83,333	2192 b	393 b	143
66,667	2289 a	411 a	1
S.E.± (df)	0.12 (4)	0.61 (4)	0.77 (4)
Interaction			
T × P.	NS	NS	NS

Means with same letter (s) in a column are not significantly different at 5 % level of probability by Duncan's Multiple Range Test, WAP: Weeks after planting T: Tillage, P: Population density CWD: Cumulative weed density

Influence of tillage and plant population density on cumulative weed dry matter production of broad leaves, grasses and sedges (kg/ha) in mango ginger plots

Tillage had significant effect on the height of mango ginger. Tilled seedbed consistently produced taller mango ginger crop than the no till seedbed. Population density significantly influenced the height of the crop. Generally, the height of mango ginger increase with decreased in population density, with the tallest plants recorded in plots with 66,667 plants/ha and shortest plants in plots planted at 166,667 plants/ha (Table 7).

Table 7: Influence of tillage and plant population density on plant height on mango ginger plots

Treatment	8 WAP	12 WAP	20 WAP
Tillage (T)			
No Till	22.5b	32.3b	43.9b
Tilled	33.6a	43.8a	60.1a
S.E. ± (df)	0.17 (1)	0.17 (1)	0.22 (1)
Population(P)			
166,667	25.7e	34.3e	47.0e
133,333	26.5d	35.7d	49.1d
111,111	27.5c	37.8c	52.2c
83,333	29.2b	39.9b	54.7b
66,667	31.3a	42.5a	57.0a
S.E. ± (df)	0.31 (4)	0.32 (4)	0.40 (4)
Interaction			
T x P.	*	NS	NS

NS - not significant, WAP – Weeks after planting

Influence of tillage and plant population density on fresh rhizome yield (t/ha) on mango ginger plots

The influence of tillage was significant on fresh rhizome yield of mango ginger. Plots with tilled seedbed produced significantly higher fresh rhizome yield than those plots with no-till seedbed in the study area. The fresh rhizome yields from tilled seedbed was 21.9 t/ha while the corresponding fresh rhizome yields from no- tilled seedbed was 13.8 t/ha. Plant population density also significantly influenced fresh weight of rhizomes in the study area. Planting at population density of 133,333 plants/ ha produced the highest fresh rhizome yield (21.9 t/ha). Planting mango ginger at 166,667 plants population produced significantly higher rhizome yield than other population density except the highest. The lowest rhizome yield was produced with planting mango ginger at 83,333 and 67,667 plants/ha (Table 8).

Influence of tillage and plant population density on length of rhizomes (cm) on mango ginger plots

Tillage significantly influenced the length of rhizomes. Plots with tilled seedbed produced significantly longer rhizomes than those with no-till seedbed in the study area. Plant population density also significantly influenced the length of rhizomes. Population density of 133,333 plants/ha produced the longest rhizomes, while the shortest rhizome was observed with population density of 111,111 plants/ha and below (Table 8).

Influence of tillage and plant population density on number of rhizomes per plant on mango ginger plots

The number of rhizomes produced per plant was significantly influenced by tillage. Plots with tilled seedbed resulted in production of higher number of rhizomes than those with no-till seedbed. Plant population density also significantly influenced the average number of rhizomes produced. Planting mango ginger at population density of 133,333 plants on a hectare gave the highest number of rhizomes. Planting mango ginger at 166,667 and 111,111 plants/ha resulted in similar number of rhizome which was significantly higher than planting mango ginger at 83,333 and 66,667 plants/ha (Table 8).

The interaction of tillage and plant population density on number of rhizomes produced was also significant. Plots with tilled seedbed and population density of 133,333 plants per hectare produced the highest number of rhizomes per plant. The lowest number of rhizome was produced on the no till plots with 83,333 and 66,667 plants/ha (Table 9).

Table 8: Influence of tillage and plant population density on fresh rhizome yield, length of rhizomes, number of rhizomes per plant in mango ginger plots

Treatment	Fresh rhizome yield (t/ha)	Length of rhizomes (cm)	No of rhizomes/ plant
Tillage (T)			
No Till	13.8 b	7.0 b	6.5 b
Tilled	21.9 a	10.9 a	10.1 a
S.E.± (df)	0.10 (1)	0.33 (1)	0.09 (1)
Population (P)			
166,667	18.2 b	9.0 b	8.2 b
133,333	21.9 a	10.7 a	10.1 a
111,111	17.1 c	8.6 c	8.1 b
83,333	16.1 d	8.3 c	7.6 c
66,667	15.7 d	8.2 c	7.4 c
S.E. ± (df)	0.18 (4)	0.22 (4)	0.15 (4)
Interaction			
T × P.	*	NS	*

Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan's Multiple Range Test, WAP: Weeks after planting T: Tillage, P: Population density

Table 9: Interactions of tillage and population density on fresh rhizome yield, length of rhizomes and number of rhizomes per plant on mango ginger plots

Tillage	Population	Fresh rhizome yield (t/ha)	Number of rhizomes / plant
No Till	166,667	14.4 e	6.5 e
	133,333	17.9 d	8.2 d
	111,111	12.6 f	6.7 e
	83,333	12.1 f	5.7 f
	66,667	11.8 g	5.7 f
Tilled	166,667	22.0 b	9.8 b
	133,333	26.0 a	12.3 a
	111,111	21.6 b	9.5 bc
	83,333	20.1 c	9.5 bc
	66,667	19.6 c	9.2 c
	S.E	0.26	0.19

Means with same letter (s) within a column are not significantly different at 5 % level of probability by Duncan's Multiple Range Test WAP: Weeks after planting

Discussion

Lower weed density and weed dry matter were recorded on plots with tilled seedbed than from those plots with no-till seedbed. Lower weed infestation on the tilled seedbed was as a result of soil disturbance from the tillage operations which would have removed completely the already existing weed on the field and destroyed the weed seeds in the soil. This confirmed previous works that tillage destroys weed seeds by being exposed to desiccation as compared to the no-tillage method which leaves the soil intact (Rashidi and Keshavarzpour, 2007). Soil tillage, according to Swanton *et al.,* (2007), enables the farmer to attack many weed survival mechanisms. For annual weeds, the tillage objective is to prevent seed production and deplete current seed reserves in the soil. (Kayode and Ademiluyi, 2004) also reported better weed control as a result of tillage operations than in no tillage. Lower weed dry matter production and density on the more populated plots could be ascribed to early canopy closure as a result of more plants per unit area of land. The crop canopy intercept the light penetration thereby reducing amount of light reaching the weeds. This reduced the growth and vigour of the weeds. Osunleti et al. (2023) had earlier reported higher weed infestation with less vigorous crop and less crop canopy cover for which crops and where?

Mango ginger grown on tilled seedbed had higher number of rhizomes, longer length of rhizomes, and higher fresh rhizome yield than those from no-till seedbed. This could be attributed to well-prepared soil that provided good environment for the crop on tilled seedbed and in turn eased root penetration, increased soil aeration, reduced weed infestation and enhanced water movement within the soil. Ujuanbi (2002) and Odumorsor (2003) reported that crop emergence and growth are higher in ridge than zero tillage. Hong et al. (2005) indicated that crop growth rate is significantly higher in mound tillage than in zero tillage.

According to Emetitiri (2004), soil has strong and positive correlation to crop growth. Soil modification through tillage is aimed at optimizing soil conditions for seed germination, seedling emergence and growth. Salako (2003) reported that the most profound effect of tillage is on soil physical properties and that tillage improves soil bulk density significantly compared with no-tillage. Improvements in bulk density encourage root growth either for cereals, tuber crops or root crops in ridge tillage and deep tillage in different agro-ecological zones (Salako *et al*., 2001).

Plant height reduced with increase in plant population. Taller plants were observed on plots with plant population density of 66,667 plants/ha and reduced significantly with population increase. This could be due to more availability of plant nutrients, moisture and light as well as less plant competition in wider spaced plants which enhanced good crop growth. Similar finding was reported by Bahadur *et al.* (2000) in turmeric where higher values for growth parameter were obtained when turmeric was planted at 50 cm x 40 cm than at 50 cm x 20 cm. There was increase in mango ginger fresh rhizome yield as a result of increase in plant population.

Closer plant spacing resulted in significantly higher fresh rhizome yield than broader plant spacing. The increase in yield as a result of higher mango ginger density could be attributed to more plant stands per plot which could have translated to more rhizomes per plot at harvest. This result is similar to that earlier reported by Bahadur *et al.* (2000) who observed significant increase in yield of turmeric under closer spacing and attributed this to higher plant density per unit area of land. Similar findings were reported by Osunleti and Lagoke (2024); Osunleti et al. (2023) in mango ginger. This suggests that plant population is one of the most important factors for optimum yield in mango ginger.

There was significant reduction in weed dry matter production and weed density as plant population increased. This was due to the wider space between the crops and the weeds made use of such open space. Also there was early canopy closure when crops were planted at closer spacing and this also resulted in smothering of weeds. This result also agrees with earlier report of Caliskan *et al.,* 2007 which indicated that closer planting of crops suppresses germination and growth of weeds.

CONCLUSSION

The results of the experiment showed that planting mango ginger on a tilled seedbed resulted in taller plants, higher mango ginger yield and reduce weed infestation than the mango produced without tillage. Therefore, mango ginger should be planted on a tilled seed bed. Mango ginger planted at a population of 133,333 plants per hectare reduced weed incidence and recorded the highest mango ginger rhizome yield compared with the other population densities. Thus, mango ginger should be planted at 133,333 plants/ha.

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