# EFFECTS CF MULCHING AND SPACING ON THE GROWTH AND YIELD OF GINGER (*Zingiber officinale* Roscoe)

**BY**

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**Zaria, Nigeria**
**$th August, 1987**

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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CERTIFICATION

This thesis entitled "EFFECTS OF MULCHING AND SPACING ON THE GROWTH AND YIELD OF GINGER (Zingiber officinale Roscoe)" by Andrew Umar Whofasa MENTA, meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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## DEDICATION

This Work is dedicated to my Uncle

MR C.A. MEHTA

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## ABSTRACT

An investigation into the effects of mulching and spacing on the growth and yield of ginger (Zingiber officinale Roscoe). was undertaken at Samaru during the 1986 wet season. The treatments comprised three levels of mulching (0, 5 and 10 cm thick), three intra-row plant spacings (10, 20 and 30 cm) with the same inter-row spacings of 15 cm and two varieties ('Tafin Giwa' and Yatsun Biri') in randomised complete block design, replicated three times.

The results revealed that mulching significantly increased the number of offshoots, plant height, number of leaves, leaf area and leaf, stem, rhizome and root dry weights.

Total rhizome yield was significant and positively correlated with yield characters. The 5 and 10 cm levels of mulch remarkably out-yielded **the** unmulched treatment by 29.5 and 21.3 per cent respectively. Generally, no differences was observed in growth and yield at mulch levels above 5 cm. Spacing had no visible effect on most of the parameters studied.

The growth and yield of the two varieties differed markedly. Variety 'Tafin Giwa' was overall superior 'Yatsun Biri' and infact out-yielded it by 17.6 per cent.

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Chapter 1

# INTRODUCTION

## 1.1 Origin and Spread

Ginger (Zingiber officinale. Roscoe) is a member of the family Zingiberaceae and sub-family Zingiberoideae. Although very little is known about the origin of the crop, it is generally accepted to be a native of Tropical South-East Asia from where it spread to other warmer parts of the world (Lewis, et al., 1972; Freeman and Chandler, 1907; Whiley, 1974). Purseglove (1975) opined that Arab traders took the plant from India to East Africa in the 13th century while the Portuguese brought it to West Africa and other parts of the Tropics in the 16th century.

While Member (1942) was of the opinion that wild forms of ginger exist in Nigeria, Edwards (1975) believed that the ginger in Nigeria was introduced from Jamaica. It follows, therefore, that the authenticity of the centre of origin for ginger has not been confirmed.

## 1.2 Botanical Characters

Ginger is a perennial herb. The underground rhizomes are thick, hard and much branched, giving rise to primaries, secondaries and tertiaries which are about 1.5 - 2.5 cm in diameter. Fine fibrous roots arise from the base of the rhizome and are confined to the top layers of the soil. Part of the stem above the ground with a height of between

30 and 100 cm, is unbranched, thin and formed by sheathing petioles of the leaves. The leaf blades are narrow and lanceolate, and are borne at about right angles to the stem with alternate arrangement. Flowers, when present are small and few with purple cap and rarely produce fruits. Propagation is always by portions of the rhizome.

## 1.3 Ecological Requirements

Ginger can be grown successfully under more adverse conditions than most other spices (Purseglove, 1975). It is grown as an 8 - 10 month crop in tropical and sub-tropical plains rising from seas level up to 1,500 m elevation (Rajendra, 1974). It requires adequate and well distributed rainfall of about 1,500 mm or more and a fairly high temperature of between 20-30 °C. Although it can be grown on a wide range of soils, it does best on well drained medium loam soils with a good supply of humus (Aiyadurai, 1966).

## 1.4 Uses

Ginger is a daily requirement in most households in one form or the other. The dried rhizome constitutes the major spice and is esteemed for its flavour, pungency and aroma. The characteristic refreshing odour of ginger is due to a volatile oil present in its rhizome while the pungent taste is due to oleo-resin which can be isolated by solvent extraction (Parry, 1972).

Oleo-resins extracted by Jacobs (1958), Lal-Nath and Rizvi (1970), are largely being used by food processing industries, particularly in the manufacture of cakes, biscuits and bread. Other uses are the manufacture of ginger-beer, soft drinks and pre-cooked canned foods. Limited quantities of ginger oil as reported by Guenther (1959), Anon. (1964) and Patel (1972) are used as an adjunct in flavours and to some extent as a modifier in perfumery products and cosmetics.

Locally, it is used for medicinal purposes and can also be ground and blended with other local spices like "masoro" and "fasakwari" for use in soups and porridge (Karikari and Musa, 1985).

## 1.5 Yields

With proper agronomic practices, high yields of 23 t/ha and 37 t/ha fresh ginger have been reported in India and Australia, respectively (Whiley, 1974; Purseglove, 1975) while as much as 120 t/ha has been obtained on experimental fields. According to Prentice (1959), average yields in Jamaica are about 1,400 kg/ha dry ginger during a good season, but may fall to 700 kg/ha in a poor season.

In Nigeria, Quinn (1973) observed that although the general husbandy of the crop at the farmers level has improved over the years, yields remained low. It was estimated at between 5 and 12.5 t/ha.

## 1.6 World Production and Trade

The major ginger producing countries, according to Senewiratne and Appadurai (1966) are India, China, Jamaica and countries in North and West Africa. In recent years, Australia and Japan have also started producing appreciable quantities (Lewis, et al., 1972).

World production of ginger is about 50,000 metric tons annually on dry weight basis (Lewis et al., 1972). According to Paulose (1972), 50 per cent of this is accounted for by India.

World exports are about 9,000 metric tones of dried ginger and of this too about one-half is from India and the remaining is from other ginger producing areas including Nigeria (Lewis, et al., 1972). Exports are mainly to Europe, America and Arab countries where there is a great demand for ginger.

## 1.7 Production and Trade in Nigeria

Southern Zaria in Kaduna state is the most important ginger growing area of Nigeria (Musa, 1985). Although ginger had been cultivated in small quantities in the area and was considered a suitable crop for expansion and marketing, serious production of the crop in Nigeria started in 1927 (Gibbon, 1953).

According to Momber (1942), from time of the first shipment in 1928 - 29 when five tons of dry ginger were purchased at Gantan, the figures had continued to rise up to 1966 after which the civil war caused some disruption in production. In 1972, about 1,500 tons of the crop was exported (Purseglove, 1975), while current production figures are not available because the government is not aware of what is being produced or traded (Karikari and Musa, 1985). Recently, however, the Nigerian Government has selected ginger as one of its priority export crops (Anon., 1985).

## 1.8 Objectives of the Study

Although, ginger is an important crop for the populace of Nigeria and especially the inhabitants of Southern Zaria, research work on the crop is limited. For example, information on basic agronomic requirements has yet not been published or made available to farmers. AERLS (1981) guide, for instance, does not have any recommendation on spacing and although mulching treatments are advised, the type and level of mulching suitable for ginger have not been investigated. There has also not been any systematic cultivar evaluation to find out which varieties are high yielding although it is known that two varieties are commonly grown in this country.

Since these basic agronomic requirements are of utmost importance in ginger cultivation (Karikari and Musa, 1985) and with the recent inclusion of ginger as one of the priority export crops by the Federal Government, it was felt necessary to study them in detail.

This work was, therefore, initiated with the objective of finding the effects of mulching and spacing and their interaction(s) on the growth and yield of ginger.

Chapter 2

# LITERATURE REVIEW

Little research work has been carried out in Nigeria with regards to the effect of cultural practices on ginger production. However, some work has been done and published in countries where ginger is widely grown, A review of these findings is necessary to provide an adequate knowledge about the crop and to serve as a guide to the best ways and means of growing and improving the crop successfully under Nigerian environmental conditions.

## 2.1 Varieties

No systematic work on correct description and classification of ginger varieties grown in different ginger growing areas has been done so far (Kennan and Nail, 1965).

In Nigeria also, no variety has yet been recommended but "Tafin Giwa" (Bold yellow ginger) is considered to be the best from the commercial view point (Anon, 1981). Other varieties grown are "Yatsun Biri" (Lark and compact ginger) and one that is usually described as "Foreign".

## 2.2 General Effect of Mulching

The benefits derived by mulching according to Edmond (1959) and Sheldrake (1967) are mainly due to weed control especially under black plastic, favourable changes in soil temperature, reduced soil water evaporation, less compaction, better aeration and microbial activity in the soil, reduced fertilizer leaching and more carbon dioxide availability to the plants. In addition, Lal (1975) reported that yield losses in some crops caused by termites in mulched plots where no treatment against termite is given, was insignificant. Therefore, it could be said with certainty that the merits of mulching superceeds its demerits.

Common materials generally used as mulches include crop residues cut and placed on the soil surface, stubble left standing after harvest, vegetation like banana leaves, straw, dead grasses, carried from elsewhere and black polythene.

### 2.2.1 Effect of type of mulching on ginger

Although organic residues as mulching material have been used in agriculture for a long time, the value of these materials in improving crop growth and proper method of use is still being debated (Ola-Adams, et al., 1990). However, [illegible] (Gill and Pierce (1961)

obtained an increase in yield of nearly 5 tons/ha of green ginger over the non-manured and non-mulched plots.

According to Kennan and Nair (1965), mulching with green leaves soon after planting is the most important operation in ginger production. Joachin and Pieris (1934) in their own trial observed that straw mulch is definitely beneficial in ginger production as yields increased significantly by 12.2% over the mean yield. The most important reason they gave for the increase is connected with the chemical and biological effects of decomposed straw. Cane trash or rice straw as mulch have also been found by Owadally, et al.(1981) to be generally beneficial to ginger.

Mohanty (1977) experimented with ginger cultivar Maran, which were mulched with banana leaves, grass or soil. The best results with regard to sprouting, yield, suppression of weeds and prevention of soil erosion were obtained from plants mulched with banana leaves. Rhizome yields in the three treatments and control were 31,000; 23,750; 17,750 and 17,960 kg/ha, respectively.

2.2.2 Effect of level of mulching on ginger

Muralidharan and Kamalam (1973) observed that mulching with 11,360 kg/ha of green leaves at the time of planting and 5,680 kg/ha each at 45 and 90 days after planting was found better than other levels and rates of mulching tried.

They also reported that mulching with 5,680 kg/ha of paddy straw at planting and repeated after 30 and 60 days were found to give favourable results.

## 2.3 Effect of Spacing on the Growth and Yield of Ginger

The growth and development of a crop is influenced by a number of agronomic practices. Plant spacing, whether under rainfed or irrigation condition is one of such important agronomic practices (Yayock, 1978).

According to Purseglove (1975), the normal spacing for ginger is 23-30 x 15-23 cm while Rodrigues (1971) recommended a spacing of 12-30 cm apart within rows 35-60 cm apart.

Anon. (1972), reported that spacing at 20 cm between seed rhizomes was superior to either 30 or 40 cm while no significant difference was found in yields at row spacings of 40, 60 and 80 cm used in the trial. The 40 cm between rows, however, gave slightly higher yields than 60 and 80 cm. It was, however, emphasized that difficulties in cultural operations encountered when planting at 40 cm between rows showed that it would be impracticable and uneconomic to plant at that spacing.

Muralidharan and Kamalam (1973) observed that a closer spacing of 22 x 22 cm or 22 x 15 cm was found to be better than wider spacings. This fact is further supported by the work of Randhawa, et al., (1972). They planted at 12 spacings ranging from 5 x 20 to 30 x 50 cm and reported highest yields from the spacings of between 20 x 20 and 20 x 30 cm.

While taking seed rhizome rate into consideration, Joachin and Pieris (1934) observed that a seed rhizome rate of 2.5 tons per hectare gave the highest yield in the trials conducted. Rodrigues (1971), in his own findings, concluded that the rate of planting varies considerably among farmers but a rate of 363 - 818 kg seed-rhizome per hectare is common. Correspondingly yields vary between 6,618 - 13,635 kg of unpeeled rhizomes per hectare.

From the foregoing, it would appear, therefore, that from the practical stand point, the closer spacing (15x20 - 20x30) cm or higher seed rhizome rates are preferable.

## 2.4 Effect of Mulching x Spacing Interaction on the Growth and Yield of Ginger

In Nigeria, a trial in southern Zaria first carried out in 1963 to test the effect of different plant spacings and the use of mulch on ginger was reported in 1964. In both years, yields were significantly improved by closer spacing and the use of mulch (Anon., 1964-66).

Chapter 3

# MATERIALS AND METHODS

## 3.1 Experimental Site

The experiment was conducted at the Institute for Agricultural Research Farm, Ahmadu Bello University, Samaru Zaria, during the 1986 wet season. Samaru is located at 11° 10'N, 7° 35'E and 686 m above sea level in the Northern Guinea Savanna ecological zone of Nigeria.

## 3.1 Treatments and Experimental Design

The treatments tested were:

i) Two varieties of ginger:

$V_1$ = "Tafin Giwa" (Bold yellow ginger)

$V_2$ = "Yatsun Biri" (Dark and compact ginger)

ii) Three levels of mulching:

$M_0$ = No mulching

$M_1$ = Straw mulch - 5 cm thick (1.5 kg/plot)

$M_2$ = Straw mulch - 10 cm thick (3 kg/plot)

iii) Three spacings (intra-row):

$S_1$ = 15 x 10 cm

$S_2$ = 15 x 20 cm

$S_3$ = 15 x 30 cm

The total number of treatment combinations was 18(2x3x3) each of which was replicated three times. The

## 3.3 Field Operations

### 3.3.1 Land preparation

The experimental site was ploughed and harrowed twice by means of a tractor to a fine tilth. Plots were then demarcated with a measuring tape, pegged and raised into flat beds (1.5 x 1.5 m) with hand hoes and labelled. The gross and net plot sizes were 2.25 $m^2$ and 0.25 $m^2$, respectively.

### 3.3.2 Fertilizer application

Phosphorus and potassium at the rate of 40 kg $P_2O_5$/ha and 50 kg $K_2O$/ha, respectively, were broadcast as basal dressing before beds were made. The sources used were single super-phosphate (18% $P_2O_5$) for phosphorus and muriate of potash (60 % $K_2O$) for potassium.

Nitrogen as calcium ammonium nitrate (26% N) was split applied at the rate of 100 kg N/ha, with half (50 kg N/ha) applied 30 days after planting (for proper establishment) and the remaining half at 90 days after planting (essentially for rhizome bulking) about 7 cm away from the plants.

### 3.3.3 Planting

Seed rhizomes were cut into setts having at least two viable eyes and weighing between 20 and 25 g each. The setts were planted singly on the 28th June, 1986, in holes about 5 cm deep and covered with soil. The spacing and mulching on each plot was as per treatment. At 5 weeks after planting sprouting percentage was recorded and the number of gaps filled.

### 3.3.4 Crop protection

Weeding was done four times at 3, 6, 9 and 15 weeks after planting (WAP), weeds on the beds were removed by hand pulling while hand hoe was used to remove weeds between the plots and along foot-paths.

### 3.3.5 Harvesting

Harvesting was done after 29 weeks by digging out the rhizomes with the aid of hoes when the aerial portions of the plants had toppled over and dried out. All rhizomes from the net plots were picked up carefully, labelled and taken to the laboratory for further observations. Seven days before harvesting, stand count of the gross and net plots was taken.

## 3.4 Data Collection

### 3.4.1 Meteorological data

Data on rainfall distribution, temperature figures, sunshine hours and relative humidity for Samaru durin[illegible] experimentation period were compiled and pre[illegible] in Table 1.

### 3.4.2 Soil Analysis

A composite soil sample (0-30 cm depth) was taken from the experimental field before the commencement of the project. At the end of the trial, samples were again

Table 1 Total rainfall, mean temperature, relative humidity and sunshing hours at ten-day intervals during the period of the trial at Samaru in 1986

| Month | Days | Total rain-fall(mm) | Mean Temperature (°C) | | Relative Humidity (%) | | Sunshine (hours) |
|---|---|---|---|---|---|---|---|
| | | | max. | Min. | a.m | p.m. | |
| May | 1-10 | 11.2 | 30.1 | 20.4 | 57 | 31.7 | 8.0 |
| | 11-20 | 18.4 | 27.7 | 21.7 | 62.9 | 47.2 | 7.0 |
| | 21-31 | 29.5 | 28.6 | 20.2 | 55 | 38.3 | 8.0 |
| June | 1-10 | 35.3 | 29.8 | 20.0 | 75.6 | 64.1 | 7.0 |
| | 11-20 | 22.6 | 30.2 | 20.6 | 74.3 | 55.8 | 9.1 |
| | 21-30 | 24.1 | 30.0 | 20.1 | 75.3 | 59.0 | 7.4 |
| July | 1-10 | 52.9 | 29.0 | 20.0 | 79.8 | 62.1 | 7.0 |
| | 11-20 | 49.4 | 27.8 | 19.5 | 83.4 | 67.3 | 6.5 |
| | 21-31 | 15.0 | 27.0 | 19.6 | 83.1 | 73.1 | 5.2 |
| August | 1-10 | 50.6 | 28.1 | 19.3 | 83.0 | 76.9 | 5.8 |
| | 11-20 | 94.9 | 28.5 | 19.7 | 84.3 | 66.0 | 7.1 |
| | 21-31 | 177.0 | 29.1 | 19.4 | 78.3 | 70.5 | 7.7 |
| September | 1-10 | 56.4 | 28.0 | 19.5 | 77.5 | 68.9 | 7.1 |
| | 11-20 | 81.2 | 29.3 | 18.6 | 72.6 | 64.2 | 8.6 |
| | 21-30 | 75.3 | 29.3 | 19.1 | 76.4 | 69.2 | 7.8 |
| October | 1-10 | 0.0 | 30.4 | 19.1 | 67.5 | 56.3 | 7.9 |
| | 11-20 | 0.0 | 31.5 | 15.8 | 45.4 | 45.3 | 9.6 |
| | 21-31 | 0.0 | 31.4 | 17.9 | 57.4 | 48.4 | 8.1 |
| November | 1-10 | 0.0 | 33.0 | 17.8 | 49.8 | 31.0 | 9.0 |
| | 11-20 | 0.0 | 30.0 | 12.0 | 24.9 | 22.4 | 8.5 |
| | 21-30 | 0.0 | 31.1 | 13.9 | 33.7 | 25.8 | 8.1 |
| December | 1-10 | 0.0 | 26.4 | 13.0 | 28.6 | 22.7 | 6.7 |
| | 11-20 | 0.0 | 27.0 | 12.4 | 24.3 | 20.4 | 6.0 |
| | 21-31 | 0.0 | 26.6 | 12.4 | 22.4 | 22.5 | 5.5 |
| January | 1-10 | 0.0 | 21.4 | 11.7 | 21.8 | 19.2 | 8.5 |
| | 11-20 | 0.0 | 24.7 | 11.7 | 18.1 | 15.7 | 9.8 |
| | 21-31 | 0.0 | 23.1 | 13.8 | 24.0 | 21.2 | 10.1 |

Source: Meteorological Unit, Institute for Agricultural Research, Samaru-Zaria, Nigeria.

collected as per mulching treatment. The soil samples were analyzed to determine their physico-chemical properties using the following procedures as described by Black (1965).

| | | |
|---|---|---|
| 1 | Particle size: | Hydrometer method |
| 2 | pH: | In water and 0.01 M $CaCl_2$, using pH meter. |
| 3 | Organic Carbon: | The standard Walkley-Black method employing a factor which assumes a 77% recovery. |
| 4 | Total Nitrogen: | By Kjeldahl process |
| 5 | Phosphorus: | By Bray I method |
| 6 | Exchangeable bases: | By Ammonium acetate saturation |
| 7 | C.E.C.: | By Ammonium acetate extraction and distillation. |

Results of the analysis are presented on Table 2.

Soil temperature ($^{o}C$) was also taken using earth thermometer at 5 and 10 cm depth as per mulching treatment at each sampling. The results are presented on Table 3.

### 3.4.3 Assessment of plant characters

At ten weeks after planting, assessment of growth characters was started. Samples were taken randomly at two weeks interval from the first row following outermost

Table 2 Physico-chemical properties of the soil at the experimental site before and after the trial at 0-30m depth.

| Soil Property | Before trial | After trial according to mulching levels (cm) | | |
|---|---|---|---|---|
| | | 0 | 5 | 10 |
| pH 1:2.5 | | | | |
| - Water | 5.30 | 4.80 | 5.00 | 5.30 |
| - 0.01 M $CaCl_2$ | 4.40 | 4.20 | 4.30 | 4.60 |
| Organic Carbon (%) | 0.46 | 0.42 | 0.46 | 0.47 |
| C.E.C. (meq/100g soil) | 5.20 | 5.60 | 5.80 | 6.20 |
| Available phosphorus (ppm) | 2.45 | 21.70 | 10.85 | 10.85 |
| Total nitrogen (%) | 0.042 | 0.042 | 0.056 | 0.057 |
| Exchangeable bases (meq/100g soil) | | | | |
| Ca | 2.25 | 2.25 | 2.46 | 3.05 |
| Mg | 0.52 | 0.52 | 0.58 | 0.76 |
| K | 0.16 | 0.16 | 0.19 | 0.35 |
| Na | 0.14 | 0.13 | 0.15 | 0.15 |
| Physical Classification | | | | |
| % clay | 11 | 11 | 9 | 11 |
| % silt | 20 | 16 | 16 | 18 |
| % sand | 69 | 73 | 75 | 71 |
| Textural class | sandy loam | loamy sand | loamy sand | loamy sand |

Table 3 Soil temperature ($^{o}C$) at 5 and 10 cm depth recorded at different periods as influenced by the mulching treatments.

| Date | 5 cm ($T^{o}C$) | | | 10 cm ($T^{o}C$) | | |
|---|---|---|---|---|---|---|
| | $M_o$ | $M_1$ | $M_2$ | $M_o$ | $M_1$ | $M_2$ |
| 26-7-86 | 26.80 | 24.80 | 24.80 | 25.40 | 24.40 | 24.20 |
| 2 -8-86 | 24.60 | 23.00 | 22.40 | 24.10 | 22.40 | 22.00 |
| 2-9-86 | 25.50 | 24.40 | 24.10 | 25.10 | 24.20 | 24.00 |
| 29-9-86 | 26.20 | 25.60 | 25.60 | 26.10 | 25.2 | 25.10 |
| 14-10-86 | 26.90 | 25.80 | 24.90 | 26.20 | 25.30 | 24.60 |
| Mean | 26.00 | 24.70 | 24.40 | 25.40 | 24.30 | 24.00 |

$M_o$ = No mulching

$M_1$ = Straw mulch - 5 cm thick

$M_2$ = Straw mulch - 10 cm thick

one. Two plants per plot were lifted at each sampling by means of a hand trowel, care being taken to recover most of the rhizome and roots. Samples from each plot were then put into polythene bags to minimize moisture loss and taken to the laboratory for detail observations. Prior to the observations, the underground parts were washed carefully with water taking care not to lose the roots. Thereafter, each sample was separated into its component parts and the following observations recorded:

- Number of off-shoots
- Number of green leaves
- Plant height from ground level to the growing point
- Leaf area: Here, the leaves of five plant samples were detached, traced on square graph sheets to determine their areas as described by Evans (1975). The leaves were then oven dried and weighed. Using this leaf area - dry weight relationship, the leaf area of the other plant samples were determined by proportion.
- Leaf fresh and dry weight
- Stem fresh and dry weight
- Rhizome fresh and dry weight
- Root fresh and dry weight.

Drying was achieved by heating the components placed in separate paper envelops in an electric oven at 70°C for at least 48 hours.

## 3.5 Analysis of Data

Analysis of variance was done to test the treatment effects for significance using the 'F' test as described by Snedecor and Cochran (1967). The effects of mulching, spacing, variety and their interactions in all parameters measured were of primary interest. Where the 'F' test showed significance, the means were compared using the Duncan's multiple range test (Duncan, 1955).

Chapter 4

# RESULTS

## 4.1 Growth Characters

### 4.1.1 Sprouting percentage

Data on the sprouting percentage of ginger as influenced by mulching, spacing and their interaction and by variety at 8 weeks after planting (WAP are presented in Table 4. The data revealed that differences due to mulching levels were highly significant with the 5 cm level being the heighest and the no mulch treatment being the lowest.

Significantly higher sprouting percentage was recorded from the 30 x 15 cm spacing as compared to the other two spacings i.e. 10 x 15 and 20 x 15 cm which did not differ significantly.

The difference in sprouting percentage was significantly influenced by variety with "Tafin Giwa" being superior to 'Yatsun Biri'.

There was a significant mulching x spacing interaction effect. For all spacings, 5 cm level of mulch produced similar and significantly highest sprouting percentage then all other interactions (Table 4).

### 4.1.2 Number of offshoots

The effect of treatments on crop establishment as reflected by the number of offshoots per plant is shown

Table 4 Sprouting percentage of ginger (8 weeks after planting) as influenced by mulching, spacing and their interaction at Samaru in 1986

| Treatment | Mulching level (cm) | | | |
|---|---|---|---|---|
| | 0 | 5 | 10 | Mean |
| Spacing (cm) | | | | |
| 10x15 | 72.33[a][1] | 92.50[a] | 88.00[c] | 84.28[b] |
| 20x15 | 70.50[b] | 94.83[a] | 89.00[c] | 84.78[b] |
| 30x15 | 86.00[c] | 94.17[a] | 91.83[b] | 90.67[a] |
| Mean | 76.28[c] | 93.83[a] | 89.61[b] | |
| SE(±) | | 1.11(mxs) | | 0.643(mxs) |
| Variety | | | | |
| Tafin Fiwa | 87.37[a] | | | |
| Yatsun Biri | 85.78[b] | | | |
| S.E.(±) | 0.52 | | | |

[1] Means followed by the same leter(s) within a treatment are not significantly different at 5% level of significance using Duncans Multing Range .est (DMRT).

in Table 5a. Significantly higher number of offshoots per plant was recorded from the mulched (5 and 10 em levels) than the non-mulched plots at all stages of sampling. Although there was no significant difference between the 5 and 10 cm levels of mulch, it was observed that the 5 cm level produced higher number of offshoots at 10, 12, 18 and 20 WAP.

Spacing and no significant effect on the number of offshoots at all sampling stages but there was a general increase in mean number of offshoots with increase in spacing.

Variety Tafin Giwa consistently produced significantly higher number of offshoots than 'Yatsun Biri'. There was significant interaction involving varieties and mulching levels at 10 and 14 WAP (Table 5b). 'Tafin Giwa' gave significantly higher number of offshoots at 5 and 10 cm levels of mulch 10 WAP and only at 10 cm level 14 WAP than all other interactions.

### 4.1.3 Plant height

Table 6a shows that plant height was significantly influenced by mulching. Significantly taller plants were recorded from the mulched than non-mulched plots throughout the trial. Within the mulched plots, the 5 cm level produced taller plants at 14, 18 and 20 WAP but the differences were not statistically significant.

Table 5a Number of offshoots of ginger recorded at two weeks interval as influenced by mulching, spacing and variety at Samaru in 1986.

| Treatment | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 | 20 |
| Mulching levels (cm) | | | | | | |
| 0 | $1.33_b$[1] | $1.78_b$ | $0.28_b$ | $2.11_b$ | $2.39_b$ | $1.67_b$ |
| 5 | $3.00_a$ | $4.16_a$ | $5.89_a$ | $4.83_a$ | $6.28_a$ | $4.56_a$ |
| 10 | $2.39_a$ | $3.89_a$ | $6.61_a$ | $6.22_a$ | $5.33_a$ | $3.56_a$ |
| SE(±) | 0.35 | 0.61 | 0.74 | 0.59 | 0.61 | 0.49 |
| Spacing (cm) | | | | | | |
| 10x15 | 2.06 | 3.22 | 4.67 | 4.80 | 4.72 | 3.56 |
| 20x15 | 2.17 | 3.39 | 5.44 | 5.00 | 5.20 | 3.89 |
| 30x15 | 2.50 | 3.25 | 5.34 | 5.20 | 5.30 | 3.90 |
| SE(±) | 0.35 | 0.62 | 0.74 | 0.60 | 0.61 | 0.50 |
| Variety | | | | | | |
| Tafin Giwa | $3.07_a$ | $4.26_a$ | $6.04_a$ | $4.78_a$ | $5.33_a$ | $8.82_a$ |
| Yatsun Biri | $1.41_b$ | $2.30_b$ | $3.81_b$ | $4.00_b$ | $4.00_b$ | $2.70_b$ |
| SE(±) | 0.28 | 0.50 | 0.61 | 0.47 | 0.49 | 0.41 |

1. Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 5b Number of off-shoots of ginger (10 and 14 weeks) after planting) as influenced by mulching x variety at Samaru in 1986

| Treatment | Mulching levels | | | | | | |
|---|---|---|---|---|---|---|---|
| | (10WAP) | | | (14 WAP) | | | |
| | 0 | 5 | 10 | 0 | 5 | 10 | Mean |
| Variety | | | | | | | |
| Tafin Giwa | $1.44_b$[1] | $4.33_a$ | $3.44_a$ | $3.00_{bc}$ | $5.78_b$ | $9.33_a$ | 4.55 |
| Yatunsin Biri | $1.22_b$ | $1.67_b$ | $1.33_b$ | $1.56_c$ | $6.00_b$ | $3.89_{bc}$ | 2.61 |
| Mean | 1.33 | 3.00 | 2.38 | 2.28 | 5.89 | 6.61 | |
| SE(±) | | 0.48 | | | 1.05 | | |

[1]Means followed by the same letter within a treatment are not significantly different at 5% level of significance using DMRT.

Table 6a Plant height (cm) recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986

| Treatment | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 | 20 |
| Mulching levels (cm) | | | | | | |
| 0 | $16.56_{b}$[1] | $13.89_{b}$ | $20.00_{b}$ | $26.67_{b}$ | $23.94_{b}$ | $22.44_{c}$ |
| 5 | $25.39_{a}$ | $24.78_{a}$ | $29.39_{a}$ | $33.00_{a}$ | $32.89_{a}$ | $32.56_{a}$ |
| 10 | $26.44_{a}$ | $27.50_{a}$ | $28.67_{a}$ | $34.94_{a}$ | $30.33_{a}$ | $29.39_{b}$ |
| SE(±) | 1.17 | 1.35 | 1.41 | 2.02 | 1.17 | 1.01 |
| Spacing (cm) | | | | | | |
| 10x15 | 22.11 | 21.50 | 24.00 | 31.11 | 27.89 | 27.00 |
| 20x15 | 22.89 | 22.17 | 26.61 | 31.67 | 30.72 | 29.67 |
| 30x15 | 23.39 | 22.50 | 27.44 | 31.83 | 28.50 | 27.72 |
| SE(±) | 1.17 | 1.34 | 1.42 | 2.02 | 1.17 | 1.01 |
| Variety | | | | | | |
| Tafin Giwa | 23.11 | 22.07 | 27.44 | 33.67 | $30.52_{a}$ | 29.26 |
| Yatsun Biri | 22.48 | 22.04 | 24.59 | 29.40 | $27.55_{b}$ | 27.00 |
| SE(±) | 0.95 | 1.10 | 1.16 | 1.65 | 0.95 | 0.82 |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Spacing treatments were not significantly different but the wider spacings (20 x 15 and 30 x 15) cm gave taller plants than the closer spacing (10 x 15) cm.

Variety 'Tafin Giwa' consistently produced taller plants at all stages of sampling than 'Yatsun Biri'. The mean difference in height was however significant only at 18 WAP.

There was significant first order interaction effects on plant height involving varieties and mulching levels. Both varieties produced significantly shorter plants in the non-mulched plots in comparison to the mulched plots (Table 6b).

### 4.1.4 Number of leaves

The number of leaves increased up to 18 WAP and thereafter started declining (Table 7a). This table also shows that the application of mulch played an important role in the formation of leaves. At all sampling stages, increasing the level of mulch from 5 to 10 cm did not significantly increase the number of leaves per plant. The mulched plots, however, produced significantly more number of leaves per plant than the unmulched at all growth stages.

There were significant varietal differences so far as this character was concerned. "Tafin Giwa" consistently

Table 6b. Plant height(cm) of ginger (10 weeks after planting) as influenced by mulching x variety at Samaru in 1986.

| Treatment | Mulching levels(cm) | | |
|---|---|---|---|
| | 0 | 5 | 10 |
| Variety | | | |
| Tafin Giwa | $20_b$[1] | $23.89_{ab}$ | $25.44_a$ |
| Yatsun Biri | $13.11_c$ | $26.89_a$ | $27.44_a$ |
| SE(±) | 1.65 | | |

[1]Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 7a Number of leaves of ginger recorced at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986.

| Treatment | Weeks after planting | | | | | |
|---|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 | 20 |
| Mulching levels (t/ha) | | | | | | |
| 0 | $14.33_b$[1] | $13.44_b$ | $29.44_b$ | $42.66_b$ | $51.78_b$ | $8.94_b$ |
| 5 | $26.22_a$ | $31.22_a$ | $70.78_a$ | $89.78_a$ | $99.11_a$ | $42.44_a$ |
| 10 | $24.11_a$ | $36.00_a$ | $81.69_a$ | $101.44_a$ | $90.22_a$ | $35.94_a$ |
| SE (±) | 1.95 | 2.10 | 7.34 | 9.31 | 8.63 | 5.73 |
| Spacing (cm) | | | | | | |
| 10x15 | 21.11 | 24.89 | 57.78 | 67.89 | 78.56 | 24.72 |
| 20x15 | 21.44 | 26.78 | 58.44 | 90.22 | 89.11 | 38.17 |
| 30x15 | 21.44 | 29.00 | 65.89 | 75.78 | 73.44 | 24.44 |
| SE(±) | 1.95 | 2.10 | 7.34 | 9.31 | 8.63 | 5.73 |
| Variety | | | | | | |
| Tafin Giwa | $27.56_a$ | $32.74_a$ | $76.15_a$ | $82.74_a$ | $95.93_a$ | $39.44_a$ |
| Yatsun Biri | $15.56_6$ | $21.04_b$ | $45.26_b$ | $73.19_b$ | $64.82_b$ | $18.78_b$ |
| SE(±) | 1.59 | 1.71 | 5.99 | 7.60 | 7.05 | 4.67 |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT

produced significantly higher number of leaves. Spacing had no significant effect on this character but like plant height it increased with increase in spacing (Table 7a)

The mulching x variety interaction was significant at 12 and 14 WAP (Table 7b). At both periods, "Tafin Giwa" produced significantly more leaves at 10 cm level of mulch as compared to all other interactions. However, both varieties gave significantly lower number of leaves when unmulched.

The influence of spacing x variety interaction was significant only at the early stages of growth (12 WAP) where 'Tafin Giwa' gave the greatest number of leaves at the closest spacing (10 x 15) cm (Table 7c). 'Yatsun Biri' generally produced significantly lower leaf number at all spacings.

4.1.5 Leaf area

The recorded data on leaf area per plant indicated that mulching at 5 and 10 cm levels were statistically at par but consistently superior to the non-mulched.

Table 8a also shows that varietal differences were highly significant at all stages with 'Tafin Giwa' giving a larger leaf area per plant than 'Yatsun Biri'. Spacing had no influence on this character.

The interaction of mulching x variety was significant only at 12 WAP. There was a general increase in leaf area

Table 7b The interaction effects of mulching x variety on the number of leaves of ginger at 12 and 14 weeks after planting at Samaru in 1986

| Treatments | Mulching levels (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 0 | 5 | 10 |
| Variety | | | | | | |
| Tafin Giwa | $15.33^{a}_{d}$ | $36.44_{b}$ | $46.44_{a}$ [1] | $36.89_{ab}$ | $78.22_{a}$ | $113.33_{a}$ |
| Yatsun Biri | $11.56_{d}$ | $24.67_{c}$ | $25.5^{1}_{c}$ | $28_{c}$ | $63.33_{bc}$ | $50.44_{bc}$ |
| SE(±) | | 2.97 | | | 10.37 | |

1

Table 7c The interaction effects of spacing and variety at Samaru on the number of leaves of ginger at 12 weeks after planting in Samaru, 1986.

| Treatment | Spacing (cm) | | |
|---|---|---|---|
| | 10x15 | 20x15 | 30x15 |
| Variety | | | |
| Tafin Giwa | $38.89_{a}$ | $29.11_{b}$ | $30.22_{b}$ |
| Yatsun Biri | $19.11_{c}$ | $25.55_{bc}$ | $19.57_{c}$ |
| SE(±) | | 2.97 | |

1
Means followed by the same letter within a treatment are not significantly different at 5% level of signifiance using DMRT.

Table 8a Leaf area ($cm^2$) per plant of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986.

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulching levels (cm) | | | | | |
| 0 | $129_b$ | $121.67_b$ | $368.33_b$ | $732.67_b$ | $734.67_b$ |
| 5 | $372.57_a$[1] | $475_a$ | $1165.7_a$ | $1604.67_a$ | $1966.0_a$ |
| 10 | $369.67_a$ | $567.67_a$ | $1225.3_a$ | $2110.33_a$ | $1523.4_a$ |
| SE (±) | | | | | |
| Spacing (cm) | | | | | |
| 10x15 | 278 | 328.33 | 780.67 | 1325 | 1352 |
| 20x15 | 285.67 | 396.33 | 955.33 | 1640 | 1510 |
| 30x15 | 307.67 | 439.64 | 1023.33 | 1482.67 | 1363 |
| SE(±) | 28.80 | 56.77 | 119.33 | 234.50 | 176.78 |
| Variety | | | | | |
| Tafin Giwa | $361.56_a$ | $482.00_a$ | $1169.78_a$ | $1784.90_a$ | $1760_a$ |
| Yatsun Biri | $219.33_b$ | $294.22_b$ | $669.78_b$ | $1180.2_b$ | $1057.4_b$ |
| SE(±) | 23.50 | 46.22 | 95.43 | 191.46 | 144.32 |

[1]Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

per plant with increasing mulch thickness for both varieties (Table 8b). However, 'Tafin Giwa' at 5 and 10 cm levels and 'Yatsun Biri' at 10 cm level were superior to all other interactions.

4.1.6 Leaf dry weight

Data recorded on leaf dry weight as influenced by mulching, spacing and variety at 6, 8, 10, 12 and 16 WAP are presented in Table 9a. Statistical analysis of the data indicates that differences due to mulching levels were significant at all the sampling stages. Increasing the level of mulch did not increase leaf dry weight per plant beyond the 5 cm level. Both 5 and 10 cm levels of mulch were, however, superior to the unmulched. At all stages of sampling, spacing had no significant effect on the leaf dry weight.

Variety 'Tafin Giwa' produced significantly heavier leaf dry weight per plant than 'Yatsun Biri' at all stages of sampling. The first order mulching x variety interaction was significant only at 12 WAP (Table 9b). Both varieties under no mulch condition gave significantly lower leaf dry weight per plant. 'Tafin Giwa' was, however, significantly superior to 'Yatsun Biri' at the 5 and 10 cm level of mulch.

Table 8b The interaction effect of mulching x variety on the leaf area ($cm^2$) of ginger at 12 s weeks after planting at Samaru in 1986.

| Treatment | Variety | |
|---|---|---|
| | [illegible] | [illegible] |
| Mulching levels (cm) | | |
| 0 | $89.33_c$ | $154_c$ |
| 5 | $669.33_a$ [1] | $260.67_{bc}$ |
| 10 | $687.33_a$ | $446_{ab}$ |
| SE(±) | 79.57 | |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 9a Leaf dry weight (gm) of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulching levels (cm) | | | | | |
| 0 | $0.44_b$ | $0.37_b$ | $1.23_b$ | $2.44_b$ | $2.45_b$ |
| 5 | $1.24_a$[1] | $1.61_a$ | $3.89_a$ | $5.36_a$ | $6.75_a$ |
| 10 | $1.23_a$ | $1.89_a$ | $4.08_a$ | $7.03_a$ | $5.11_a$ |
| SE (±) | 0.09 | 0.19 | 0.40 | 0.78 | 0.60 |
| Spacing (cm) | | | | | |
| 10x15 | 0.93 | 1.09 | 2.60 | 4.42 | 4.55 |
| 20x15 | 0.95 | 1.32 | 3.18 | 5.47 | 5.03 |
| 30x15 | 1.03 | 1.46 | 3.41 | 4.95 | 4.76 |
| SE(±) | 0.09 | 0.19 | 0.40 | 0.78 | 0.60 |
| Variety | | | | | |
| Tafin Giwa | $1.20_a$ | $1.61_a$ | $3.90_a$ | $3.96_a$ | $5.67_a$ |
| Yatsun Biri | $0.73_b$ | $0.97_b$ | $2.23_b$ | $3.93_b$ | $3.69_a$ |
| SE(±) | 0.08 | 0.15 | 0.33 | 0.64 | 0.49 |

[1]Means followed by the same letter within a treatment are not significantly different at 5% level of significance using DMRT.

Table 9b The interaction effect of mulching x variety at 12 weeks after planting on the leaf dry weight (gm) of ginger at Samaru in 1986.

| Treatment | Variety | |
|---|---|---|
| | Tafin Giwa | Yelsum Kiri |
| Mulching levels (cm) | | |
| 0 | $0.30_{d}$[1] | $0.43_{d}$ |
| 5 | $2.25_{ab}$ | $1.00_{cd}$ |
| 10 | $2.29_{a}$ | $1.49_{bc}$ |
| SE (±) | 0.27 | |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

4.1.7 Stem dry weight

Table 10 shows the data on stem dry weight per plant as influenced by mulching, spacing and variety at different sampling stages. Statistical analysis of the data clearly indicated that mulching levels 5 and 10 cm which are statistically at par were significantly superior to the non-mulched condition. Spacing had no significant influence on the stem dry weight per plant throughout the trial.

Between the varieties, 'Tafin Giwa' produced significantly heaviery dry stems per plant than 'Yatsun Biri' at all growth stages.

All first and second order interactions among mulching, spacing and variety were not significant.

4.1.8 Shoot dry weight

The effects of treatments on shoot dry weight at different stages of sampling are presented on Table 11. Statistical analysis of the data shows that the differences due to mulching and variety were significant at every sampling period.

Mulching at 5 and 10 cm were statistically the same but gave significantly higher shoot weight per plant when compared to the absence of mulch. The main shoot weight at the 10 cm level was higher than that of the 5 cm level at 12, 14 and 18 WAP.

Table 10 Stem dry weight (gm) of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulching levels (t/ha) | | | | | |
| 0 | 0.42$_b$ | 0.62$_b$ | 1.69$_b$ | 1.72$_b$ | 1.54$_b$ |
| 5 | 0.84$_a$ | 1.06$_a$ | 2.47$_a$ | 3.83$_a$ | 4.96$_a$ |
| 10 | 0.69$_a$ | 1.37$_a$ | 2.90$_a$ | 5.44$_a$ | 3.80$_a$ |
| SE (±) | 0.09 | 0.17 | 0.27 | 0.61 | 0.44 |
| Spacing (cm) | | | | | |
| 10x15 | 0.696 | 0.807 | 168 | 3.16 | 3.17 |
| 20x15 | 0.658 | 0.812 | 2.22 | 3.96 | 3.64 |
| 30x15 | 0.902 | 1.06 | 2.28 | 3.71 | 3.51 |
| SE(±) | 0.09 | 0.17 | 0.270 | 0.62 | 0.45 |
| Variety | | | | | |
| Tafin Giwa | 0.95a | 1.15$_a$ | 2.59$_a$ | 4.38$_a$ | 4.23$_a$ |
| Yatsun Biri | 0.56$_b$ | 0.63$_b$ | 1.53$_b$ | 2,84$_b$ | 2.65$_b$ |
| SE(±) | 0.07 | 0.13 | 0.22 | 0.50 | 0.36 |

[1]Means followed by the same letter within a treatment are not significantly different at 5% level of significance using DMRT.

Table 11 Shoot weight (gm) of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulching levels (cm) | | | | | |
| 0 | 0.66$_b$[1] | 1.00$_b$ | 2.09$_b$ | 3.99$_b$ | 4.20$_b$ |
| 5 | 2.18$_a$ | 2.70$_a$ | 6.35$_a$ | 11.75$_a$ | 9.30$_a$ |
| 10 | 2.13$_a$ | 3.30$_a$ | 6.97$_a$ | 8.92$_a$ | 12.30$_a$ |
| SE(±) | 0.18 | 0.35 | 0.66 | 1.03 | 1.39 |
| Spacing (cm) | | | | | |
| 10x15 | 1.61 | 1.91 | 5.40 | 7.72 | 7.57 |
| 20x15 | 1.62 | 2.13 | 5.70 | 8.67 | 8.67 |
| 30x15 | 1.93 | 2.52 | 4.30 | 8.30 | 9.43 |
| SE(±) | 0.18 | 0.35 | 0.66 | 1.03 | 1.39 |
| Variety | | | | | |
| Tafin Giwa | 2.15$_a$ | 2.76$_a$ | 6.49$_a$ | 10.10$_a$ | 10.34$_a$ |
| Yatsun Biri | 1.29$_b$ | 1.61$_b$ | 3.76$_b$ | 6.34$_b$ | 6.77$_d$ |
| SE(±) | 0.15 | 0.28 | 0.56 | 0.84 | 1.13 |

[1] Mean followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

'Tafin Giwa' yielded significantly higher shoot weight per plant than 'Yatsun Biri' throughout the growing season.

Varying the spacing failed to influence the shoot weight per plant throughout the growing season. Same applies to first and second order interactions among the treatments.

4.1.9 Rhizome dry weight

The data on rhizome dry weight per plant as influenced by mulching, spacing and variety at 10, 12, 14, 16 and 18 WAP are presented on Table 12. It was observed that differences due to mulching were significant at all sampling stages. Like in most other characters observed, the mulched treatments (5 and 10) cm yielded statistically the same rhizome dry weight per plant but were consistently superior to the no-mulch treatment. Spacing treatments did not have any significant effect on rhizome dry matter yield.

The varietal differences were significant. 'Tafin Giwa' maintained significantly higher rhizome dry weight per plant over 'Yatsun Biri' at all stages of sampling. No interaction effect among the different treatments was recorded for this character.

Table 12 Rhizome dry weight (g) of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1966.

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulching levels (cm) | | | | | |
| 0 | $0.30_b$ | $0.30_b$ | $0.9[illegible]_b$ | $[illegible].55_b$ | $5.50_b$ |
| 5 | $0.72_a$[1] | $1.25_a$ | $3.52_a$ | $[illegible].74_a$ | $11.27_a$ |
| 10 | $0.81_a$ | $1.10_a$ | $3.46_a$ | $6.62_a$ | $10.56_a$ |
| SE(±) | 0.09 | 0.22 | 0.35 | 0.74 | 0.68 |
| Spacing (cm) | | | | | |
| 10x15 | 0.55 | 0.69 | 2.19 | 3.82 | 8.43 |
| 20x15 | 0.58 | 0.77 | 2.77 | 4.93 | 9.30 |
| 30x15 | 0.70 | 1.17 | 2.99 | 4.55 | 9.70 |
| SE(±) | 0.09 | 0.22 | 0.35 | 0.74 | 0.68 |
| Variety | | | | | |
| Tafin Giwa | $0.76_a$ | $1.22_a$ | $3.44_a$ | $5.49_a$ | $10.43_a$ |
| Yatsun Biri | $0.46_b$ | $0.56_b$ | $1.86_b$ | $3.38_b$ | $7.83_b$ |
| SE(±) | 0.07 | 0.18 | 0.28 | 0.60 | 0.56 |

[1] Means followed by the same letter within a treatment are not significantly different at 5% of significance using DMRT.

4.1.10 Root dry weight

Results of the effects of mulching, spacing and variety on root dry weight per plant 1 at 10, 12, 14, 16 and 18 WAP are shown in table 13a. The results did not follow a definite pattern especially between the first and second sampling periods but there was a general trend of increment with time.

The differences due to mulching were highly significant with no mulching giving significantly lower root dry weight per plant at all sampling stages except at 16 WAP where it was at par with 5 cm level of mulch.

Spacing had no significant influence on root dry weight at all the sampling stages. The varietal differences were significantly in favour of 'Tafin Giwa' at all stages except at 16 WAP where it was not different from 'Yatsun Biri'.

The interaction effect on spacing x variety was significant at 16 WAP (Table 13b). 'Tafin Giwa' at 20 x 15 cm spacing was superior to all other interactions. Both varieties at 10 x 15 cm space produced significantly the lowest root dry weight.

## 4.2 Effect of mulching, spacing, variety and their interactions on the yield and yield components of ginger

### 4.2.1 Stand count at harvest

Table 14a shows the data on the stand count at harvest of ginger recorded at 28 WAP as influenced by

Table 13a Root dry weight (gm) of ginger recorded at 2 weeks interval as influenced by mulching, spacing and variety at Samaru in 1986.

| Treatment | Weeks after planting | | | | |
|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 |
| Mulch levels (cm) | | | | | |
| 0 | $0.09^{1}_{b}$ | $0.09_{b}$ | $0.17_{b}$ | $0.27_{b}$ | $0.36_{b}$ |
| 5 | $0.23_{a}$ | $0.27_{a}$ | $0.41_{a}$ | $0.61_{a}$ | $1.02_{a}$ |
| 10 | $0.17_{a}$ | $0.23_{a}$ | $0.36_{a}$ | $0.71_{a}$ | $0.64_{a}$ |
| SE(±) | 0.02 | 0.02 | 0.09 | 0.08 | 0.09 |
| Spacing (cm) | | | | | |
| 10x15 | 0.15 | 0.14 | 0.32 | 0.44 | 0.62 |
| 20x15 | 0.16 | 0.15 | 0.45 | 0.50 | 0.83 |
| 30x15 | 0.18 | 0.15 | 0.52 | 0.51 | 0.85 |
| SE(±) | 0.02 | 0.02 | 0.09 | 0.08 | 0.09 |
| Variety | | | | | |
| Tafin Giwa | $0.20_{a}$ | $0.17_{a}$ | $0.54_{a}$ | 0.54 | $0.90_{a}$ |
| Yatsun Biri | $0.13_{b}$ | $0.12_{b}$ | $0.31_{b}$ | 0.42 | $0.63_{b}$ |
| SE(±) | 0.02 | 0.02 | 0.07 | 0.07 | 0.07 |

[1]Means followed by the same letter within a treatment are not significantly different at 5% level of significance using DMRT

Table 13b The interaction effect of spacing x variety at 16 weeks after planting on the root dry weight (g) of ginger at Samaru in 1986

| Treatment | Variety | |
|---|---|---|
| | Dafin Gawa | Katsu [illegible] |
| 10x15 | $0.67_{bc}$ | $0.50_{bc}$ |
| 20x15 | $1.19_{a}$ | $0.45_{bc}$ |
| 30x15 | $0.63_{abc}$ | $0.67_{ab}$ |
| SE (±) | 0.13 | |

1 Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 14a Stand count at harvest of ginger at 26 weeks after planting as influenced by mulching, spacing and variety at Samaru in 1986.

| Treatment | Weeks after planting |
|---|---|
| | 26 |
| Mulching (t/ha) | |
| 0 | 34$_b$ |
| 5 | 41.67$_a$ |
| 10 | 43.67$_a$ |
| SE (±) | 2.32 |
| Spacing (cm) | |
| 10x15 | 45.67$_a$ |
| 20x15 | 38.61$_b$ |
| 30x15 | 30.10$_c$ |
| SE (±) | 2.32 |
| Variety | |
| Tafin Giwa | 43.44$_a$ |
| Tafin Giwa | 32.78$_b$ |
| SE(±) | 1.90 |

[1] Means followed by the letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

mulching, spacing and variety. The table reveals that the mean difference in the number of plants per plot at harvest between the mulch treatments was highly significant. No mulch treatment produced significantly lower number of plants as compared to the 5 and 10 cm mulch treatments which were statistically the same.

Spacing also had a significant effect on stand count at harvest. The 10 x 15 cm treatment was the most superior while the 30 x 15 cm treatment yielded significantly the lowest number of plants at harvest.

The varietal differences were highly significant with 'Tafin Giwa' being significantly superior to 'Yatsun Biri'.

Spacing x variety interaction effects on this character are presented on Table 14b. 'Tafin Giwa' at 10 x 15 and 20 x 15 cm spacings gave significantly higher number of plants than all other interactions. 'Yatsun Biri' at 30 x 15 cm spacing produced significantly the lowest number of plants at harvest.

### 4.2.2 Dry rhizome weight

Table 15 a shows that mulching has influenced the yielding capacity of ginger. The mean total dry rhizome

Table 4b The interaction effects of spacing x variety at 26 weeks after planting on the stand count at harvest of ginger at Samaru in 1986.

| Treatment | Variety | |
|---|---|---|
| | [illegible] | [illegible] |
| S.S.D.W. (cm) | | |
| 10x15 | $39.33_{a}$ [1] | $34.00_{bc}$ |
| 20x15 | $40.00_{ab}$ | $37.22_{bc}$ |
| 30x15 | $31.00_{bc}$ | $29.11_{c}$ |
| SE(±) | 3.30 | |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT

Table 15a Dry rhizome yield (kg/ha) of ginger at 29 weeks after planting as influenced by mulching, spacing and variety at Samaru in 1986

| Treatment | Weeks after Planting |
|---|---|
| | 29 |
| Mulching level (t/ha) | |
| 0 | 448.60[b] |
| 5 | 570.10[a] |
| 10 | 636.10[a]1 |
| SE(±) | 39.57 |
| Spacing (cm) | |
| 10x15 | 553.54 |
| 20x15 | 587.65 |
| 30x15 | 536.40 |
| SE(±) | 39.57 |
| Variety | |
| Tafin Giwa | 613.25[a] |
| Yatsun Biri | 505.26[b] |
| SE (±) | 32.31 |

1 Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

yield (kg/ha) increased significantly from 448 kg/ha in the unmulched plots to 570.10 and 636.10 kg/ha in the 5 and 10 cm mulched plots, respectively, which were statistically the same. The 10 cm level, however, gave the highest mean yield.

Increase in spacing had no significant effect on the total dry rhizome yield but the 20 x 15 cm spacing gave the highest mean yield.

Variety 'Tafin Giwa' significantly out-yielded 'Yatsun Biri'.

There was a significant spacing x variety interaction (Table 15b). For variety 'Tafin Giwa' there was a general non-significant decrease in yield with increase in spacing. For variety 'Yatsun Biri', the 10 x 15 cm spacing yielded significantly lower than the 20 x 15 and 30 x 15 cm spacings which were the same statistically. The 20 x 15 cm spacing however gave the highest mean yield in this variety.

Like in other parameters, no significant second order interaction was recorded for total dry rhizome yield.

## 4.3 Correlation

Results of the combined correlation analysis of some of the paramters indicated that there was high signficiant positive correlation between rhizome yield and plant height (r=0.431), number of leaves (r=0.509), leaf area (0.456) and stand count at harvest (r=0.531) as presented on table 16. Generally, there was significant positive correlation between most of the parameters and yield.

Table 15b Total dry rhizome yield (kg/ha) of ginger at 30 weeks after planting as influenced by spacing x variety interaction at Samaru in 1986

| Treatment | Variety | |
|---|---|---|
| | Tafin Giwa | Yatsun Biri |
| Spacing (cm) | | |
| 10x15 | $708.79_{a}$[1] | $398.29_{b}$ |
| 20x15 | $589.59_{a}$ | $586.11_{a}$ |
| 30x15 | $541.36_{ab}$ | $531.38_{ab}$ |
| SE(±) | 55.96 | |

[1] Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 16 Correlation between rhizome yield, number of offshoots, plant height, number of leaves, leaf area, leaf dry weight, stem dry weight, rhizome dry weight, root dry weight and stand count at harvest in 1986.

| | Rhizome yield (Kg/ha) | No. of offsho-ots | Plant height | No. of leaves | Leaf area | Leaf dry weight | Stem dry weight | Rhizome dry weight | Root dry weight | Stand count at harvest |
|---|---|---|---|---|---|---|---|---|---|---|
| Rhizome yield (Kg/ha) | 1 | | | | | | | | | |
| Number of offshoots | 0.285* | 1 | | | | | | | | |
| Plant height | 0.413** | 0.314* | 1 | | | | | | | |
| Number of leaves | 0.409** | 0.628** | 0.482** | 1 | | | | | | |
| Leaf area | 0.456** | 0.621** | 0.748** | 0.792** | 1 | | | | | |
| Leaf dry weight | 0.294* | 0.505** | 0.749** | 0.791** | 0.999** | 1 | | | | |
| Stem dry weight | 0.283* | 0.628** | 0.754** | 0.781** | 0.973** | 0.973** | 1 | | | |
| Rhizome dry weight | 0.319* | 0.768** | 0.751** | 0.656** | 0.924** | 0.924** | 0.907** | 1 | | |
| Root dry weight | 0.319* | 0.380** | 0.509** | 0.852** | 0.668** | 0.668** | 0.696** | 0.569** | 1 | |
| Stand count at harvest | 0.531** | 0.336* | 0.532** | 0.445** | 0.505** | 0.505** | 0.519** | 0.471** | 0.547** | 1 |

Values above 0.208 (*) are significant at 5% level of significance
Values above 0.350(**) are signficant at 1% level of signficiance

Chapter 5

# DISCUSSION

## 5.1 Effect of Mulching

The results emphasize the beneficial effects of mulching as shown by its influence on vegetative growth and yield components of the rhizome.

The application of straw mulch up to 10 cm thick significantly increased sprouting percentage at 8 weeks after planting (WAP) over the non-mulched treatment. This could be adduced to the effectiveness of straw to maintain lower soil temperature (as shown on Table 3), favourable moisture condition, and better aeration since appreciable biodeterioration may not have occurred at this stage of growth. Similar observations were made by Edmond (1959) and Sheldrake (1967). Although not significant the higher sprouting percentage observed in the 5 cm than the 10 cm level may be attributed to the smothering effect of the thicker level (10 cm).

Plant height and number of offshoots per plant were also significantly increased by mulching. The 5 cm level of mulch produced 30.6% and 66.5% taller plants and higher number of offshoots respectively than the non-mulched treatment. These results are in agreement with that of stem dry weight. This was expected since the stem dry weight is a product of both plant height and the number of offshoots.

The great differences so observed may be attributed to higher soil temperature for the unmulched plots at the early stages of growth. In addition, the young leaves of the unmulched plots plants showed chlorotic symptoms. This may be partly due to the restricted root growth and therefore poor fertilizer efficiency of the unmulched plots. These symptoms of high temperature induced nutrient deficiency were also demonstrated by Lal (1974) and Walker (1969) in maize.

Number of leaves and leaf area per plant were also significantly positively improved by mulching from the early stages of development. Both parameters increased with increase in age up to 18 WAP. The significantly higher values obtained in the mulched plots could, according to Sheldrake (1967), be associated with reduced fertilizer leaching, improved microbial activity in the soil, reduced water evaporation and more carbon dioxide availability to the plants. Senescence set in after the 20th week of planting but the process was slower in the mulched than non mulched treatments. All leaves were lost in the unmulched treatment plots 4 weeks before the mulched. This prolonging of foliage lifespan by mulching was advantageous because a longer period was allowed for the production of assimilates by the foliage.

Leaf, stem, shoot and rhizome dry weights were all significantly increased by mulching. reduced competition between the ginger plants and weeds for water, nutrients, light and other growth inputs could be responsible for this. Similar observations were made by Quinn (1973) and

Adelana (1978) who worked with tomatoes. They noted that on the unmulched plots there was rapid weed emergence, whereas on the grass-mulched plots weed emergence was much slower. Nevertheless, some weeding had to be done on the grass-mulched plots and this was virtually restricted to hand pulling as the mulch prevented the use of hoe. It must, however, be noted that increasing the mulch level from 5 cm to 10 cm level was not advantageous as there was no significant difference in the dry weights obtained.

Although significant, the indefinite pattern recorded for the root dry weight especially during the first and second sampling periods would be attributed to the brittle nature of the roots and their interwining with neighbouring plants which might have prevented full root recovery. However, there was a general increment with time and the mulched plots gave significantly higher dry root weights in comparison to the unmulched ones. Better soil aeration and lesser compaction under mulched conditions could be responsible for this better performance.

In addition, Lal (1975) and Prihar et al., (1979) reported that in the tropics soil temperatures are often supra-optimal. This fact according to them invariably retarded root growth and yield in some cereals and legumes. Mulching is one of the approach to overcome this limitation and this could be adduced as a reason for the observed difference in root dry weight between the mulched and the unmulched plots.

The agronomic importance of rhizome yield increase by mulching was highlighted in this trial. A yield increment of 21.3% and 29.5% was recorded for the 5 and 10 cm levels of mulch respectively over the non-mulched treatment. The most important reason could be the improvement in the fertility status of the mulched plots as reflected on Table 2. The C.E.C., Total nitrogen, Available phosphorus and Exchangeable bases (Ca, Mg, K, Na) all increased appreciably with mulching. The mean dry rhizome yields (448.6, 570.10 and 636.10 kg/ha) for 0, 5 and 10 cm levels of mulch, respectively) were much lower than that obtained in other ginger growing areas like Jamaica where Prentice (1959) obtained a yield of about 1,500 kg/ha dried ginger during a good season and about 800 kg/ha in a poor season. Differences in ecological conditions and especially moisture availability and distribution during the growing season may explain this discrepancy. The ginger growing areas of Jamaica for example receive a rainfall of about 2000 mm or more per annum which is higher than that of Zaria (about 1,066 mm). Moreover, planting was delayed to June ending instead of late April due to the erratic nature of rainfall experienced during the 1986 growing season.

The increase in rhizome yield by mulching may be attributed to a decrease in soil temperature (Walker, 1969), improved condition and a variety of resultant chemical and biochemical factors associated with mulching.

The moisture factor is likely to become important in the drier late season since production was under rain-fed condition. In general, yield increases of the mulched over the non-mulched plots could have resulted from the combine effect of optimal temperature and increase of organic matter through biodeterioration. Similar observations were made by Chaudhry and Prihar (1974) and Minchin et al. (1976) while working with plantain. Furthermore, effective weed control from the time of planting in the mulched plots eliminated interspecific weed competition on nutrients, water and space to the benefit of the ginger plants prior to canopy closure. Similar conclusion was recorded by Ndubizu (1983) for plantain.

Ginger is susceptible to some fungal induced diseases. Therefore another factor which may have contributed to the lower yields in the unmulched plots is soil splash which carries soil borne pathogens to the lower leaves of the plants. Like many other tropical areas, the northern and southern Guinea savanna zones of Nigeria sometimes experience severe storms. Rainfall can be intense, 40-60 mm per hour being common, and winds strong. Under such conditions and especially where there is no protective surface mulch, soil splash to a height of 0.4 m is general. Similar conclusions were drawn by Quinn (1975) for tomato.

Generally, the yield acruing from straw mulching in this trial is in conformity with that of Joachin and Pieris (1934). They reported that straw mulching is definitely beneficial in ginger production as yields increased significantly by 12.2% over the mean yield. Similar results were also obtained by Mohanty, (1977) and Owadally *et al*. (1981).

## 5.2 Effect of Spacing

Vegetative growth and yield were not significantly influenced by spacing although there was a tendency for the dry weights per plant of the various parameters studied to increase with increase in spacing.

The growth andyield in the field indicated two kinds of competition as a result of spacing. Competition between plants which may be important at close spacing and competition within plants (between shoots) which is significant at a wider spacing and with large number of shoots. In this trial, although the closer spacing (10 x 15 cm) outyielded the widest (30 x 15) cm, the yield advantage of the closer spacing (553.54 kg/ha) over the wider spacing (536.40 kg/ha) on a dry weight basis does not justify the extra cost of planting material for the closer spacing. This result was partly in conformity with that of Beukema and Van Der Zaag (1979) in their trial with potatoes. They reported that

if high yield is desired then specing shoulc be close.

An important explanation for higher yields at close spacing is that more leaves and shoots are produced per unit area, thereby enhacing rapid ground cover. With the high leaf area of closely spaced plants, more radiation is intercepted by the foliage for conversion into dry matter. On the other hand, the decrease in dry weights per plant with decrease in spacing must have been as a result of competition between plants for light, nutrients and water. This competition might be so severe as observed in this trial as to decrease the crop stand at harvest (Survival of the fittest). Furthermore, Wilson (1977) reported that the maximum leaf area index (LAI) calculated for ginger at a planting density of 148,000 plants/ha substantially exceeds that of most other root crop species. With the high LAI observed during the period 16-18 WAP of this trial, values for the vegetative growth parameters for the 10x15 cm spacing were lower than expected. This could be attributed to the dense canopy in a mature stand of ginger, which has many horizontal leaves resulting in excessive mutual shading., Duncan (1971) made similar observations.

With regard to rhizome size, increase in spacing resulted in larger sized rhizomes per plant in comparison to the closer spaced plants. This fact may have been the reason why the closer treatment did not yield better than

the wider spacing. This could be attributed to the fact that although rhizome size per plant increased as spacing increased, the closely spaced plants had a considerable advantage in rhizome numbers per unit area, leading to more intense inter-rhizome competition and restriction in rhizome growth. In potatoes, Findlay and Sykes (1938), Brenner et al (1961) and Murr (1974) reported a decrease in the yield of small sized tubers with increase in spacing between plants. In contrast, however, they observed that increase in the number and size of the tubers per plant with wide spacing did not compensate for the reduction in number of plants. Therefore, there was a reduction in total yield as spacing distance increased.

In general, therefore, the main effect of spacing on growth and yield in this trial can be attributed to the differences in light interception at different spacings. Highest yield was obtained from 20 x 15 cm spacing. This is in conformity with the results of Randhawa et al (1972) and Muralidharan and Kamalam (1973). They obtained their highest yields at spacings of 20 x 15 and 22 x 15 cm respectively.

## 5.3 Effect of Variety

Variety 'Tafin Giwa' excelled variety 'Yatsun Diri' in yields, yield components and vegetative growth at all

stages of sampling. However, the growth and development pattern of both varieties was similar.

Number of offshoots and height per plant were significantly higher in 'Tafin Giwa'. This observation was not in conformity with Musa (1986) who registered significantly taller plants in 'Yatsun Biri'. Differences in treatment combinations utilized in the trials might be responsible for this disparity.

'Tafin Giwa' also exceeded 'Yatsun Biri' in leaf, stem, shoot, rhizome and root dry weights throughout the trial. This apparent difference with regard to the above traits could be due to genetic variations between the varieties.

The results also revealed that 'Tafin Giwa' out-yielded 'Yatsun Biri' by 17.6%. Even the difference in rhizome size is an indication of this fact. The yield advantage over 'Yatsun Biri' is in conformity with Musa's findings (1986), wherein 'Tafin Giwa' gave 13.5% greater yield than 'Yatsun Biri'. The larger number of shoots per plant (which may be genetic) in 'Tafin Giwa' could be a reason for this difference since each shoot is capable of accumulating assimilates for onward translocation to the sink (rhizome).

The better response of 'Tafin Giwa' to mulching and its accompanying winduced microclimate (like reducing excessive soil temperatures) may also be a factor here.

## 5.4 Interactions

### 5.4.1 Spacing x Mulching

Spacing x mulching interaction significantly increased sprouting percentage. 5 cm level of mulch at all the spacings adopted was superior to the unmulched. This clearly indicated how beneficial mulching is at whatever spacing adopted in ginger production. This is in conformity with the observations of Joachim and Pieris (1934) and Kennan and Kaira (1965).

### 5.4.2 Mulching x variety

Number of offshoots was significantly influenced by mulching x variety interaction at 10 and 14 WAP. 'Tafin Giwa' at 5 and 10 cm levels (10 WAP) and 10 cm level (14 WAP) gave higher number of offshoots than all other interactions. Similar results were obtained for plant height at 10 WAP except that in this case there was no difference between both varieties at 5 and 10 cm levels of mulch but 'Tafin Giwa' still produced taller plants in the unmulched plots than 'Yatsun Biri'. Number of leaves, leaf area and leaf dry weight were also influenced by this interaction. In all cases 'Tafin Giwa' was superior to 'Yatsun Biri'. This simply shows that 'Tafin Giwa' responds more to mulching than 'Yatsun Biri'

### 5.4.3 Spacing x variety

This interaction was observed for number of leaves, stand count at harvest and total dry rhizome yield. Here also variety 'Tafin Giwa' proved to do better than 'Yatsun Biri' at all spacing treatments adopted.

## 5.5 Correlation

The significant positive correlation between rhizome yield and number of offshoots/number of leavers per plot seem to suggest that increasing plant density could increase rhizome yield. Also, the highly significant positive correlation between total dry rhizome yield on one hand and leaf area on the other implied that a good canopy is necessary for efficient light interception for the manufacture of assimilates. This agrees with Duncan (1971) who found that maximum photosynthetic efficiency required a canopy with a predominanc of vertically oriented leaves.

The positive correlation between leaf dry weight and rhizome yield implied that high partitioning efficiency was necessary for high yield. These factors probably accounted for the variation in yield responses. between the two varieties.

Taken over-all, therefore, the positive correlation between leaf area and rhizome yield was vital in the performance of ginger.

## SUMMARY AND CONCLUSION

The trial was carried out to determine the effects of mulching, spacing and variety on the growth and yield of ginger (Zingiber officinale Roscoe). The experiment was conducted at the Institute for Agricultural Research Farm, Samaru, Zaria, during the 1986 wet season. A randomized complete block design with factorial arrangement was used. Treatments consisted of three levels of straw mulching (0, 5 and 10 cm thick) and three spacings (10 x 15, 20 x 15 and 30 x 15) cm tested on two varieties ('Tafin Giwa' and 'Yatsun Biri').

Mulching had a remarkable effect on the vegetative growth of ginger. The number, area and dry weights of leaves, number of offshoots, plant height, stalk dry weight and rhizome dry weight were all significantly increased by mulching. Rhizome yield per hectare was also increased significantly by mulching. The 5 and 10 cm levels of mulch out-yielded the non-mulched treatment by 29.5 and 21.3% respectively. Increase in mulching level above 5 cm did not increase yield significantly.

Except for sprouting percentage, spacing had no effect on growth, yield and yield components. However, the closest spacing (10 x 15 cm) produced the highest number of rhizomes per unit area but the medium spacing (20 x 15 cm)

gave the highest yield. Therefore, 15 x 20 cm spacing appeared to be the best even from visual observation in the field. Ground cover at this spacing was adequate and it produced a good proportion of rhizome.

Of the two varieties, 'Tafin Giwa' was superior to 'Yatsun Biri' in terms of growth and yield.

The investigation has, therefore, shown that ginger responds to straw mulching up to the 5 cm level which gave the highest yield while spacing was found to give little response. This little response to spacing may be attributed to the fact that the critical close spacing has not been reached. Therefore, there is a need for more work to be carried out along this line so that an optimum spacing can be determined, possibly by using closer spacings. Model studies on the influence of mulching on thermal properties, for example, thermal conductivity and thermal capacity of soil in relation to crop growth should be conducted to clarify the effect of thermal regime. Mulching is one of the approaches to overcome this limitation. It does not only decrease soil temperature hazards and improve soil nutrient and moisture conditions but also reduce soil erosion.

It is, thus, concluded that mulching influenced the performance of ginger and yield differed between the different varieties.

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