Growth Performance of Ginger and Tumeric as Influenced by Cropping System and NPK Fertilizer 15:15:15

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Abstract: **With growing interest in ginger and turmeric, many health professionals, researchers, farmers, and food and beverage professionals are turning their attention towards these healthy spices. In order to cultivate new ideas and further grow the industry, University of Abuja has gave the opportunity to conduct this research on the university research farm within the permanent site during the 2018 raining season to investigate the performance of ginger and turmeric as influenced by cropping system and NPK fertilizer 15:15;15. The experiment was performed based on split plot system laid in randomized complete block design (RCBD) with 3 replicates used in the study. The treatment with their various level and the intercrop were organized using the various combinations indicated and were filtered into the design used (RCBD). Each replicate contains 12 plots and separated from the plot by one meter pathway. Hence a total of 36 experimental plots were used in the research. The result of the experiment has shown significance in the use of fertilizer and also when compare between monocropping and intercropping of the plant discovery was made that there was not much significant difference. Hence ginger and turmeric can be cultivated on same plot without effect. The plant with N. P. K fertilizer of 300g did better than the 50g and 150g respectively in the height, leaf number, fresh leaf and dry leaf weight, rhizomes fresh and rhizomes dry as well as other secondary analysis. Therefore, it is recommended and can be approved for large scale planting and production of ginger and turmeric.**

Key Words: **Ginger, turmeric, fertilizer, cropping system, farmers, rhizomes, plants.**

I. INTRODUCTION

Spices are aromatic or pungent vegetable substances used primarily to season food. Parts of plants from which they are derived include the bark, the flower, the roots, the seeds, and the fruits. Spices play a major role in the lives of millions of both rural and urban dwellers. The global interest in plants as sources of medicine and cosmetics is gaining prominence and creating multiple opportunities for cultivation, conservation and extraction of new plant products (Adewale and Oyesola, 2013). Plants used as spices and condiments are usually aromatic and pungent (Achinewu, *et al*, 1995). They can also be used to hide other flavours and many of them have antimicrobial properties. Spices may have other uses, including medicinal, religious ritual, cosmetics or perfume production (Iwu, 1993; Macmillan, 1984 and Dziezak, 1989). A spice may be available in several forms: fresh, whole dried, or pre-ground dried.

Among the common spices grown and used in Nigeria and the world at large are Ginger (*Zingiberofficinale*) and turmeric (*Curcumalonga*). Ginger and turmeric are an integral part of daily culinary preparation for their aromatic pungency scent and tasty flavor (Halder, *et al*., 2007). Ginger (*ZingiberofficinaleRosc*.) .(*Zingiberaceae*), a perennial herbaceous monocotyledon, usually grown as annual, is known to human generations as .a medicinal and spice crop. It is a plant of very ancient cultivation and the spice has long been used in Asia. It is one of the earliest oriental spices known to Europe and is still in large demand today (Purseglove*et al*. 1981). The economic part is the underground rhizome, which is pungent and aromatic and used for culinary purposes, in ginger .bread, biscuits, cakes, puddings, soups and pickles. Ginger is traded in three. basic forms - green (fresh), pickled or preserved and dry. Only dry ginger (whole, peeled or sliced) is regarded as a spice; green or fresh ginger is considered basically as vegetable, while pickled or preserved ginger is destined largely for the trade connected with Chinese and Japanese cuisine. In addition, ginger oil and oleoresins are also traded. Although a number of countries produce ginger, exports of dry ginger on a significant scale are limited to India and China, the two dominant suppliers, followed by Nigeria, Sierra Leone, Australia, Fiji, Bangaladesh, Jamaica, Nepal and Indonesia. The USA, United Kingdom, Saudi Arabia, Morocco, Japan, Germany, Republic of Yemen and Canada are important importers of ginger. Ginger is native of Asia and is distributed around the West Indies, Jamaica and Africa. Ginger is said to be a rain forest monocot and is from the family *Zingeraceae*, Genus *zingiber*, Species *OfficinaleRoscoe*(Ahktar*et al*., 2013).

Turmeric is a rhizomatous herbaceous perennial plant known scientifically as Curcuma longa of the family, Zingiberaceae. It is a native to South east Asia(Jagadeeswaran*et al.,* 2005). Turmeric rhizome contains essential oil which includes ar-turmerone and ar-curcumene as major constituents. Some other compounds are α- and β-pinene, sabinene, myrcene, a-terpinene, limonene, pcymene, perillyl alcohol, turmerone, eugenol, iso-eugenol, eugenol methyl ether and iso-eugenol methyl ether. Curcumin and related compounds have also been reported as major constituents of the rhizomes. A number of sesquiterpenes have also been reported from *C. longa* (Husain *et al.*, 1992).

Turmeric is used to flavour and to colour foodstuffs. It is used in brine pickles and to some extent in mayonnaise and relish formulations, non-alcoholic beverages, gelatins, butter and cheese, etc. The colour curcumin extracted from turmeric is used as a colourant. Turmeric is also used as a dye in textile industry. It is used in the preparation of medicinal oils, ointments and poultice. It is stomachic, carminative, tonic, blood purifier and as antiseptic. It is used in cosmetics. The aqueous extracts have biopesticidal properties (Chandrashekar, 2013).

Intercropping is common practice among small holder farmers (Barnabas and Ajah, 2014).Ginger can be grown as a sole cropunder open or shade apart from as a component in inter, mixed and undercropping systems. Ginger is intercropped with vegetables (cabbage, tomato, chillies, french bean and lady's finger), pulses (pigeon pea, black -gram .and horse gram), cereals (maize, finger . millet), oilseeds (castor, soybean, sunflower and niger) and other crops (sesbania, tobacco and pineapple). Intercropping with soyabean (Quimbo, Cadiz and Aycardo 1977; AICRPS 1992), lady's finger (Chowdhury 1988) and pineapple (Lee 1972).was advantageous. Ginger can also be grown as mixed crop with castor, redgram, fingermillet and maize. As ginger requires partial shade it can be grown as an undercrop in coconut, arecanut, rubber, orange, stone fruit, litchi, guava, mango, papaya, loquat, peach, coffee and poplar plantations. Singh, Rai andPradham (1991) stated that ginger was the most favoured crop component under agroforestry.Turmeric has also been intercropped with other range of crops.

Most of our indigenous plants are gradually going into extinction owing to infrastructural development or environmental degradation. Also, most farmers have left the cultivation of some crops as a result of inadequate knowledge or poor resource base of the farmers. Examples of such crops are ginger and turmeric (Amin, *et al*., 2013). Despite the fact that ginger and turmeric are fast becoming important spices by for export, the production of these two crops have been left in the hands of resource poor or peasants who lack the capacity to produce at a commercial scale to meet up with the market demand of the commodity.

Nwaogu (2017) opined that lack of awareness on the potentials and uses of ginger and turmeric is among key reasons why most people do not go into the production of the crops. In some areas where the crop is still being produced, it is mostly left in the hands of women, hence it is often considered a woman's crop .Another important factor for low production of ginger and turmeric is the belief that the crops exhausts the soil fertility and leave the soil bare of nutrient. Hence most farmers would prefer to plant other crops that are not too tasking in terms of soil nutrient consumption (Sanghamithre, 2014).

Dawang*et al*, (2016) noted that the production of most spices is been hampered by many factors among which are: poor research into the crops, poor storage and processing techniques, lack of credit facilities for expansion f the crop and poor extension services. It is therefore imperative that we explore the production techniques of these important spices in a bid to increase production of the crops.

Ginger and turmeric are said to have huge potentials for local industries and export, owing to their wide range of uses. While many researchers have worked on the nutrient requirement of both ginger and numeric using both organic and inorganic as well as a combination of both (Hussain*et al*., 1992; Bose *et al*., 2008; Akham, *et al*., 2010; KAU, 2011), there is dearth of information on intercropping ginger and turmeric as components of the same cropping system.

Therefore, the objectives of this study include in the following: To assess the effect of NPK fertilizer on the growth performance of ginger and turmeric; To determine whether growing of ginger in mixture with turmeric will influence the yield and performance of the individual crops; To assess the impact of growing ginger and turmeric on some soil properties; To make recommendations to farmers on the best option(s) for growing ginger and turmeric with the best economic returns.

II. THE STUDY AREA

The experiment was conducted in the cropping season of 2018 at the Teaching and Research Farm of the Faculty of Agriculture University of Abuja, Abuja, Nigeria. Abuja is the Federal Capital Territory of Nigeria located in the center of the country. It is a planned city and was built mainly in the 1980s replacing the country's most populous city of Lagos as the capital on 12th December 1991. The FCT falls within the Southern Guinea Savanna Mosaic zone of West African sub-region (FCT Diary, 2016).

The rainy season begins from April and ends in October, when day time temperature reach 28^{o}C (82.4^{o}F) to 30^{o}C (86.0^{o}F) and night time temperature hovers around 22^{o}C (71.6^{o}F) to 23^{o}C (73.4^{o}F). in the dry season, day time temperature can soar to as high as 40^{o}C (104.0^{o}F) and night time temperature can drop to 12^{o}C (53.6^{o}F). NIMET (2010) reports showed that the area maintains an average annual rainfall of 2500 mm and a relative humidity of 85 percent.

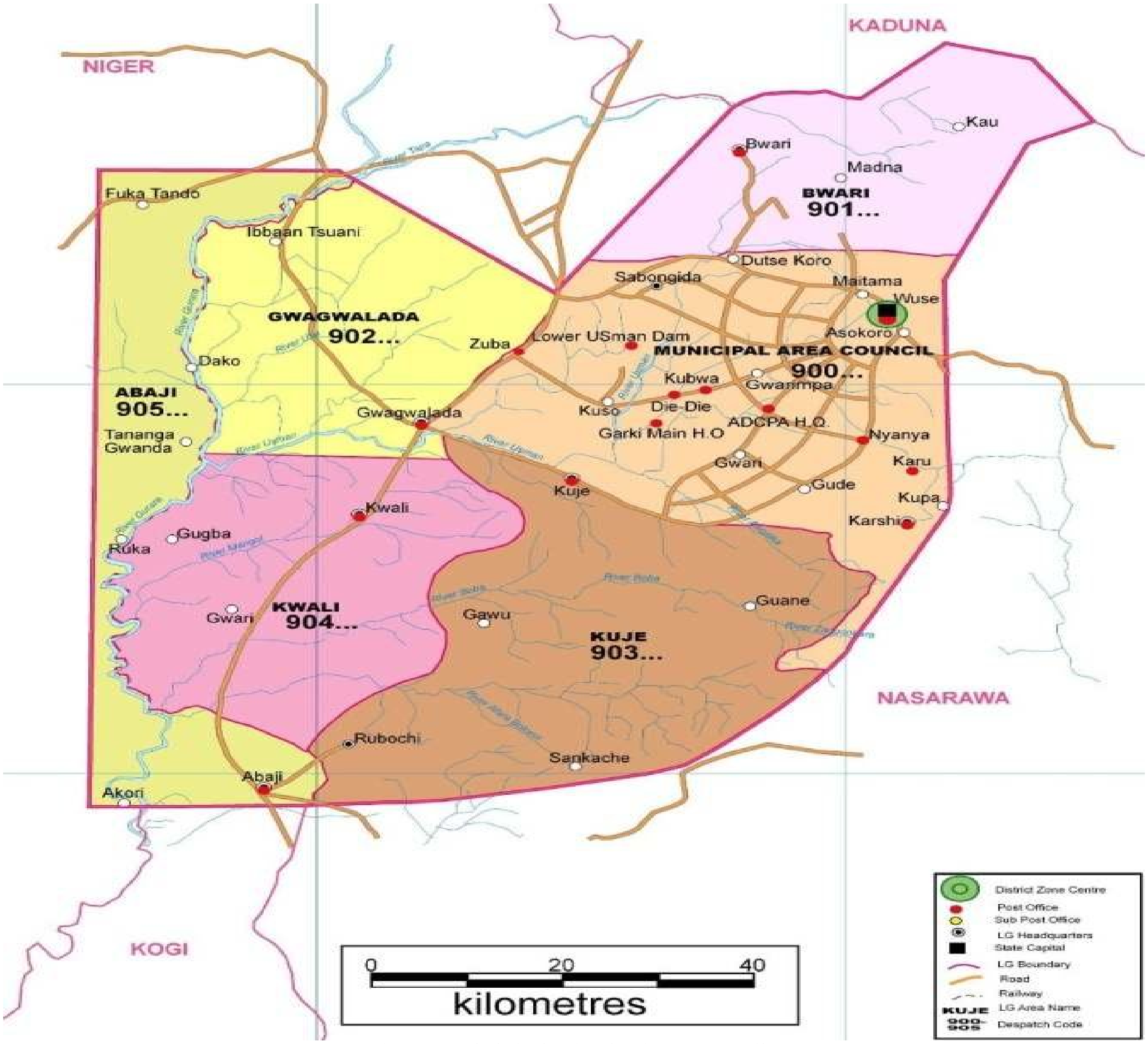

Fig.1: Map of Abuja showing the Six Area Councils
Source: Sylvester Abomeh Ofobruku (2017) Article no.JEMT.33438

III. MATERIALS AND METHODS

3.1 Pre-Planting Soil Sampling

Soil samples were collected prior to planting of the ginger and turmeric using the cup auger. Random auger borings were made within the field at depth of 0 – 30cm. the samples were from different spots and later bulked together to form composite sample. This was prepared by air drying at room temperature for about 14 days, crushed and sieved with a 2mm sieve, packaged and sent to laboratory for routine analysis (physical and chemical properties).

3.2 Land Preparation

The experimental land was cleared before the onset of the rainy season. The land was prepared mechanically through ploughing and harrowing before it was laid out for the experiment. After marking of the field, the beds were raised using the native hoe.

3.3 Experimental Materials

The experimental materials are ginger seed, turmeric seed and NPK 15:15:15 fertilizer. The Ginger and turmeric rhizomes were collected from the National Root Crop Research Institute Umudike, while the NPK fertilizer was sourced from WACOT Agrochemicals Company in SabonWuse, Niger State, a reputable supplier of Agrochemicals and fertilizers in Northern Nigeria.

3.4 Experimental Treatments

The treatments are comprised of cropping systems (sole cropping and intercropping of ginger/turmeric) and four levels of N.P.K 15:15:15 fertilizer (0, 50, 150 and 300 kg ha^{-1}). The treatment combinations include:

A_1B_1= Sole ginger + 0 $kgha^{-1}$ NPK

A_1B_2 = Sole ginger + 50$kgha^{-1}$ NPK

A_1B_3 = Sole ginger + 150 $kgha^{-1}$ NPK

A_1B_4 = Sole ginger + 300 $kgha^{-1}$ NPK

A_1B_5 = Sole turmeric + 0 $kgha^{-1}$ NPK

A_1B_6 = Sole turmeric + 50 $kgha^{-1}$ NPK

A_1B_7= Sole turmeric + 150 $kgha^{-1}$ NPK

A_1B_8 = Sole turmeric + 300 $kgha^{-1}$ NPK

A_1B_9 = Intercrop ginger and turmeric +0 $kgha^{-1}$ NPK

A_1B_{10} = Intercrop ginger and turmeric + 50 $kgha^{-1}$ NPK

A_1B_{11} = Intercrop ginger and turmeric + 150 $kgha^{-1}$ NPK

A_1B_{12} = Intercrop ginger and turmeric + 300 $kgha^{-1}$ NPK

3.5 Experimental Design

Randomized Complete Block Design with 3 replicates was used. The treatments with their various levels were combined using split plot arrangement and then fitted in the design used. The cropping system is the main plot and NPK fertilizer was the sub plot. A fieldwith dimension of 29.5m X 8m was used. The experimental field was partitioned into plots of 2mx2m each separated by 0.5m inter row spacing and 1m column spacing. The number of plots that is involved is thirty -six (36) plots.

3.6 Agronomic Operations and Treatment Application

The selected field was ploughed and harrowed using tractor before it was laid out. Selected seed rhizomes of ginger and turmeric were planted on the prepared beds at a spacing of 25cm x 25cm thus giving a total of 64 stands per plot and a total plant population of 2,304 stands in the entire experimental field comprising of thirty-six plots (64 stands x 36 plots). Planting was done at a depth of 3 – 5cm to facilitate easy sprouting.

Weeding was done manually at four (4) weeks after planting (WAP), and the field was kept weed free throughout the period of the field trial. The entire field was monitored for possible incidence of pests and diseases. The various fertilizer treatments were applied using the ring method at six weeks after planting.

3.7 Post harvest Soil Chemical Analysis

After the harvest of the crop, soil samples were collected from each plot using cup auger for postharvest soil chemical analysis. The collected soil samples were air dried at room temperature for 14 days, crushed and packaged before being sent to the laboratory for analysis.

3.8 Data Collection

3.8.1 Growth parameters

Plant Height (cm) of Ginger and Turmeric:

Plant height was determined fortnightly at 6, 8, 10 and 12 WAP. This was achieved through measurement from base of plant to tip of longest shoot using a measurement tape. Three tagged plants were measured in each plot and average taken per plot.

Number of leaves per plant of Ginger and turmeric:

Leaf count was made on three tagged plants per plot and average taken. Number of leaves was counted at 6, 8, 10 and 12 WAP.

Fresh weight of leaf (g) of Ginger and Turmeric

This was the weight of leaves per plant at the destructive stage.

Dry weight of leaf (g) of Ginger and Turmeric:

This was the weight of leaves per plant after the leaves have been dried to a constant weight.

Leaf Area Ratio (LAR):

This is the ratio of the total leaf area to the whole plant dry weight and as a further measure of the efficiency of the leaf surface in producing dry matter (Radford, 1967).

$$LAR = \frac{L1+L2}{W1+W2} = \frac{Total\ Leaf\ Area}{Total\ Dry\ matter}$$

Where: L1 and L2 represent the leaf area and W1 and W2 represent the whole plant dry weight

Crop Growth Rate (CGR):

It is simply a measure of the rate of dry matter production per unit of time. Crop dry weight per unit area at one harvest (W1) is deduced from that at the next harvest (W2) and the difference is divided by the number of days between the harvests, (T2 – T1 in days) (Radford, 1967).

$$CGR = \frac{W2-W1}{T2-T1}$$

Where: W = dry weight of plant material per unit area of ground

T = time in days, and the subscripts 1 and 2 refers to first and second harvest.

Relative Growth Rate (RGR):

It indicates the dry weight increase in plant matter over time interval in relation to the initial weight which is the parameter used to measure crop plant growth over time (Radford, 1967).

$$RGR = \frac{Log2W2 - LogeW1}{T2 - T1}$$

Where: W1 = crop dry weight at first harvest

W2 = crop dry weight at second harvest

T1 = Days for the first harvest

T2 = Days for the second harvest

Log_e = Natural logarithm

Net Assimilation Rate (NAR):

It is a measure of the productive efficiency of the leaf surface of the crop. It is normally expressed as gram per square meter per week (Radford, 1967).

$$NAR = \frac{(W2-W1)(LogeI2-Log\ \ I1)}{(T2-T1)(I2-I1)}$$

Where: W_1 = crop dry weight at first harvest

I_1 = crop dry weight at first harvest

W_2 = crop dry weight at second harvest

I_2 = crop dry weight at second harvest

T_1 = days to first harvest

T_2 = Days to second harvest

Log_e = natural logarithm

Leaf Weight Ratio (LWR):

It is a ratio of the leaf dry weight to total dry weight of the crop and is calculated as:

$$LWR= \frac{\left(\frac{LW_1}{W_1}\right)+\left(\frac{LW_2}{W_2}\right)}{2}$$

Where:

LW_1 = is the leaf dry weight at first harvest

LW_2 = is the leaf dry weight at second harvest

W_1 = is the crop dry weight at first harvest

W_2 = crop dry weight at second harvest

Specific Lear Weight (SLW):

Is the ratio of leaf weight to the leaf area.

$$SLW = \frac{\frac{LW1}{LA1}+\frac{LW2}{LA2}}{2}$$

Where:

LW = leaf dry weight

LA = Leaf Area

Specific Leaf Area (SLA):

It is a measure of the change in leaf area per unit of leaf weight between harvest (Radford, 1967).

$$SLA= \frac{\frac{LA1}{LW1}+\frac{LA2}{LW2}}{2}$$

Where;

LA = leaf area

LW = leaf weight

3.8.2 Yield Parameters

Dry Matter Yield ($kgha^{-1}$):

The leaves of the crop were collected after harvest. The leaves of 3 sampled plants were collected and dry weight was obtained after drying in the oven at a temperature of 80^0C for two days

Rhizome fresh weight (g):

This is the weight of the rhizomes per plant taken immediately after harvest

Rhizome Dry weight (g)

This is the weight of the rhizomes per plant determined after drying the rhizome to a constant weight.

3.9 Method of Statistical Analysis

All the data collected were subjected to analysis of Variance (ANOVA) using the Genstat statistical package and the means were separated using DMRT as described by Onuh and Igwemma (2000).

IV. RESULTS AND DISCUSSION

4.1.1. Ginger Plant Height (Cm)

The plant height of ginger at 12WAP showed significant difference under cropping systems and at different fertilizer rates. The result showed that ginger planted as a sole crop was highest in plant height up to 56.16cm, while plant height as intercropped with turmeric was 37.13.cm.

The result of ginger height as influenced by different rates of NPK 15:15: is fertilizer showed that 300kg/ha NPK rate produced the highest in terms of plant height while 0kg/ha of NPK produced shortest plant heights. The readings were significantly different ($P<0.05$) across the different fertilizer rates. The trends observed showed that plant height for ginger significantly increased as fertilizer rate increases.

4.1.2. Ginger Number of Leaves

The result for number of leaves of ginger is presented in Table 1. The result showed that there was no significantly statistical difference on the number of leaves between sole and intercropped ginger. The different fertilizer rates showed that 300kg/ha of NPK produced statistical higher number of leaves which was statistically different from 0, so and 150kg/ha rates of NPK. However, the 0kg/ha and 50kg/ha of NPK did not show any statistical difference on the number of leaves of ginger at 12WAP. The trend of increase in the number of leaves of ginger as influenced by different rates of NPK

15:15:15 was in the order of 0kg/ha<50kg/ha<150kg/ha<300kg/ha. This implied that increasing the fertilizer rate significantly increased the number of leaves produced by ginger. The interaction between cropping system and fertilizer rates was significantly different for plant height, but for number of leaves, the result was not significantly different.

Table 1 Effect of Cropping System and Fertilizer Rate on Ginger plant height and Number of leaves

Treatment	Ginger Plant Height @ 12 WAP (cm)	Ginger Number of leaves @ 12 WAP
Cropping System (CS)		
Ginger Sole	56.16[a]	23.00
Ginger – Turmeric	37.13[b]	23.33
LSD	0.18	0.48
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	40.62[d]	21.83[c]
50	45.03[c]	22.17[c]
150	48.80[b]	23.67[b]
300	52.13[a]	25.00[a]
LSD	0.25	0.68
Interaction		
CS * FR	*	NS

* = Significant at $P \leq 0.05$, NS = Not significant, Means with the same letter in a column for each factor are not significantly different ($P \leq 0.05$), LSD = Least Significant Difference, WAP = weeks after planting.

4.1.3. Ginger leaf Fresh and Dry Weight (kg/plant)

The fresh leaf weight and dry leaf weight of ginger are presented in Table 2. The fresh lead weight of ginger was significantly different for the cropping systems. Sole planted ginger produced statistically higher fresh leaf weight (0.063kg/plant) while the intercropped was 0.041kg/plant. For the different fertilizer rates, the result showed that fresh leaf weight of ginger was higher under 300kg/ha and 50kg/ha of NPK was applied (0.071kg/plant). This was followed by 150kg/ha rate of NPK which produced 0.048kg/plant. The least fresh leaf weight was obtained with 0kg/ha rate of NPK fertilizer.

For the ginger leaf dry weight, sole planted ginger produced the highest dry leaf weight of 0.031kg/ha which was significantly different (higher) from the intercrop of ginger and turmeric which rate of NPK produced the highest fresh rhizome weight (0.124kg/plant) followed by 150kg/ha rate of NPK fertilizer which produced 0.108kg/plant. The least weight fresh rhizome weight was recorded under 0kg/ha NPK rate. This implied that as the fertilizer rate increased, there was a corresponding increase in the fresh rhizome weight of ginger. For the dry rhizome weight, increase the fertilizer rate up of 150kg/ha of NPK also increased the dry rhizome weight of ginger up of 0.067kg/plant. Further increase of NPK fertilizer to 300kg/ha decreased the dry weight of ginger to 0.047kg/ha (about 30% decrease in weight). However, the 0kg/ha rate of NPK produced the least dry rhizome weight of ginger.

The result also showed a significant difference ($P<0.05$) on the interaction between cropping system and fertilizer rates on the fresh and dry rhizome weight of ginger.

Table 2 Effect of Cropping System and Fertilizer Rate on Ginger Leaf fresh and Dry Weight

Treatment	Ginger Leaf Fresh Weight (kg/plant)	Ginger Leaf Dry Weight (kg/plant)
Cropping System (CS)		
Ginger Sole	0.063[a]	0.031[a]
Ginger – Turmeric	0.041[b]	0.023[b]
LSD	0.001	0.001
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	0.017[c]	0.012[d]
50	0.071[a]	0.036[b]
150	0.048[b]	0.023[c]
300	0.071[a]	0.038[a]
LSD	0.001	0.001
Interaction		
CS * FR	*	*

* = Significant at $P \leq 0.05$, NS = Not significant, Means with the same letter in a column for each factor are not significantly different ($P \leq 0.05$), LSD = Least Significant Difference.

4.1.4. Ginger Rhizome Fresh and Dry Weight.

The results of ginger rhizome fresh and dry weights are presented in Table 3. The result showed that there is a significant difference in the fresh and dry rhizome weight of ginger when planted as a sole crop and as an intercrop between ginger and turmeric. The result showed that sole planted ginger produced highest fresh rhizome and dry rhizome weights (0.125kg/plant and 0.069kg/plant respectively. In. both cases, ginger-turmeric intercrop gave the least in rhizome fresh and dry weight.

The different fertilizer rates also significantly influenced the fresh and dry rhizome weight of ginger. The result showed that 300kg/ha.

In terms of fertilizer rates, 300kg/ha of NPK 15:15:15 produced statistically tallest plants (42.88cm) followed by 150kg/ha of NPK which produced plant height of 39.12cm. The least plant height was observed under 0kg/ha of NPK (34.70cm). There was a significant difference in plant height when cropping system and fertilizer rates interacted.

Table 3 Effect of Cropping System and Fertilizer Rate on Ginger Rhizome Fresh and Dry Weight

Treatment	Ginger Rhizome Fresh Weight (kg/plant)	Ginger Rhizome Dry Weight (kg/plant)
Cropping System (CS)		
Ginger Sole	0.125	0.069^{a}
Ginger – Turmeric	0.062	0.029^{b}
LSD	0.001	0.001
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	0.063	0.030^{d}
50	0.079^{c}	0.054^{b}
150	0.108^{b}	0.067^{a}
300	0.124^{a}	0.047^{c}
LSD	0.001	0.002
Interaction		
CS * FR	*	*

* = Significant at P ≤ 0.05, NS = Not significant, Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05), LSD = Least Significant Difference

4.1.5. Turmeric Number of Leaves

The number of leaves of turmeric at 12WAP is shown in Table 4. There was no statistical difference in the number of leaves produced by turmeric when planted as sole and as an intercrop of ginger – turmeric.

In terms of fertilizer rates, there was no significant difference between 0kg/ha and 50kg/ha at 12WAP. However, as fertilizer rate increased to 150kg/ha, number of leaves of turmeric increased to 10.50. The highest number of leaves for turmeric was obtained when 300kg/ha of NPK was applied to the plants. The interaction between cropping systems and fertilizer rates did not show any significant difference (P<0.05). 4.1.4. Turmeric Plant Height

The result of turmeric plant height is shown in Table 4. The plant height of turmeric at 12WAP was highest where turmeric was planted as a sole crop (45.15cm) while the intercrop between ginger and turmeric produced the least plant height for turmeric (31.59cm). the ANOVA test showed that the two readings were statistically different produced 0.023kg/ha as dry leaf weight. The result of different rates of NPK should that the highest dry leaf weight of ginger (0.038kg/plant) was obtained when 300kg/ha of NPK was applied this was followed by the application of 50kg/ha and 150kg/ha of NPK respectively. The least dry leaf weight of ginger was obtained under the control treatment. The result for the interaction between cropping system and fertilizer rate showed a significant difference (P<0.05) for the fresh weight and dry leaf weight.

Table 4 Effect of Cropping System and Fertilizer Rate on Turmeric plant height and Number of leaves

Treatment	Turmeric Plant Height @ 12 WAP (cm)	Turmeric Number of leaves @ 12 WAP
Cropping System (CS)		
Ginger Sole	45.15^{a}	10.17
Ginger – Turmeric	31.59^{b}	10.25
LSD	0.71	0.35
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	34.70^{d}	9.33^{c}
50	36.78^{c}	9.50^{c}
150	39.12^{b}	10.50^{b}
300	42.88a	11.50^{a}
LSD	1.01	0.49
Interaction		
CS * FR	*	NS

* = Significant at P ≤ 0.05, NS = Not significant, Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05), LSD = Least Significant Difference, WAP = weeks after planting

4.1.6. Turmeric Fresh and Dry Leaf Weight.

The fresh and dry leaf weights of turmeric are presented in Table 5. The result for cropping system showed that sole planted turmeric produced the least fresh leaf weight of 0.033kg/plant highest fresh intercrop of ginger – turmeric produced the highest fresh leaf weight of 0.041kg/plant. The result of Analysis of variance showed that there was a statistical significant difference between the two observations. In terms of the different fertilizer rates, the control (okg/ha) NPK produced the highest fresh leaf weight of 0.48kg/plant followed by 50kg/ha of NPK which produced 0.036kg/plant. The least fresh leaf weight of turmeric (0.031kg./plant) was obtained when 150kg/ha of NPK fertilizer rates. The result indicated that increasing the fertilizer rates significantly decreased the fresh leaf weight of turmeric.

Conversely, the dry leaf weight of turmeric was highest under sole cropping and produced a reading of 0.32kg/plant while the intercrop of Ginger – Turmeric produced statistically lower dry leaf weight of turmeric (0.022kg/plant). The fertilizer rates also showed significant difference in the dry leaf weight per plant, weight of 0.033kg/plant followed by 150kg/ha of NPK which produced 0.031kg/ha/plant dry leaf weight. The least dry leaf weight of turmeric (0.019kg/plant) was obtained when 300kg/ha of NPK was applied.

The interaction between cropping systems and fertilizer rate was statistically significant for both the fresh leaf weight and dry leaf weight of turmeric.

Table 5 Effect of Cropping System and Fertilizer Rate on Turmeric Leaf fresh and Dry Weight

Treatment	Turmeric Leaf Fresh Weight (kg/plant)	Turmeric Leaf Dry Weight (kg/plant)
Cropping System (CS)		
Ginger Sole	0.033[b]	0.032[a]
Ginger – Turmeric	0.041[a]	0.022[b]
LSD	0.001	0.001
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	0.048[a]	0.026[c]
50	0.036[b]	0.033[a]
150	0.031[d]	0.031[b]
300	0.034[c]	0.019[d]
LSD	0.001	0.001
Interaction		
CS * FR	*	*

* = Significant at P ≤ 0.05, NS = Not significant, Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05), LSD = Least Significant Difference

4.1.7. Turmeric Rhizome Fresh and Dry Weight.

The Turmeric rhizome fresh and dry weights are presented in Table 6. Under the cropping system, the sole planted turmeric produced the least rhizome fresh weight of 0.073kg/plant while the intercrop of ginger – turmeric produced the highest rhizome fresh weight of 0.104kg/plant. For the different fertilizer rates, applying up to 150kg/ha of NPK fertilizer produced the highest fresh rhizome weight of 0.174kg/plant while the least fresh rhizome weight was observed when 50kg/ha of NPK was used. Increasing the fertilizer rate to 300kg/ha reduced the fresh rhizome weight to 0.085kg/plant.

In terms of rhizome dry weight of turmeric, sole planted turmeric produced the highest rhizome dry weight (0.037kg/plant) while the intercrop between ginger-turmeric had the least dry rhizome weight of 0.020kg/plant. The analysis of variance showed a significant difference between the two observations. Again, looking at the fertilizer rates, 300kg/ha of NPK produced the highest rhizome dry weigh of 0.042kg/plant while 50kg/ha of NPK produced the least rhizome dry weight of turmeric (0.022kg/plant). There was no statistical difference in the dry rhizome weight between 0kg/ha and 150kg/ha fertilizer rate application. However the ANOVA showed a significant interaction between cropping system and fertilizer rates for both the fresh rhizome weight and dry rhizome weigh of turmeric.

Table 6 Effect of Cropping System and Fertilizer Rate on Turmeric Rhizome Fresh and Dry Weight

Treatment	Turmeric Rhizome Fresh Weight (kg/plant)	Turmeric Rhizome Dry Weight (kg/plant)
Cropping System (CS)		
Ginger Sole	0.073	0.037[a]
Ginger – Turmeric	0.104	0.020[b]
LSD	0.002	0.001
Fertilizer Rate (FR) (NPK 15:15:15) (kg ha^{-1})		
0	0.051[c]	0.025[b]
50	0.045[d]	0.022[c]
150	0.174[a]	0.025[b]
300	0.085[b]	0.042[a]
LSD	0.004	0.001
Interaction		
CS * FR	*	*

* = Significant at P ≤ 0.05, NS = Not significant, Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05), LSD = Least Significant Difference

4.1.8 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Area Ratio (LAR)

The Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Area Ratio (LAR) were shown in (Table 4.7). The results of the leaf area ratio were significantly greater in the 0kgNPK in Ginger sole followed by 300kg, 50kg and 150 kg. Likewise, the leaf area ratio was significantly greater in the 50kgNPK in Turmeric sole followed by 150kg, 300kg and 0 kg.

The leaf area ratio was significantly greater in the 0kgNPK in Ginger - Turmeric sole followed by 50kg, 150kg and 300 kg. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4:7 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Area Ratio (LAR)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	261.74 ± 1.00^{d}	281.76 ± 1.15^{a}	1927.08 ± 1.00^{d}
50	83.1600 ± 1.00^{b}	1929.35 ± 1.00^{d}	1442.62 ± 2.00^{c}
150	80.0700 ± 1.00^{a}	1460.65 ± 1.00^{c}	1275.20 ± 1.00^{b}
300	211.4200 ± 1.00^{c}	942.31 ± 1.00^{b}	1133.33 ± 1.00^{a}

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05). Whereas, superscript with different letters along the column indicates significant differences at (P< 0.05) according to Ducan's Multiple Range Test (DMRT)

4.1.9 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Crop Growth Rate (CGR)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Crop Growth Rate (CGR) were shown in (Table 4.7). The findings of the study revealed that there were no statistically significant difference in the Crop Growth Rate for all the treatments (0kg, 50kg, 150 kg and 300kg) with NPK in Ginger sole, Turmeric sole and Ginger-Turmeric respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.8: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Crop Growth Rate (CGR)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	0.002 ± 0.001^{a}	0.001 ± 0.001^{a}	0.001 ± 0.001^{a}
50	0.003 ± 0.001^{a}	0.001 ± 0.001^{a}	0.001 ± 0.001^{a}
150	0.003 ± 0.001^{a}	0.001 ± 0.001^{a}	0.003 ± 0.001^{a}
300	0.002 ± 0.001^{a}	0.002 ± 0.001^{a}	0.001 ± 0.001^{a}

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05) according to Duncan's Multiple Range Test (DMRT)

4.1.10 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Relative Growth Rate (RGR)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Relative Growth Rate (RGR) were shown in (Table 4.8). The result of the relative growth rate was significantly greater in the 0kgNPK in Ginger sole as compared to other treatments (50kg, 150 kg and 300kg) of Ginger sole but there were no statistically significant difference in the Relative Growth Rate for all the treatments (0kg, 50kg, 150 kg and 300kg) with NPK in Turmeric sole and Ginger-Turmeric respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.9: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Relative Growth Rate (RGR)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	0.0390 ± 0.0001^{b}	0.0003 ± 0.0001^{a}	0.0002 ± 0.0001^{a}
50	0.0010 ± 0.0001^{a}	0.0003 ± 0.0001^{a}	0.0002 ± 0.0001^{a}
I50	0.0010 ± 0.0001^{a}	0.0004 ± 0.0001^{a}	0.0004± 0.0001^{a}
300	0.0010 ± 0.0001^{a}	0.0005 ± 0.0001^{a}	0.0004 ± 0.0001^{a}

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05). Whereas, superscript with different letters along the column indicates significant differences at (P< 0.05) according to Duncan's Multiple Range Test (DMRT)

4.1.11 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Net Assimilation Rate (NAR)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Net Assimilation Rate (NAR) were shown in (Table 4.9). The findings of the study revealed that there were no statistically significant difference in the Net Assimilation Rate (NAR) for all the treatments (0kg, 50kg, 150 kg and 300kg) with NPK in Ginger sole, Turmeric sole and Ginger-Turmeric respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.10: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Net Assimilation Rate (NAR)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	0.002± 0.001^{a}	0.001 ± 0.001^{a}	0.001 ± 0.001^{a}
50	0.003 ± 0.001^{a}	0.001 ± 0.001^{a}	0.001 ± 0.001^{a}
150	0.003 ± 0.001^{a}	0.001 ± 0.001^{a}	0.001 ± 0.001^{a}
300	0.002 ± 0.001^{a}	0.002 ± 0.001^{a}	0.001 ± 0.001^{a}
	.		

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05) according to Duncan's Multiple Range Test (DMRT)

4.1.12 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Weight Ratio (LWR)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Weight Ratio (LWR)were shown in (Table 4.10).The result of the leaf weight ratio was significantly greater in the 300kgNPK in Ginger sole followed by 150kg whereas, 50kg and 0 kg are not statistically significant (P>0.05).

The leaf weight ratio was significantly greater in the 150kgNPK in Turmeric sole followed by 50kg, 300kg and 0 kg.

The leaf weight ratio was significantly greater in the 50kgNPK in Ginger - Turmeric sole followed by 0kg, 300kg and 150 kg respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.11: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Leaf Weight Ratio (LWR)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	0.06 ± 0.01^{a}	0.07 ± 0.01^{a}	0.57 ± 0.01^{c}
50	0.07 ± 0.01^{a}	0.24 ± 0.01^{c}	0.61 ± 0.01^{d}
I50	0.09 ± 0.01^{b}	0.26 ± 0.01^{d}	0.13 ± 0.01^{a}
300	0.21 ± 0.01^{c}	0.11 ± 0.01^{b}	0.18 ± 0.01^{b}

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05). Whereas, superscript with different letters along the column indicates significant differences at (P< 0.05) according to Duncan's Multiple Range Test (DMRT)

4.1.12 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Weight (SLW)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Weight (SLW) were shown in (Table 4.11). The result of the specific leaf weight was significantly lower in the 0kgthanin the 50kg, 150kg and 300 kg NPK of Ginger sole which are not statistically significant from each other. Furthermore, the result also revealed that there was no statistically significant difference in the Specific Leaf Weight (SLW) for all the treatments (0kg, 50kg, 150 kg and 300kg) with NPK in Turmeric sole.

In addition, the specific leaf weight was significantly greater in the 0kgand 50kgthan in the 150kg and 300kg NPK of Ginger–Turmeric which are not statistically significant from each other respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.12: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Weight (SLW)

Treatment Fertilizer Rate (NPK15:15:15) (Kgha^{-1})		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	0.0002 ± 0.0001^{a}	0.0002 ± 0.0001^{a}	0.0003 ± 0.0001^{b}
50	0.0007 ± 0.0001^{b}	0.0001 ± 0.0001^{a}	0.0004 ± 0.0001^{b}
I50	0.0007 ± 0.0001^{b}	0.0002 ± 0.0001^{a}	0.0001 ± 0.0001^{a}
300	0.0007 ± 0.0001^{b}	0.0001 ± 0.0001^{a}	0.0001 ± 0.0001^{a}

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at (P< 0.05). Whereas, superscript with different letters along the column indicates significant differences at (P< 0.05) according to Duncan's Multiple Range Test (DMRT)

4.1.13 Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Area (SLA)

Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Area (SLA) were shown in (Table 4.12). The result of the specific leaf area was significantly greater in the 0kg NPK in Ginger sole followed by 50kg, 150kg and 300kg respectively.

The specific leaf area was significantly greater in the 300kg NPK in Turmeric sole followed by 150kg, 50kg and 0 kg respectively.

The specific leaf area was significantly greater in the 150kg NPK in Ginger - Turmeric followed by 300kg, 0kg and 50 kg respectively. Analysis of variance shows significant differences with treatment levels and Control at a 0.05 level of significance.

Table 4.13: Effect of Cropping System and Fertilizer Rate on Ginger and Tumeric Plant Specific Leaf Area (SLA)

Treatment Fertilizer Rate (NPK 15:15:15) ($Kgha^{-1}$)		Cropping System (CS)	
	Ginger Sole	Turmeric Sole	Ginger-Turmeric
0	1328.85 ± 1.00^{d}	1147.73 ± 1.00^{a}	889.42 ± 1.00^{b}
50	352.90 ± 1.00^{b}	2164.63 ± 1.00^{c}	656.72 ± 1.00^{a}
I50	375.00 ± 1.00^{c}	1546.57 ± 1.00^{b}	3137.20 ± 1.00^{d}
300	335.90 ± 1.00^{a}	2826.92 ± 1.00^{d}	1888.89 ± 1.00^{c}
	.		

Values are expressed as Mean ± SD of each group (n=3). Superscript with similar letters along the column indicates no significant differences at ($P< 0.05$). Whereas, superscript with different letters along the column indicates significant differences at ($P< 0.05$) according to Duncan's Multiple Range Test (DMRT)

A cross section of Tumeric crop

A cross section of Ginger crop

A cross section of the intercropping model

4.2 Discussion

The following indices: crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area rate (LAR), leaf weight rate (LWR) and specific leaf area (SLA) are indices which often use for evaluation of plant productivity capability and environmental efficiency (Anzoua et al., 2010; De Sclaux et al., 2000).

Considering the leaf area ratio (LAR), which represents the leaf area in use by the plant to produce a gram of dry mass, no interaction ($P>0.05$) was detected between NPK levels × growth ages as seen in (Table 4.6).

The leaf area ratio reduction with increasing NPK levels as seen in (Table 4.6) indicates lower investment in the area of light capture at higher doses, possibly due to the investment in supporting structures of the plant, as the canopy becomes heavier with higher nitrogen levels. This downward trend of the LAR in response to NPK fertilization can also be justified by the initial condition of the structure and mass of the canopy at higher nitrogen levels, in which the higher residual mass after cutting resulted in a greater amount of stem, possibly due to the investment in supporting structures of the plant, as there was an increase in biomass (Pompeu et al., 2009), and therefore provided lower values of LAR, at the highest levels of nitrogen.

Usually, LAR decreases with age due to variations in the source/sink ratio. In this way, during the vegetative growth stage there is greater input of assimilates for the leaf production in order to increase the capture of incident light, and promote fast growth. A drop in the LAR values with the plant maturity is associated with variations in leaf weight ratio (LWR) and specific leaf area (SLA). A decrease in LAR during the development reflects greater allocation of assimilates for the development of stem, roots and reproductive parts at the expense of leaf production, during the linear growth phase (Oliveira et al., 2000). However, annual grasses, in general, tend to have lower LAR and SLA than perennials, so it is not necessarily clear that these traits were unique to invaders in this system (Garnier 1992).

Crop Growth Rate (CGR) is the rate of increase in the dry matter per unit of land and of time. There were no statistical significant difference (P>0.05) in the crop growth rate with increase in NPK level in Ginger sole, Turmeric sole and Ginger-Turmeric as seen in (Table 4.7). This findings is in line with the work of Shukla et al., (2002) who reported that using sulphur and zinc as supplementary nutrients resulted in 20.5 and 23% increase in Crop Growth Rate (CGR) in Indian mustard although the effect were not statistical difference . It is perhaps related to the new and actively photosynthesizing tissue which grow during this period of growth

Interestingly, the relative growth rate results in (Table4.8) are below the range between 0.02 and 0.5 g/g.day-1 reported by Beadle (1993) for most species of C4 plants under diverse environmental conditions. Given this, several factors can influence the RGR values, such as species or variety (Garnier, 1992; Ludlow & Wilson, 1970), growth stage (Pinto, 1993) or variations in climatic conditions (Benincasa, 1988). Moreover, the differences in the growth rates can also result from how these values have been obtained. Also, the lower values recorded in the present study were possibly due to the cultivation in field (University of Abuja research farm), where there was a lower control in environmental and hydric conditions, leading to higher responses in the RGR of the Ginger sole, Turmeric sole and Ginger-Turmeric.

There is no resultant increase in NAR in response to increasing NPK fertilizer levels as seen in (Table 4.9) is due to no increase in the number of cells, leading to a higher development of leaves with higher photosynthetic potential. According to Andrade et al. (2005), the greater availability of nitrogen affects the photosynthesis because it is a component of chlorophyll molecule and part of the molecular structures of the entire protein synthesis apparatus involved in the photosynthetic process. In fact, there are reports of increased photosynthetic rate and the relative chlorophyll index in response to the levels of nitrogen fertilizer (Cândido et al., 2009).

The low values of NAR in Ginger sole, Turmeric sole and Ginger-Turmeric at the most advanced plant maturity (end of the cycle) probably occurred due to the increase in the average age of the leaves coupled to the mutual shading of the leaves in the plant, thus reducing their photosynthetic efficiency. Furthermore, with the advance in plant maturity there is greater supply of assimilates for the stem development and other parts, enhancing the plant respiratory losses, leading to a reduction in NAR (Oliveira et al., 2000).

In this context, the net assimilation rate represents the difference between the dry matter produced by the photosynthesis and consumed by respiration and photorespiration (Lambers, 1987). Nevertheless, according to Watson et al. (1966), NAR reduction is mainly due to the drop in the photosynthetic rate that occurs with increased respiratory losses of the plant. Importantly, NAR is not only determined by the photosynthetic rate, but also by the size of leaf area, in addition to the duration of vegetative period, architecture of upper part, translocation, and assimilate partitioning (Bernardes, 1987).

Considering that the leaf blades are the organs responsible for the production of dry mass via photosynthesis and the other components of the plant depend on the exportation of photoassimilates produced in the leaves, the leaf weight ratio (LWR) expresses the fraction of dry mass not exported from the leaves to such components of the plant (Benincasa,1988). For this variable (LWR) there is significant interaction (P<0.05) between NPK levels and growth ages were recorded in Ginger sole, Turmeric sole except in Ginger-Turmeric as seen in (Table4.10).

By this pattern of response of the LWR, ones can infer that the increase in NPK fertilization probably promoted retention of photosynthates in the leaves, which constitute the most relevant fraction of the animal feeding. Contrastingly, under conditions of nitrogen deficiency leaves export more photosynthates to the roots than those leaves suitably supplied with nitrogen (Santos Júnior et al., 2004).

The specific leaf area (SLA) is the morphological and anatomical component of the LAR, since it relates the surface with the dry mass of the leaf itself, and its inverse (specific mass of the leaf) expresses the leaf thickness (Benincasa, 1988). For this variable (SLA) there is a significant interaction (P<0.05) between the NPK levels and growth ages of the Ginger sole, Turmeric sole and Ginger-Turmeric were recorded

The reduction in the estimates of specific leaf area with increasing NPK levels as seen in (Table4.12) reflects the effect of this nutrient on the weight growth of the leaves relatively on the leaf area, thus indicating the increase in leaf thickness. This indicates a morphological re-adaptation of the leaf, with lower investment in area of light capture and greater investment in thylakoid stacking in photosynthetic cells and synthesis of carboxilation enzymes (Taiz & Zeiger, 2009).

Although there were no significant differences in the SLW with different NPK levels, yet the highest SLW (0.0007) was obtained with 50kg, 150kg and 300kg respectively, followed by 0kg (0.0002) in Ginger sole, and the highest SLW (0.0002) was obtained with 0kg and 150kg followed by the lowest SLW (0.0001) was recorded with 50kg and 300kg in Turmeric sole. More also, highest SLW (0.0004) was obtained with 50kg followed by the lowest SLW (0.0001) was recorded with 150kg and 300kg in Ginger-Turmeric (Table 4.11). The interaction between NPK source x crops indicated that Ginger sole had the higher SLW with 50kg, 150kg, 300kg but Turmeric sole and Ginger-Turmeric had the highest SLW with 0kg, 150kg and 50kg respectively (Table4.11).

The SLW was higher in Ginger sole and Ginger-Turmeric than Turmeric sole which indicated that transpiration probably may be more in Turmeric sole. Byrd and May (2000) suggested that switch grass cultivar with higher SLW had higher transpiration efficiency than cultivar with lower SLW. Gutschick (1991) also found a positive correlation between ET and SLW in two alfalfa (Medicago sativa L.) cultivars, which was attributed to greater leaf biochemical capacity (or possibly greater mesophyll conductance) at greater values of SLW, and thus SLW was considered as a useful predictor of TE. According to Ismail and Hall (1993) there was no relationship between SLW and TE in cowpea, suggesting that for some species other factors are more closely related to TE than SLW. Luo (1979) suggested that SLW in rice leaves was found to be highly environmentally controlled; while Kumura (1975) reported that temperature was negatively related to SLW and solar radiation was positively related to SLW. SLW is reported to be related to drought tolerance in several crops and has been suggested as a selection criterion for breeding programs targeting low rainfall areas. According to (Brown and Byrd, 1997), transpiration efficiency (TE) is the weight of dry matter produced per unit of transpiration, and that TE is correlated with SLW.

V. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Both ginger and turmeric have been proven safe by many studies and have shown great benefits to the health of individuals. The use of cropping system (sole cropping and intercropping of ginger and turmeric) and the application of fertilizer has shown great advantage which is certified to be useful with a spacing of 25cm x 25cm.

Getting a viable planting material was paramount from a reputable research institute.

Randomized complete block design was used in the experimental design. This study was carried out for a maximum of 6 months and all parameters used for analysis starting counting at exactly 4 weeks after application of treatments.

5.2 Conclusion

The study has demonstrated that ginger and turmeric can be grown in adverse rocky soil which will require a good supply of nutrient and adequate rainfall.

It was also found that availability of fertilizer helped to induce fast growth of the plants. The application of NPK fertilizer at different levels was equally used to compare the plots with the cropping system adopted.

It was further observed that the application of fertilizer and the use of cropping system did not show any adverse effect and thus recommended for future use.

Therefore, turmeric and ginger are good sources of income and employment to farmers who cultivate them and so deserve planned and continuous attention.

5.3 Recommendations

Based on the findings of this study, we therefore recommend that precision nutrition-crop monitoring techniques which allow for optimum fertilizer application, resulting in less input and lower cost of production should be encouraged among farmers that cultivate ginger and turmeric.

Government and other stakeholders should create awareness among farmers by increasing the knowledge and education for maximum production of the crops, and also train farmers and entrepreneurs on the production and local utilization of the crops.

REFERENCES

[1]. Andrade, A. C.; Fonseca, D. .M.; Lopes, R.S. et al. (2005). Análise de crescimento do capim-elefante napier adubado e irrigado. Ciência e Agrotecnologia, 29(2).415-423.

[2]. Anzoua, K. G., Junichi, K, Toshihiro, H, Kazuto, I, Yutaka , J. (2010). Genetic improvements for high yield and low soil nitrogen tolerance in rice (Oryza Sativa L.) under a cold environment. Field Crops Research 116, 38-45.

[3]. Beadle, C.L. Growth analysis. In: HALL, D.O.; Bolharnordenkampf, H.R.; Leegood, R.C. et al. (1993) (Eds.).Photosysthesis and production in a changing environment: a field and laboratory manual. London, 1993. .36-46.

[4]. Benincasa, M.M.P. (1988). Análise de crescimento de plantas: noções básicas. Jaboticabal: Fundação de Estudos e Pesquisas em Agronomia, Medicina Veterinária e Zootecnia, 1988, 41.

[5]. Bernardes, M. S. (1987). Fotossíntese no dossel das plantas cultivadas. In: Castro, P.R.S. et al. (Eds.) Ecofisiologia da produção agrícola. Piracicaba: Associação Brasileira para Pesquisa da Potassa e do Fosfato, 1987, 12-48.

[6]. Brown, R. H., and Byrd, G. T. (1997). Transpiration efficiency, specific leaf weight, and mineral concentration in peanut and pearl millet. Crop Science 36: 475–480.

[7]. Byrd, G. T. and May, P. A. (2000). Physiological comparisons of switch grass cultivars differing in transpiration efficiency. Crop Science, 40: 1271–1277

[8]. Cândido, M .J. D.; Lopes, M. N.; Lacerda, C. F. et al. (2009). Características fisiológicas de Panicum maximum x Panicum infestum cv. Massai sob doses crescentes de adubação nitrogenada. In: Reunião Anual Da Sociedade Brasileira De Zootecnia, 46., Maringá. Anais... Maringá: Sociedade Brasileira de Zootecnia (CD-ROM).

[9]. De Sclaux,. D, Huynh, T. T., Roumet, P. (2000).Identification of soybean plant characteristics that indicate the timing of drought stree. Crop Science, 40, 716-722.
[10]. Garnier, E.(1992). Growth analyses of congeneric annual and perennial grass species. Journal of Ecology, 80(5), 665-675.
[11]. Gutschick, V. P. (1991). Modeling canopy photosynthesis and water-use efficiency of canopies as affected by leaf and canopy traits. In: Modeling Crop Photosynthesis from Biochemistry to Canopy, eds. K. J. Boote, and R. S. Loomis, pp. 57–73.. CSSA Spec. Publ. 19. Madison, WI: CSSA and ASA
[12]. Ismail, A. M., and A. E. Hall. 1993. Inheritance of carbon isotope discrimination and water-use efficiency in cowpea. Crop Science 33: 498–503.
[13]. Kumura, K. 1975. Leaf area development and climatic factors. In: Crop Productivity and Solar Energy Utilization in Japan, ed. Y. Murata, pp. 60–66. Tokyo: University of Tokyo Press.
[14]. Lambers, H. (1987). Does variation in photosynthetic rate explain variation in growth rate and yield? Netherlands Journal of Agricultural Science, 35(4), 505-519.
[15]. Ludlow, M. M., Wilson, G. L. (1970). Studies on the productivity of tropical pasture plants. II. Growth analysis, photosynthesis, and respiration of 20 species of grasses and legumes in acontrolled environment. Australian Journal of Agriculture Research, 21(2), 183-194.
[16]. Luo, C. C. (1979). Specific leaf weight as related to the yield and its components in rice. Botanical Bulletin Academia Sinica Taipei, 20: 145–157
[17]. Oliveira, M.A.; Pereira, O.G.; Gomide, J.A. et al (2000) Análise de crescimento do capim-bermuda “Tifton 85” (Cynodon spp.). Revista Brasileira de Zootecnia, 29(6), 1930-1938.
[18]. Pinto, J.C. Crescimento e desenvolvimento de Andropogon gayanus, Panicum maximum e Setaria anceps cultivadas emvasos, sob diferentes doses de nitrogênio. (1993). 149f. Tese (Doutorado em Zootecnia) - Universidade Federal de Viçosa, Viçosa, MG.
[19]. Pompeu, R.C.F.F.; Lopes, M.N.; Cândido, M.J.D. et al. (2009). Características estruturais do resíduo pós-corte do capim-massai sob níveis crescentes de nitrogênio. In: Congresso De Forragicultura E Pastagens, 3., 2009, Anais... Lavras: [2009] (CD-ROM).
[20]. Santos Júnior, J. D. G.; Monteiro, F. A.; Lavres Junior, J. (2004). Análise de crescimento do capim-marandu submetido a doses de nitrogênio. Revista Brasileira de Zootecnia, 33(6), 1985-1991.
[21]. Shukla, R. K. , Arvind, K. , Mahapatra, B. S. and Basanth, K. (2002). Integrated Nutrient Management Practices in relation to morphological determination of seed yield in Indian mustard (Brassica junea). Indian Journal of Agricultural Science, 72, 670-672.
[22]. Watson, D. J., Wilson, J. H., Ford, M. A. et al. (1966). Changes with age in the photosynthetic and respiratory components of the net assimilation rates of sugar beet and wheat. New Phytologist, 65(4), 500-508.