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Effect of Fertilizer on Forage Maize and Ginger Production in Maize/Ginger Intercrop under Alley System in Umudike, Nigeria

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Abstract
The fertilizer effect on forage maize dry matter and ginger rhizome yield in maize (*zea mays*) + ginger (*zingiber officinale*) intercrop under *Dactyladenia barteri* based alley system was investigated in 2011 and 2012 in Umudike South-east Nigeria. Test consist of 3 levels of cropping systems (sole maize, sole ginger and ginger + maize) and three (3) levels of inorganic fertilizer (NPK 15: 15: 15) (0, 350 and 450 kg/ha), laid in a randomized complete block design with three (3) replications. Planting was done in May each year using a plot size of 2.5m x 2.5m, ginger sett weighing 20g and maize (Kewesoke) were planted at a spacing of 0.5m x 0.5m on ridges made in-between the *Dactyladenia barteri* hedgerows (Alley). The plots were mulched with 5 t/ha fresh pruning of *D. barteri* two days after planting. Data on plant survival, plant height, leaf number, rhizome and maize dry matter yield were taken and subjected to analysis of variance. Results showed that fertilizer rates and cropping systems had no significant effect on forage maize survival, plant height and number of leaf in both years of study. Significant differences were observed for fertilizer treatments on forage maize dry matter. The 450 and 350 kg/ha fertilizer rates had a pooled mean value of 10.7 and 8.40t/ha respectively. These values were significantly higher than the 0t/ha, which had a mean value of 7.42t/ha dry matter. Mean ginger plant survival and plant height showed no significant response for both fertilizer treatments and cropping systems, while significant differences ($P<0.05$) were observed for ginger leaf number and ginger rhizome yield for fertilizer treatments: 7.25,5.08 and 4.23t/ha for 450,350 and 0kg/ha respectively. Cropping system (intercropping) showed no significant effect on ginger rhizome yield under alley systems, indicating that intercropping may not influence maize and ginger growth, and yield under *Dactyladenia barteri* based alley system.

Keywords: Forage maize, Dactyladenia barteri, Alley system, Intercropping, Ginger

Introduction

In rural areas particularly belonging to tropical rain fed zone, Agroforestry is a common strategy adopted by farmers as a common tool for preventing environmental degradation, while increasing food production at the same time (Prabesh, 2022). Application of multipurpose trees and shrubs (MPTS) in an intercrop situation with arable crops is changing the entire agricultural landscape (Jaswa *et al*., 2003; Pandey, 2017). Crop diversification displayed by intercropping has long been a prominent feature of small holder crop production in sub Saharan Africa (Bharti *et al*., 2006). Farmers are generally concerned about the risk inherent in monoculture and intercropping enhances productivity per unit land and guarantees security against potential crop failure associated with monoculture (Lyrocks *et al.*, 2013). Trees on farm land play vital roles in rehabilitating degraded land and enhancing the total productivity of the land. Arable crops are usually combined with trees in an agroforestry system to provide livelihood security to the farmer (Prabesh, 2022). Ginger is an important spice crop, grown globally for its medicinal and industrial uses. Nigeria exported 12million USD worth of ginger in 2021(523,000 metric tones which represent 14% of the global supply of Ginger (NBS, 2021).

Ginger is known to perform better under tree canopies, Lyocks *et al*. (2013) reported that ginger is a shade loving crop that takes advantage of the shade and nutrient provided by the system to optimize growth and yield. Ginger requires moderate to high level of soil fertility. Organic management has been identified as an important means of conserving and improving the fertility status of the soil for ginger production (Chukwu and Emehute, 2002; Kumar *et al*., 2010). Fertilizer requirement of ginger based on soil test value for total N in Nigeria are 100, 50 and 30kg N/ha where the soil is low, medium and high respectively. The recommended compound fertilizer (N:P:K 15:15:15) rate for low fertility soil in Nigeria is 300kg/ha applied at 12 weeks after planting (WAP). At 12th week (WAP), 400kg/ha^{-1} NPK, Mg (12:12:17:2) and 100kg urea/ha should be applied in low fertility soils (Nwogu, 2003). In the humid tropics where the soil is at high risk of soil erosion, particularly after clearing the land for cultivation, mulching offers a number of benefits that are difficult to achieve in an unmulched and unprotected soil surface which is prone to severe accelerated soil erosion (Pandey *et al*., 2017) and overall soil degradation (Kumar *et al*., 2010 and Lyrocks *et al*., 2013).

Traditionally, Zingiber Officinale (Ginger) requires mulch for optimal growth and production. Ahaiwe *et al.*, 2016), reported that mulched plots (at 5cm and 10 cm thickness) significantly increased the number of off-shoots, plant height, number of leaves, leaf area and stem diameter, rhizome and root dry weight of ginger than un-mulched plots. Maize or corn (*Zea mays* L.) is a versatile crop grown over a range of agro climatic zone (Alhassan, 2021). Large percentage of maize produced in Africa is utilized for house hold consumption and most recently for feeding of animals. The grain and silage is a valued energy source in ruminants. In dairy cows, it can support high milk yield because of high starch content, providing adequate amount of starch and also promote rumen bacterial growth; thus enhancing forage digestibility, rumen cycling and subsequent feed intake (Heuze *et al*., 2017).

The insecurity in Nigeria heightened by recurrent farmers/herders clash has led to the call for ranching to reduce nomadic and traditional movement of cattle from place to place by herders. The production of low input forage maize in Nigeria to support ranching has become timely if the call for ranching in Nigeria is to be sustainable. Maize makes high quality silage for dairy cattle, beef and sheep at less cost than silage made from grass (PDA, 2008). Edward (2008) reported that silage made from forage maize can increase milk yield and milk protein content, while reducing supplementation with concentrate leading to subsequent increase in profitability.

Recent studies in the mid hill ecosystem of the western Himalayas indicated that maize performed relatively well when intercropped with ginger, turmeric and some agroforestry trees. Species like populous deltoids and *Flamingia microphylla* (Jaswal *et al*., 2003). Further investigation by Pandey *et al.* (2017) reported higher rhizome yield of ginger under Sapota-Jatropha based agroforestry system. Previous investigation on the production of ginger and turmeric below tree canopies of Teak, Tumarind and coconut provided data which supported intercropping in ginger and maize production (Jaswal *et al*., 2006 and Kumaw *et al.*, 2010). Ginger is a shade loving plant which requires mulching and fertile soils, rich in organic matter for optimum productivity. Alley system which is an agroforestry system naturally provides continuous litter fall as much and source of organic matter to provide conducive environment for ginger production. Performance of ginger and maize under *Dactyladenia bartei* alley has not been widely reported. The objectives of this study were to determine the effect of intercropping and NPK fertilizer on the growth and yield of ginger and forage maize under *Dactyladenia barteri* based alley system in Umudike Nigeria.

Materials and Methods

The experiment was carried out in 2011 and repeated in 2012 at the research farm of the National Root Crops Research Institute Umudike located at latitude 05 29″N and longitude 07 033″E in South east agro-ecological zone of Nigeria. The plot size was 2.5m x 2.5m and ginger sett (UG1) with an average weight of 20g and maize (local best) was planted at a spacing of 0.5m x 0.5m on ridges made in-between the alleys of the *Dactyladenia berteri* hedgerows. Treatments consist of three levels of cropping systems; sole maize (SM), sole ginger (SG) and ginger + maize intercrop (M+G), three levels of NPK 15:15:15 fertilizer at, 0, 350 and 450 (kg/ha). They were laid in a randomized complete block design with three replications. The field was manually prepared and planting done in May for both years. The plots were mulched with *Dactyladenia barteri* fresh pruning at 5t/ha two days after planting. Fertilizer was applied at 12 weeks after planting (WAP). Composite soil samples were collected per plot before planting and analyzed for physical and chemical properties. Weeding was done once (10WAP). Plant germination count (no\plot), plant height (cm plant-1) and leaf number (no plant-1) was done 4 and 8WAP. Ginger rhizome yield and forage maize, dry matter yield were measured at harvest and data obtained subjected to analysis of variance (ANOVA) using GenStat Discovery Edition 4. Significant treatment means were separated using least significant difference (LSD) at 5% level of probability.

Results and Discussion

Table 1 shows the soil properties of the experimental site before planting, the particle size distribution varied with sand dominating. The textural class was sandy loam, acidic (mean pH value for both years was 4.74), while organic carbon content was moderate (0.10%), and for total nitrogen content at 0.21%. The available phosphorus was high (68.42g/kg mean for both years), while the exchange complex of the soil were dominated by Mg^+ and Ca^+ indicating that soils under alley system has the potential to support multiple cropping system because of the inherent litter fall and decomposition mechanism of the system. No significant differences (P> 0.05) were recorded for cropping systems and fertilizer treatments on forage maize plant survival, plant height and leaf number for both years of study; however significant differences were observed for fertilizer treatments on maize dry matter yield (Table 2). The 450kg/ha NPK 15:15:15 rate gave maize dry matter values of 9.34 and 10.80t/ha respectively in 2011 and 2012. These values were significantly higher than the control (0kg/ha) which gave the least results for both years. Ginger growth attributes and survival count showed no significant response for fertilizer treatment and cropping systems, however, significant differences (P<0.05) were observed for ginger rhizome yield. The 450, 350 and 0kg/ha NPK 15:15:15 gave 7.28, 4.92 and 4.21 t/ha and 7.21, 5.19 and 4.25t/ha fresh rhizome yield in 2011 and 2012 respectively (Table 3). The treatments interaction (F *x* Cs) showed no significant effect (P>0.05). This study revealed non-significant effects of both fertilizer treatments and cropping system on some growth and yield attributes of ginger and maize under *Dactyladenia barteri* based alley system. The possible reasons may be the adequate pre-cropping nutrient status of the experimental site which was described earlier to be moderate to high. Again the different growth habits of the component crops and trees in the system (Ginger, Maize and the *D barteri* alley hedge rows) have different demand on light and growth resources which are not competitive (Sugar *et al*., 2021). Similar studies by Lyocks *et al*. (2013) and Prabesh (2022) observed no significant response in some growth and yield attributes of ginger and maize in an intercrop situation. Jaswal *et al*. (2003) also reported non-significant effect of fertilizer and intercropping on plant height, tiller number, leaf number and rhizome and dry matter yield of ginger and maize under Populus (Popular deltoids "G-3" Mash) based agroforestry ecosystem in India. A comparison of rhizome yield performance of sole and intercropped (Ginger + Maize) showed that ginger performed better in the intercropping system. The *Dactyladenia barteri* alley component increased partial shade offered by the component maize in the system. This arrangement improved the micro-climate environment offered by the component fast growing maize and also the shade loving ginger and thus increased the degree of complementarities of the system. Similar observations confirming this study have been observed by Sagar *et al.* (2021), who reported no significance yield response of maize and ginger intercrop under similar growth conditions. Again the similar leaf number and maize dry matter of both sole and intercropped maize as observed in this study could be as a result of the *Dactyladenia baretri* shading effect. Generally, shading reduces node number and leaf number as well as the size of plants especially in C4-plants. Maize is a C4-plant and performs poorly under shade (Houyan *et al.*, 2015 and Cui *et al.*, 2015). The results of the relative yield or combined LER and relative crowding coefficient (K),(Tables 4 and 5) revealed a yield advantage in the system and less competition on growth resources. The values obtained in 2011 and 2012 (1.83 and 1.87 respectively) showed a yield advantage. Sagar *et al*. (2021) reported a standard LER value of 1.40 for Nigerian agro ecosystem. Bebul (2022) stated that LER measures the level of intercrop interference in the cropping system.

Conclusion

Results obtained in this study indicated a yield advantage in the system. Therefore, if the agro ecological characteristics of each crop in the mixture are different as witnessed in this study, the degree of complementarities will be enhanced with little or no competition for growth resources. Farmers are therefore advised to consider the different growth habits of member crops in an intercropping situation to make intercropping productive and profitable under alley system.

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Table1: Mean Physical and Chemical properties of the experimental site at Umudike

Soil properties	Values
Sand (%)	58.4
Clay (%)	14.1
Silt (%)	27.5
Texture	Sandy Loam
PH (H_20)	4.74
Available P (g/kg)	68.42
Total N (%)	0.21
Organic Carbon (%)	0.10
Ca (.mg 100^{-1} g soil)	0.70
Mg (mg 100^{-1} g soil)	0.50
K (mg 100^{-1} g soil)	0.10
Na (mg 100^{-1} g soil)	0.10
Exch. Acidity (mg 100^{-1} g soil)	0.06
ECEC (mg 100^{-1} g soil)	1.45

Table 2: Dry matter yield of forage maize (t/ha) as influenced by fertilizer and cropping systems in 2011 and 2012

NPK Fertilizer Rate(kg/ha	Sole maize	Ginger + maize 2011	Mean	Sole maize	Ginger + maize 2012	Mean
0	8.20	6.88	7.54	6.97	7.65	7.30
350	8.50	7.22	7.88	9.16	8.63	8.91
450	8.88	9.80	9.34	11.24	10.55	10.80
Mean	8.53	7.98		9.12	8.88	
FLSD(0.05)						
Fertilizer (F)	0.66			2.04		
Cropping Systems(CS)	NS			NS		
Interaction (FxCS)	NS			NS		

Table 3: Ginger rhizome yield (t/ha) as influenced by fertilizer and cropping systems in 2011 and 2012

Fertilizer kg/ha	Sole Ginger	Ginger + Maize 2011	Mean	Sole Ginger	Ginger + Maize 2012	Mean
0	4.67	3.75	4.21	4.72	3.77	4.25
350	4.87	5.07	4.97	5.28	5.09	5.19
450	2.82	6.73	2.28	7.47	6.95	7.21
Mean	5.79	5.18		5.83	5.25	
LSD (0.05)						
Fertilizer	0.50			0.80		
Cropping systems	NS			NS		
Interactive (FXC)	NS			NS		

Table 4: Partial and combined land equivalent ratios of ginger and maize in ginger + maize intercropping in *Dactyladenia barteri* based alley system

Year	Cropping mode(t/ha)		Cropping mode(t/ha)		Partial LER		Relative Yield Total or Combine LER
	Sole ginger	Ginger + maize	Sole maize	Ginger + maize	Ginger	Maize	
2011	5.70	5.78	8.53	7.98	0.89	0.94	1.83
2012	5.83	5.25	9.12	8.88	0.90	0.07	1.87

Table 5: Relative Crowding Coefficient (k) of Ginger + Maize Intercropping in *Dactyladenia barteri* Based Alley System in 2011 and 2012

Year	Sole ginger (t/ha)	Ginger + maize (t/ha)	Sown proportion of ginger relative to maize	Relative crowding coefficient (k) of ginger + maize
2011	5.79	5.18	50:25 (2:1)	2.12
2012	5.83	5.25	50:25 (2:1)	2.26