EFFECT OF RHIZOME STORAGE DURATION ON THE VARIETAL GROWTH, YIELD AND YELLOW LEAF SPOT DISEASE INCIDENCE OF GINGER (Zingiber *officinale*) IN A HUMID TROPICAL RAINFOREST OF SOUTH EASTERN NIGERIA

NWAOGU, E.N., OKONKWO, J.C. AND UKPABI, U.J.

National Root Crops Research Institute, Umudike, P.M.B. 7006, Umuahia, Abia State

ABSTRACT

A field study was conducted at the research farm of the National Root Crops Research Institute, Umudike in 2006 and 2007 cropping seasons to determine the effect of rhizome storage duration on the subsequent field performance of ginger in humid tropical rainforest ecology of Nigeria. Treatments consisted of three ginger varieties {Maran (MN), Wynad local (WYL) and yellow ginger (UGI)} in factorial combinations with six rhizome storage durations {0, 2, 4, 6, 8 and 10 months after harvest (MAH)}. The design used was randomized complete block with three replications. Results showed that the best plant establishment, vigour and fresh rhizome yield was obtained when rhizomes were stored for not more than 2MAH. Rhizome storage for more or less than 2MAH reduced ginger plant vigour and yield but increased yellow leaf spot disease of ginger. Highest incidence of the disease was recorded at 6MAP and Maran was more susceptible to the disease than Wynad local and yellow ginger.

KEYWORDS: Rhizome, storage duration, leaf spot, Ginger, rain forest

INTRODUCTION

Increased awareness of the economic, industrial and medicinal potentials of ginger has led to the increased production of the crop in Nigeria. Nigeria is now rated the 4th largest producer of ginger in the world with an estimated output of 90,000mt in 2001 and with an average production area of 174,000 ha representing 54% of the total world production area (Egunyomi, 2008). Like any other agricultural crop, ginger production in Nigeria has many challenges the greatest of which are the storage and disease problems (Onwualu, 2008).

In South Eastern Nigeria, ginger is harvested between November and January and stored from then to May of the following year before being planted again in the field. Harvested ginger rhizomes are stored in small heaps under shade for 4-6 months after harvest depending on time of harvest. Many methods have been reported in the literature for the storage of ginger rhizomes. These include leaving matured rhizomes un-harvested in the ground until needed; storage of rhizomes in big baskets covered with dry grasses; storage of rhizomes in small heaps under shade and burying in pits lined with dry grasses among others(Nnodu and Okwuowulu,1988). So far, no one storage method is adjudged the best as the efficiency of each method is relative (Akamine(1962).

Ginger rhizomes if stored under ambient conditions dehydrate very fast after harvest due to its high moisture content which ranges from 70-80% and low relative humidity during the dry season (Vasundhara et al., 2008). Ginger rhizomes while in storage also, undergo some physiological breakdown and rapid loss of weight due to dehydration, sprouting and rot as a result of microbial attack (Hamzaa,2001) thereby resulting in a reduction of the food reserve of the rhizomes. Rhizome losses as high as 70% of harvest have been reported in the literature due to microbial deterioration while under storage (Hamzaa, 2001).

Since the size of the planted mother rhizome sett influences the multiplication ratio, yield and inflorescence bearing ability of ginger (Okwuowulu and Odurukwe 1988), physiological changes that impact on the size and food reserve of the rhizomes are bound to influence the agronomic performance of the subsequent ginger crop grown from it. The objectives of this study therefore, are:

i. To establish the effect of rhizome storage duration on the field performance of subsequent ginger crop in a tropical humid rainforest zone of south eastern Nigeria.

ii. To ascertain if there is a relationship between storage duration and incidence of yellow leaf spot disease of ginger.

MATERIALS AND METHODS

The study was carried out at the research farm of the National Root Crops Research Institute, Umudike (Latitude 05^0 29' N; Longitude 07^0 33' E) in 2006 and 2007 cropping seasons. Treatments were three ginger varieties {Maran (MN), Wynad Local (WYL) and yellow ginger (UGI)} factorially combined with six storage regimes (0, 2, 4, 6, 8 and 10 months after harvest (MAH).

Rhizome setts weighing about 20g were cut from large, healthy and disease-free mother rhizomes of the three ginger varieties being studied and planted up on seed beds measuring 2m x 2m made on a tractor-slashed, ploughed and harrowed land. The rhizome seeds were sown at an intra-row spacing of 0.20m and inter row spacing of 0.20m. The inter-plot distance was maintained at 0.5m. The treatments were laid out in a randomized complete block design with three replications. Planting was done on 10th May and 16th May for 2006 and 2007 respectively.

The plots received NPK 15:15:15: fertilizer at the rate of 300kg/ha. Fertilizer application was by broadcasting in two split doses: half dose during planting and half 12 weeks after planting. The plots were mulched 2 days after planting (DAP) with mature wilted *Panicum maximum* grass at 20t/ha.

At the maturity of the planted rhizomes, staggered harvesting was done to coincide with the rhizome storage intervals of being evaluated. Harvesting was done using digging fork. All harvested rhizomes were covered with dry *Panicum maximum* grass and stored in small heaps under shade provided by a number of Avogado trees after taking records of their fresh weights. The rhizomes were kept in storage to cover a period of 0, 2,4,6,8 and 10 MAH being evaluated. While in storage, seed rhizomes damaged by rot were periodically sorted out and removed. At the end of the storage, the final weight of seed rhizomes were also recorded.

Data on % establishment (6WAP), plant height (20WAP), disease score (4, 5 and 6 WAP), fresh rhizome yield, number of leaves per plant (20WAP) and tillering capacity (20WAP) were collected in the field. Data on plant height, number of tillers and number of leaves per plant were collected on five plants from the inner most row of each plot. Disease score was made using visual observation and ranking according to the following format described by Ford and Herwitt (1980):

Severity estimation (%)	Scale	Interpretation
0	0	No infection
1-20	1	Slight infection
21-40	2	Moderate infection
41-60	3	Extensive infection
61-80	4	Very extensive infection
81-100	5	Leaves completely infected

The two year yellow leaf spot disease data were pooled after a non-significant test for heterogeneity of variances was established (Gomez and Gomez, 1984).

Data were analyzed statistically using ANOVA and treatment differences were tested using LSD (0.05).

RESULTS AND DISCUSSION

Storage duration significantly ($P > 0.05$) affected ginger plant establishment. Planting ginger rhizomes immediately after harvesting resulted in the least establishment while highest field establishment was recorded with rhizomes stored for two months after harvest (Table 1). The lower establishment observed when rhizomes were planted without storage is attributed to lack of curing. Eke-Okoro et al., (2005) identified rhizome curing as an important agronomic practice in ginger production. Also, it could be that the rhizomes were still dormant when the measurement was taken.

The three ginger varieties responded similarly to plant establishment.

Table 1: Effect of rhizome storage on the varietal establishment of ginger in an ultisol of South Eastern Nigeria

	2006				2007			
STORAGE	Ginger plant establishment (%) ginger variety				Ginger plant establishment (%) ginger variety			
DURATION	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	62	65	60	62.3	64	68	70	67.3
2MAH	95	90	93	92.7	92	98	92	94.0
4MAH	88	95	90	91.0	89	94	90	91.0
6MAH	80	83	86	83.0	84	91	88	87.7
8MAH	70	77	74	73.7	76	80	78	78.0
10MAH	67	70	74	68.3	66	74	71	70.3
Mean	77.0	80.0	79.5		78.5	84.2	81.5	
	LSD (0.05):				LSD (0.05):			
	Variety = NS				Variety = NS			
	Storage = 6.2				Storage = 6.5			
	Variety x Storage = NS				Variety x Storage = NS			

Both variety and length of rhizome storage significantly affected ginger plant height (Table 2). UG1 produced the tallest plant heights across all the storage regimes evaluated. The best plant height performance was recorded when rhizomes were stored for 2 MAH. Rhizome storage less or more than 2MAH resulted in relatively shorter ginger plants irrespective of variety. Ginger variety x storage interaction effect for plant height was significant only in 2007.

Table 2: Effect of rhizome storage on the varietal plant height response of ginger in an ultisol of south eastern Nigeria.

	2006				2007			
Storage	Ginger plant height (cm) Ginger variety				Ginger plant height (cm) Ginger variety			
Duration	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	93.1	86.7	77.4	85.7	99.7	94.5	96.6	96.9
2MAH	103.4	99.6	90.3	97.8	126.3	110.1	106.3	114.2
4MAH	96.3	94.1	89.0	93.1	116.4	101.7	98.7	105.6
6MAH	96.1	99.0	82.6	92.6	99.9	90.3	101.3	97.2
8MAH	88.7	83.4	82.6	84.9	86.3	90.1	90.6	89.0
10MAH	86.7	80.1	80.6	82.5	89.0	88.3	80.4	85.9
Mean	94.1	90.5	83.8		102.9	95.8	95.6	
	LSD (0.05):				LSD (0.05):			
	Variety = 2.6				Variety = 1.9			
	Storage = 3.9				Storage = 7.2			
	Variety x Storage = NS				Variety x Storage = 1.3			

Highest fresh rhizome mean yields of 17.37 and 18.70t/ha were obtained in 2006 and 2007 respectively from rhizomes stored for 2 MAH (Table 3). These figures represented 59.4 and 48.4% yield increases over those obtained from 0 MAH. However, increasing the rhizome storage duration from 2 MAH to

10 MAH resulted in 27% reduction in rhizome mean yield for 2006 and 2007 respectively. Although there was no significant yield difference among the three varieties across all the storage regimes, WYL consistently out-yielded the other two varieties. This may be attributed to increased photosynthetic activity as a result of higher number of leaves (Table 6).

Table 3: Effect of rhizome storage on the varietal yield response of ginger in a humid rainforest zone of South Eastern Nigeria

	2006				2007			
Storage	Fresh rhizome yield (t/ha) ginger variety				Fresh rhizome yield (t/ha) ginger variety			
Duration	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	9.6	11.2	12.0	10.9	12.4	13.9	11.5	12.60
2MAH	16.8	18.9	16.4	17.37	20.2	19.6	16.3	18.70
4MAH	14.9	16.6	13.3	14.93	15.9	17.3	14.9	16.03
6MAH	14.6	15.8	12.8	14.40	15.6	17.1	12.8	15.17
8MAH	12.9	14.8	12.3	13.30	13.5	15.9	12.6	14.00
10MAH	12.1	12.5	13.6	12.73	13.0	15.4	12.6	13.67
Mean	13.48	14.97	13.40		15.1	16.53	13.45	
	LSD (0.05)				LSD (0.05)			
	Variety = NS				Variety = NS			
	Storage = 1.6				Storage = 1.6			
	Variety x storage = NS				Variety x storage = NS			

Table 4: Effect of rhizome storage on the varietal yellow leaf spot disease occurrence of ginger in a humid tropical rainforest of south eastern Nigeria

	4 MAP				5MAP				6MAP			
Storage duration	**No. of diseased plants/plot Ginger variety**				**No. of diseased plants/plot Ginger variety**				**No. of diseased plants/plot Ginger variety**			
	UGI	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	3	2	8	4.3	12	20	26	19.3	27	30	36	31.0
2MAH	9	10	15	11.3	18	21	26	21.7	22	36	42	33.3
4MAH	7	12	18	12.3	11	27	32	23.3	17	33	44	31.3
6MAH	12	14	21	15.7	26	31	39	32.0	30	39	48	39.0
8MAH	10	12	19	13.7	15	16	27	19.3	31	42	49	40.6
10MAH	16	20	30	22.0	23	29	46	32.7	33	38	52	41.0
Mean	9.5	11.7	18.5		17.7	24.0	32.7		26.7	36.3	45.2	
	LSD (0.05):				LSD (0.05):				LSD (0.05):			
	Variety = 2.3				Variety = 3.9				Variety = 4.5			
	Storage = 4.5				Storage = 3.4				Storage = 2.8			
	Variety x Storage = 0.3				Variety x Storage = 0.5				Variety x Storage = 0.61			

Both variety and storage duration significantly affected the number of leaves produced per plant (Table 6).Rhizomes stored for 2 MAH produced the highest mean number of leaves per plant while WYL gave the best

performance among the three varieties in the 2 years of the study.

Table 4 shows the effect of rhizome storage on the varietal yellow leaf spot disease incidence of ginger at various stages of growth. In general, incidence of yellow leaf spot disease increased with increase in duration of storage as well as in time of planting irrespective of variety. The first observable symptoms of the disease was recorded at 4 MAP indicating that any measure adopted for its control should commence much earlier than 4 MAP in order to be effective. At any of the growth stages of ginger the disease was scored, both variety and storage duration significantly affected incidence of the disease. MN was more susceptible to the disease than WYL and UGI. The longer the storage duration, the more the occurrence of the disease indicating that the incubative stage of the disease organism falls within the period when rhizomes are in storage. This result also has implications in the design of any measure for its effective control.

Table 5: Effect of rhizome storage on the tillering capacity of different ginger varieties in a humid tropical rainforest of South Eastern Nigeria

	2006				2007			
Storage	Number of tillers/plant ginger variety				Number of tillers/plant ginger variety			
Duration	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	8.8	9.1	9.1	9.0	10.2	11.3	9.1	10.2
2MAH	13.6	14.7	14.4	14.2	16.0	16.3	13.3	15.2
4MAH	11.8	13.7	12.1	12.5	13.0	14.0	12.4	13.1
6MAH	11.3	13.0	11.8	12.0	12.9	13.9	10.0	12.3
8MAH	10.7	12.2	11.0	11.3	11.2	13.0	10.4	11.5
10MAH	9.3	10.4	10.0	9.9	10.7	12.7	9.9	11.1
Mean	10.9	12.2	11.4		12.3	13.5	10.9	
	LSD (0.05): Variety = NS Method = 3.7 Variety x Method = NS				LSD (0.05): Variety = NS Method = 4.6 Variety x Method = NS			

Wholesomeness (rotlessness) of ginger seed rhizome was significantly affected by storage duration irrespective of variety (Table 7). The longer the storage duration, the more the rhizome damage due to rot. Rhizome storage for up to 10 MAH resulted in as high as 45% rot damage in 2006 (Table 7). Generally, Maran was mostly affected by storage in terms of rot than Wynad Local and Yellow ginger. A significant variety x storage duration interaction effect was also recorded for the two years of the study.

Similarly, there was also a significant progressive seed rhizome weight loss with increase in storage duration (Table 8). At the highest storage interval of 10 MAH, 26 and 29% weight losses were recorded in 2006 and 2007 respectively. Rhizome weight loss was least in rhizomes stored for 2 MAH. This observation probably explains the better yield results obtained with rhizomes stored for not more than 2 MAH in Table 3.

Table 6. Effect of rhizome storage duration on the number of leaves per plant of three ginger varieties in a humid tropical rainforest of South Eastern Nigeria

	2006				2007			
Storage	Number of leaves/plant ginger variety				Number of leaves/plant ginger variety			
Duration	**UGI**	**WYL**	**MN**	**Mean**	**UGI**	**WYL**	**MN**	**Mean**
0MAH	27.3	40.6	31.2	33.0	30.1	40.0	26.3	32.1
2MAH	36.7	48.3	38.0	41.0	40.4	56.3	28.6	41.8
4MAH	29.6	43.6	33.0	35.4	27.9	43.6	20.0	30.5
6MAH	27.2	38.3	27.8	31.1	40.0	44.0	22.6	35.5
8MAH	33.6	44.6	15.7	31.3	31.2	46.7	30.4	36.1
10MAH	30.3	40.9	27.8	33.0	29.7	36.8	31.3	32.6
Mean	30.8	42.7	28.9		33.2	44.6	26.5	
	LSD (0.05): Variety = 5.31 Storage duration = 2.20 Variety x Storage duration =0.11				LSD (0.05): Variety = 5.73 Method = 2.30 Variety x Storage duration = 0.26			

Table 7. Effect of rhizome storage duration on the % rotlessness of three ginger varieties in a humid ultisol of south eastern Nigeria.

	2006				2007			
Storage	% Rotlessness of Seed Rhizome Ginger Variety				% Rotlessness of Seed Rhizome Ginger Variety			
Duration	**UG1**	**WYL**	**MN**	**Mean**	**UG1**	**WYL**	**MN**	**Mean**
0 MAH	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2 MAH	96.7	98.3	92.4	95.8	97.4	96.6	94.0	96.0
4 MAH	80.6	82.7	76.3	79.9	89.2	82.7	66.8	79.6
6 MAH	68.1	70.2	63.4	67.2	68.5	61.7	60.3	63.5
8 MAH	60.2	64.5	50.6	58.4	66.6	60.2	53.4	60.1
10 MAH	57.7	60.1	47.3	55.0	63.4	55.7	49.6	56.2
Mean	96.2	79.3	71.7		80.9	76.2	70.7	
	LSD(0.05): Variety = 6.1 Storage Duration = 11.5 Variety x Storage Durati on = 3.6				LSD(0.05): Variety = 2.5 Storage Duration = 11.2 Variety x Storage Duration= 3.1			

Table 8. Effect of rhizome storage duration on the % seed rhizome weight loss of three ginger varieties in a humid ultisol of south eastern Nigeria.

Storage Duration	2006 % Seed Rhizome Weight Loss Ginger Variety				*2007 % Seed Rhizome Weight Loss Ginger Variety*			
	UG1	**WYL**	**MN**	**Mean**	***UG1***	***WYL***	***MN***	***Mean***
0 MAH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
2 MAH	3.9	5.4	7.3	5.5	6.9	10.0	12.3	*9.8*
4 MAH	10.4	16.7	21.2	16.1	10.6	18.9	23.6	*17.7*
6 MAH	11.2	18.9	26.3	18.8	13.4	21.7	29.8	*21.6*
8 MAH	15.6	22.9	30.3	22.9	20.1	24.6	32.6	*25.8*
10 MAH	17.3	26.4	33.7	25.8	22.4	28.6	36.9	*29.3*
Mean	9.7	15.1	19.8		12.2	17.3	22.5	
LSD(0.05): *Variety = 2.4* *Storage Duration = 5.2* *Variety x Storage Duration = NS*					*LSD(0.05):* *Variety = 2.7* *Storage Duration = 5.0* *Variety x Storage Duration= NS*			

CONCLUSION

Rhizome storage duration and varietal considerations are important factors affecting yield of ginger in a humid tropical rainforest of south eastern Nigeria. Rhizome storage for less or more than 2MAH reduces growth, yield but increases the incidence of yellow leaf spot disease occurrence of ginger. UGI variety is more resistant to the disease than WYL and MN.

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