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ECONOMIC EVALUATION OF THE INCIDENCE OF YELLOW LEAF SPOT DISEASE ON THE YIELD OF GINGER IN THE RAINFOREST AGRO ECOLOGY OF NIGERIA

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ABSTRACT
This study evaluated the economic effects of the incidence of yellow leaf spot disease on cost of production and yield of ginger. A field experiment was conducted at the research farm of National Root Crops Research Institute Umudike in Abia State in 2014 and 2016 planting seasons. The study involved six treatments replicated two times. Three (3) rates of Ridomyl and Z-force (both fungicides) each were applied in a completely randomized block design, during the two year cropping season. Data were collected on weekly, bi-weekly and monthly bases depending on treatment, the incidence of leaf spot disease was assessed by counting the number of infected plants per plot which also depends on the number of sprouted plants and this was done between 13WAP and 24WAP when infestation was most prevalent. The economic evaluation of the incidence of yellow leaf spot on the yield of ginger was done using a modified gross income analysis by holding other variable costs constant for all the treatments except the cost of controlling yellow leaf spot, which is assumed to be the only source of variability among the treatment combinations. The result showed that all the plots, including the control had varying levels of incidence of leaf spot disease, implying that none of the treatment combinations were able to completely eradicate yellow leaf spot in the study area. However, it was observed that incidence becomes critical if it is above 20%. This implies that although yellow leaf spot is likely to infect ginger crops in the rainforest zone, its yield may not be critically affected below 20% infestation. TR3 (R. 7g/monthly) had the highest gross income of ₦2,488,500 with TR1 recording the highest cost implication of ₦125,000. Also, TR12 (Z. 7.5g/monthly) had the least cost implication of ₦16,000. Results showed no significant difference in yield and value of output among the treatment means in 2014 and 2016. Further analysis indicated that a significant difference existed in the incidence of yellow leaf spot in 2014 and 2016, with 2014 recording higher incidence. It was therefore concluded that yellow leaf spot is most likely to occur in ginger farms located in the tropical rainforests of Nigeria. But only disease incidences above 20% are likely to affect the economic yield of ginger in the study area. It is therefore recommended that Redomyl 7g applied monthly to check incidence while optimizing the best economic return.

Keywords: Ginger, yellow leaf spot, incidence, yield, control, and fungicides

Introduction

Ginger is a monocotyledonous herbaceous rhizomatous perennial plant belonging to the family *zingiberaceae*. Its flavouring type is classified as *Zingiber officinale* which is the most popular hot spice in the world, belonging to the order; *suitaminae* and the family *Zingiberaceae.* Ginger is a unique crop because of its low volume and high value attributes. The crop is believed to be a native of Tropical Asia (Mishra *et al*., 2012). It is cultivated in the tropical and sub-tropical regions of the world as a spice and medicinal crop. It has obtained a significant stature among the spices worldwide due to its universal appeal (Barun Rai, 2015). It is a plant of very ancient cultivation and the spice has long been used in Asia, also it is one of the earliest oriental spices known to the Europe (Kandiannan *et al*., 1996) which is still in large demand today. The plant possesses a combination of many attributes and properties thereof making its utility diverse. Ginger contains volatile oil, fixed oil, pungent compounds, resins, starch, protein, and minerals. The characteristic organoleptic properties are contributed by the volatile oil and non-volatile solvent-extractable pungent compounds. Among the many components, alpha Zingiberene is the predominating component of the oil. Gingerol and shogaol are the pungency-contributing components. The refreshing aroma and the pungent taste make it an essential ingredient of most world cuisine and of the food processing industry (Ravindran and Babu, 2004). Ginger is one of the world's most popular and useful plants, used for centuries as spices for flavouring food and as a medicinal plant. About half of its world's production comes from India, whereas, its cultivation is extended to China, Australia, Malaysia, Nigeria, Fiji, Brazil and Mexico (Sanderson *et al.*, 2002). Ginger adds to the flavour of a meal creating a fresh, spicy pungent taste which is now becoming a valued commodity all over the world. It is revered as one of the most important and valued spices of the world. Ginger is now used in many different ways and is a complement to many different dishes and flavours. It complements coconut milk curries, lemon grass and gravy. It can be used raw, fried, dried, pickled or as a juice and is a favourite in tea and ale. Ginger is now grown as a cash crop in Africa and Latin America and has entered many local cuisines. Recently it has been introduced in a crystallized form creating a type of sweet appropriate for dessert or snack. This form of ginger is very popular in the western world and is a great way to add value to the product. Nigeria is one of the world's leading producers of ginger. In 2016, Nigeria recorded a production of 522,964 tons of ginger to place second in the world's 10 top ginger producing countries having 16% share of world ginger production (www.factfish.com).

At the moment, the country has the second largest land area for ginger production (111,196ha) but sadly with a low level of productivity. Apart from the low yielding varieties that are being cultivated, Yellow leaf spot disease of ginger has over the years threatened the advancement of Nigeria in ginger production. The history of yellow leaf spot in ginger started with a report by Ramakrishnan (1942) who mentioned leaf spot disease for the first time in Godavari and Malabar regions of India. Later on, the disease was reported from Sarawak (Anonymous, 1972). Sohi *et al* (1964) had reported the disease in Himachal Pradesh, and it also occurs widely in Kerala state (Anonymous, 1974). Singh *et al* (2000a) reported the disease from Chhatisgarh. This disease is now widespread in most ginger-growing countries of the world. Leaf spot is caused by *Phyllosticta zingiberi*. It is characterized by numerous circular or elongated yellow spots on the leaves (Agropedia, 2013). At a later stage, the spots enlarge and turn brown with white papery centers. Small, oval to elongated spots, measuring 1 to 10 mm X 0.5 to 4 mm appear on younger leaves. The spots have white papery centers and dark brown margins surrounded by yellowish halos (Ramakrishnan, 1942). The spots later increase in size and coalesce to form larger lesions. The affected leaves become shredded and disfigured and may suffer extensive desiccation. As the plants put forth fresh leaves, they subsequently become infected. The crop attains a gray disheveled look as a result of infection (Sohi *et al*., 1964; Shukla and Haware, 1972). In Nigeria, the disease begins to appear toward the end of June when the plants are at the most susceptible stage (three- to four-leaf stage) and have received high cumulative rainfall that is conducive for the disease spread. During this period, the temperature varies between 23.4 and 29.6°C and relative humidity is between 80 and 90 percent. Later in July, when the number of rainy days and total rainfall increase, the disease aggravates and spreads fast. As the number of rainy days decrease, disease spread also decreases (Brahma and Nambiar, 1984).

Ginger plants up to the age of 6 to 7 months are susceptible to the disease and 2-week-old leaves are most susceptible. The extent of dispersal of the causal fungus depends upon the intensity of precipitation. A higher intensity of rain accompanied by wind seems to exert a greater impact on leaves, as a result pycnidia are splashed on more leaves and to greater distances, resulting in liberation of a greater amount of spores and spreading the disease incidence (Brahma and Nambiar, 1984). Some portions of the white areas may drop off, producing a shot-hole effect. Infected leaves may be torn into shreds, causing withering and premature death of plants. Leaf spot diseases appear and remain prevalent during the growth period of the crop and may have less or severe effect depending on the environmental conditions. Barun Rai, (2015) in a study of leaf spot in India reported that the major leaf spot diseases are *Phyllosticta*, *Helminthosporium*, *Cercospora*, *Pyricularia*, *Rhizoctonia* and *Septoria* leaf spots etc. Among these *Phyllosticta* leaf spot caused by *Phyllosticta zingiberi* is considered to be the most destructive appearing in mild or severe form in all the ginger growing tracts of the country (Sood and Dohroo, 2005; Singh, 2015).

Grasses serve as reservoir hosts, whereas rainwater and wind are dispersing agents (Karuppiyan *et al*, 2014). The disease is widespread in the ginger-growing world and resists benomyl (Benlate 50w), mancozeb (Diathane m-45), and Kocide 101 (copper hydroxide) treatments in Nigeria. Despite the appearance of early signs of the disease, severity is usually noticed towards the end of its vegetative growth period in the rainforest agro ecology of Nigeria. The study investigated economic evaluation of the incidence of yellow leaf spot disease on the yield of ginger in the rainforest agro ecology of Nigeria.

Methodology

The study was conducted at the Research field of NRCRI Umudike, Abia state Nigeria. Umudike lies on geographical coordinates of $5^0 28' 33''$N, $7^0 32' 56''$E. Abia state is located in the southeastern region of Nigeria and lies within approximately latitudes 4° 40' and 6° 14' north, and longitudes 7° 10' and 8° east. The study involved six treatments replicated two times. Three (3) rates of Ridomyl and Z-force (both fungicides) each were applied in a completely randomized block design with a plot size of 2 x $3m^2$. All activities and input costs were recorded. Data were collected on weekly, bi-weekly and monthly bases depending on treatment, between 13WAP and 24WAP when the disease is most prevalent. After harvest, the data was analyzed by the use of a modified simple cost and return analysis, where all average variable costs were held constant for all the treatments excepting the cost of controlling yellow leaf spot on the different plots.

The model was specified as follows:

GI = TVP- TCA (1)

Where;
GI = Gross income
TVP = Total value of output
TCA = Total Cost of Application

Furthermore a paired sample t-test statistics was used to determine significant differences in the mean of yield and output value and Disease Incidence Count in 2014 and 2016. The paired sample t-test has 4 main assumptions that were fulfilled in this study. The assumptions are:

- The dependent variable must be continuous (interval/ratio).
- The observations are independent of one another.
- The dependent variable should be approximately normally distributed.
- The dependent variable should not contain any outliers.

The model was specified as follows:

$$t = \frac{\bar{d} - \mu_d}{s_d / \sqrt{n}} \quad (2)$$

It should be noted that the standard error of $\bar{d}$ is $\frac{s_d}{\sqrt{n}}$

Where,
s_d = the standard deviation of the differences
μ_d = the mean.

Results and Discussion

The result shows that in 2014, the plots that were applied Ridomyl at the rate of 6g/liter weekly (TR4) had the highest yield (16.67 t/ha), followed by plots treated with Z-force at 10g/liter applied bi-weekly (TR8) with a yield of 14.75 t/ha. In that year, TR6 (R. 6g/monthly) and TR11 (Z. 7.5g/2wkly) with yields of 7.5 and 8.0 t/ha had the lowest yields respectively. This trend was however not sustained in 2016. For 2016, TR3 (R. 7g/monthly) and TR7 (Z. 10g/wkly) had the highest yields of 21.67 t/ha and 16.02 t/ha. The values of production are dependent on the yield.

The incidence of leaf spot disease was assessed by counting the number of infected plants per plot which also depends on the number of sprouted plants and this was done between 13WAP and 24WAP when infestation is most prevalent. The least incidence count recorded in 2014 was in TR12 plots treated with Z-force at the rate of 7.5g/liter applied monthly which had 15 infected stands representing 13.8% of sprouted plants. In 2016, the least incidence was recorded in TR3 (R. 7g/ monthly) as shown in table 2 below. This relatively moderate incidence of leaf spot shows that the treatment is likely to reduce the incidence of the disease. Generally, low incidence of yellow leaf spot was recorded in 2016 than in 2014. From the table, the highest incidence in 2014 was observed in TR6 (R. 6g/monthly) with a count of 35 representing 33.33% of the sprouted plants as against 15 (25%) in the same treatment for 2016. However all the plots, including the control had varying levels of incidence of leaf spot disease did not affect yield when compared.

The mean yield and incidence shows that TR3 (R. 7g/monthly) had the highest yield of 16.8t/ha. Whereas TR6 (R. 6g/monthly) recorded the least level of incidence. From table 3 below, the highest incidence (29.15%) was observed with TR6 (R. 6g/monthly) whereas least incidence was observed with TR12 (Z. 7.5g/monthly). From the result, it was observed that incidence becomes critical if it is above 20%. This means that although yellow leaf spot is likely to infect ginger crops in the rainforest zone, its yield may not be critically affected below 20% infestation. It was also observed from the result that except reduced yield at above 20% infestation, no other clear trend was established.

Based on the assumption that production costs remain constant and that the only source of variability is the cost of procuring fungicides, the cost of controlling yellow leaf spot disease shows that TR3 (R. 7g/monthly) had the best income of ₦2,488,500 with TR1 recording the highest cost implication of ₦125,000. Also, TR12 (Z. 7.5g/monthly) had the least cost implication of ₦16,000.

A paired t-test was run on sampled treatments to determine if statistically significant mean difference between the mean of yield and output value as well as Disease Incidence Count was the same in 2014 and 2016.

Table 5 shows an insignificant t-value of 0.9690 implying that the null hypothesis of average difference in yield is 0 in 2014 and 2016 is accepted. This indicates that the mean yield of 2014 and 2016 was not significantly different.

Also, Table 6 shows an insignificant t-value of 0.9773 implying that the null hypothesis of average difference in value of output is 0 in 2014 and 2016 is accepted. This indicates that the value of output for 2014 and 2016 yield was not significantly different. However, Table 7 showed a significant t-value of 0.0011 implying that the null hypothesis of average difference in Disease Incidence Count is 0 in 2014 and 2016 is rejected, hence we accept the alternative hypothesis that the mean difference of Disease Incidence Count is not 0.

Conclusion

Yellow leaf spot affected all the plots. This implies that none of the treatments could stop the infestation of yellow leaf spot in the rainforest agro ecology, which spreads across most parts of South Eastern Nigeria. However, some of the treatments were able to reduce the incidence to a very large extent implying the incidence varied according to treatment. The result also indicated that a pattern was established to show that above 20% incidence becomes critical to ginger yield and could adversely affect the economic returns to the enterprise. Controlling yellow leaf spot increases cost of production but its economic implications depends on severity and level of applications of selected treatment. Based on the findings of this study, administering Ridomyl at 7g/ monthly appear promising to control yellow leaf spot in the rainforest agro ecology of southeast Nigeria.

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Table 1: Treatments, yield and value of output in 2014 and 2016

Treatments	Yield (t/ha)		Value of output (₦M)	
	2014	2016	2014	2016
TR1(R. 7g/wkly)	10.42	8.67	1,563,000	1,300,500
TR2(R. 7g/ 2wkly)	11.83	9.7	1,744,500	1,455,000
TR3(R. 7g/ monthly)	12.00	21.67	1,800,000	3,250,500
TR4 (R. 6g/wkly)	16.67	6.1	2,500,500	915,000
TR5 (R. 6g/2wkly)	11.42	12.34	1,713,000	1,851,000
TR6(R. 6g/monthly)	7.50	6.1	1,125,000	915,000
TR7 (Z. 10g/wkly)	10.83	16.02	1,624,500	2,403,000
TR8 (Z. 10g/2wkly)	14.75	11.00	2,212,500	1,650,000
TR9(Z. 10g/monthly)	11.92	8.00	1,788,000	1,200,000
TR10(Z. 7.5g/wkly)	7.67	8.00	1,151,500	1,200,000
TR11(Z. 7.5g/2wkly)	8.00	14.02	1,200,000	2,103,000
TR12(Z. 7.5g/monthly)	10,42	13.00	1,563,000	1,950,000
TR13 (control)	11.58	9.67	1,737,000	1,450,500

Table 2: Treatment and Incidence of yellow leaf spot in 2014 and 2016

Treatments	Disease Incidence Count		Percentage Incidence	
	2014	2016	2014	2016
TR1(R. 7g/wkly)	23	13	21.4	11
TR2(R. 7g/ 2wkly)	23	15	21.4	14
TR3(R. 7g/ monthly)	23	11	21.4	9
TR4 (R. 6g/wkly)	19	12	17.6	18
TR5 (R. 6g/2wkly)	27	16	25.7	11
TR6(R. 6g/monthly)	35	15	33.3	25
TR7 (Z. 10g/wkly)	18	18	16.6	12
TR8 (Z. 10g/2wkly)	20	14	18.5	11
TR9(Z. 10g/monthly)	19	21	16.6	18
TR10(Z. 7.5g/wkly)	20	15	18.5	16
TR11(Z. 7.5g/2wkly)	25	15	23.8	10
TR12(Z. 7.5g/monthly)	15	15	13.8	10
TR13 (control)	22	18	20.9	19

Table 3: Mean yield, value of output and incidence of yellow leaf spot

Treatments	Yield (t/ha)	Value of yield (₦)	Incidence of yellow leaf spot	% incidence of yellow leaf spot
TR1(R. 7g/wkly)	9.5	1,425,000	18	16.2
TR2(R. 7g/ 2wkly)	10.8	1,620,000	19	17.7
TR3(R. 7g/ monthly)	16.8	2,520,000	21	14.2
TR4 (R. 6g/wkly)	11.4	1710,000	15	17.8
TR5 (R. 6g/2wkly)	11.9	1,785,000	22	18.35
TR6(R. 6g/monthly)	6.8	1,020,000	25	29.15
TR7 (Z. 10g/wkly)	13.43	2,014,000	18	12.3
TR8 (Z. 10g/2wkly)	12.9	1,935,000	17	13.75
TR9(Z. 10g/monthly)	10	1,500,000	20	17.3
TR10(Z. 7.5g/wkly)	7.8	1,170,000	17	17.25
TR11(Z. 7.5g/2wkly)	11.1	1,665,500	20	16.9
TR12(Z. 7.5g/monthly)	11.7	1,755,000	15	11.9
TR13 (control)	10.6	1,590,000	20	19.95

Table 4: Cost of Controlling Yellow Leaf Spot using Ridomyl and Z- Force

Treatments	Cost Of Fungicide/Ha (₦)	Cost Of Labour (₦)	Total Cost of Application (₦)	Value Of Output (₦)	Gross Income (₦)
TR1	93,000	32,000	125,000	1,425,000	1,300,000
TR2	47,000	16,000	63,000	1,620,000	1,557,000
TR3	23,500	8,000	31,500	2,520,000	2,488,500
TR4	80,000	32,000	112,000	1,710,000	1,598,000
TR5	40,000	16,000	56,000	1,785,000	1,729,000
TR6	20,000	8,000	28,000	1,020,000	992,000
TR7	42,560	32,000	74,560	2,014,000	1,939,440
TR8	21,440	16,000	37,440	1,935,500	1,897,560
TR9	10,560	8,000	18,560	1,500,000	1,481,440
TR10	32,000	32,000	64,000	1,170,000	1,106,000
TR11	16,000	16,000	32,000	1,665,000	1,633,000
TR12	8,000	8,000	16,000	1,755,000	1,739,000
TR13	-	-	-	1,590,000	1,590,000

Table 5: Paired t-test on yield (t/ha)

Variable	Obs	Mean	Std. Err.	Std. Dev.
Yield in 2016	13	11.15462	.7249639	2.613894
Yield in 2014	13	11.09923	1.210915	4.366015
combined	26	11.12692	.6914359	3.525645
diff		.0553846	1.411342	-2.857483

t-value = 0.0392
degrees of freedom = 24
H_1: mean(diff) ≠ 0
Pr(|T| > |t|) = 0.9690

Table 6: Paired t-test on Output value (₦M)

Variable	Obs	Mean	Std. Err.	Std. Dev.
Output value for 2016 (₦M)	13	1670962	108559.1	391415.4
Output value for 2014(₦M)	13	1664885	181637.2	654902.3
combined	26	1667923	103667.2	528601.1
diff		6076.923	211606.1	-430656.7

T value = 0.0287
degrees of freedom = 24
H_1: mean(diff) ≠ 0
Pr(|T| > |t|) = 0.9773

Table 7: Paired t-test on Disease Incidence Count

Variable	Obs	Mean	Std. Err.	Std. Dev.
Disease Incidence Count for 2016	13	15.23077	.7351421	2.650593
Disease Incidence Count for 2014	13	22.23077	1.37819	4.969136
diff	13	-7	1.644727	5.930149

t = -4.2560
degrees of freedom = 12
H_1: mean(diff) ≠ 0
Pr(|T| > |t|) = 0.0011