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Full Length Research Paper

Effect of NPK fertilization on yield and inflorescence blight of cashew (*Anacardium occidentale*)

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Application of three levels of nitrogen as Urea (0, 60 and 120 kg/ha), phosphorus as single super phosphate (SSP) (0, 72 and 144 kg/ha) and potassium as muriate of potash (MOP) (0, 24 and 48 kg/ha) fertilizers on inflorescence blight of cashew caused by *Lasiodiplodia theobromae* and yield of cashew were studied on acid sand soils of Ochaja, Nigeria in 2000 and 2001. Results showed that single application of SSP at 144 kg/ha significantly reduced infection and slightly increased yield during the second year. Combination of urea at 120 kg/ha with MOP at 48 kg/ha gave the highest yield of 3.53 kg/tree and lowest disease infection (90 inflorescence panicles infected) for the first year, while NPK fertilizer when applied as urea at 60 kg/ha, SSP at 144 Kg/ha and MOP at 24 kg/ha gave the highest yield for the second year and significantly reduced the disease infection (125 inflorescence panicles infected). Appropriate management of NPK fertilizers leading to a reduction in infection of inflorescence blight and increase in yield is an additional tool for minimizing the use of pesticides on cashew.

Key words: *Anacardium occidentale*, cashew, fertilizer, inflorescence blight, yield.

INTRODUCTION

Cashew, *Anacardium occidentale* L. is an important commodity cash crop which grows in most agro-ecological zone of Nigeria, right from the coast in the south to the sub-desert areas of the North (Topper et al., 2001). It has tremendous potential as a cash crop to generate foreign exchange, create employment, to curb desertification in the Northern states, while ornamental and alley trees are used to prevent soil erosion by protecting the watersheds and dams in the South.

Inflorescence blight caused by *Lasiodiplodia theobromae* is one of the major limiting factors in cashew production, causing about 40 - 45% crop loss annually (Ohler, 1979; Olunloyo, 1979). The symptoms include withering of petals and other parts of the flower, followed by a progressive dieback of small peduncles from the tips and downward to the main floral shoots (Adejumo, 2005). The disease spreads through insects which create wounds and predisposes inflorescence axes to infection. Among the effective ways of managing this disease are the use of resistant varieties, chemicals and botanicals (Adejumo and Otuonye, 2002; Adejumo, 2005). Cashew is grown as a casual crop by smallholder farmers and as a result its fertilizer requirements are overlooked. The trees are long standing and frequently grown in poor qua-lity soils, which become depleted and results in decline productivity. Yields of trees grown in this way are very much lower than the potential that could be gained if fertilizer was applied (FAO, 2004) . Azam- Ali and Judge (2001) reported that potential yield of 10 to 15 kg per tree could be obtained under optimum conditions.

The objective of this experiment was to assess the effect of NPK fertilizers, singly and in combinations on inflorescence blight infection and yield of cashew on acid sand soils of Ochaja, Nigeria.

MATERIALS AND METHODS

The experiment was carried out in the South West 4 plots occu-pying 2 ha at Ochaja substation of the Cocoa Research Institute of Nigeria, Ibadan. The cashew cultivars were planted in 1982 and maintained at a plant density of 120 trees/ha. The fertilizers applied were urea (nitrogen source) applied at 0, 500 and 1000 g per tree (or 0, 60 and 12 kg/ha); single super phosphate (phosphorus source) at 0.600 and 1200 g per tree (0, 72, and 144 kg/ha) and muriate of potash (potassium source) at 0, 200 and 400 g per tree (0, 24 and 48 kg/ha) in a 3 x 3 factorial experimental with a total of 27 treatments.

Each treatment combination was replicated 5 times with one tree per treatment. Fertilizer was applied after weeding and cleaning of the base of the individual trees within a 1 - 2 m radius, the fertilizer was broadcast in a circular strip (1 - 1.5 m wide) and about 0.5 - 1.0 m away from the base of the tree. All the treatment combinations

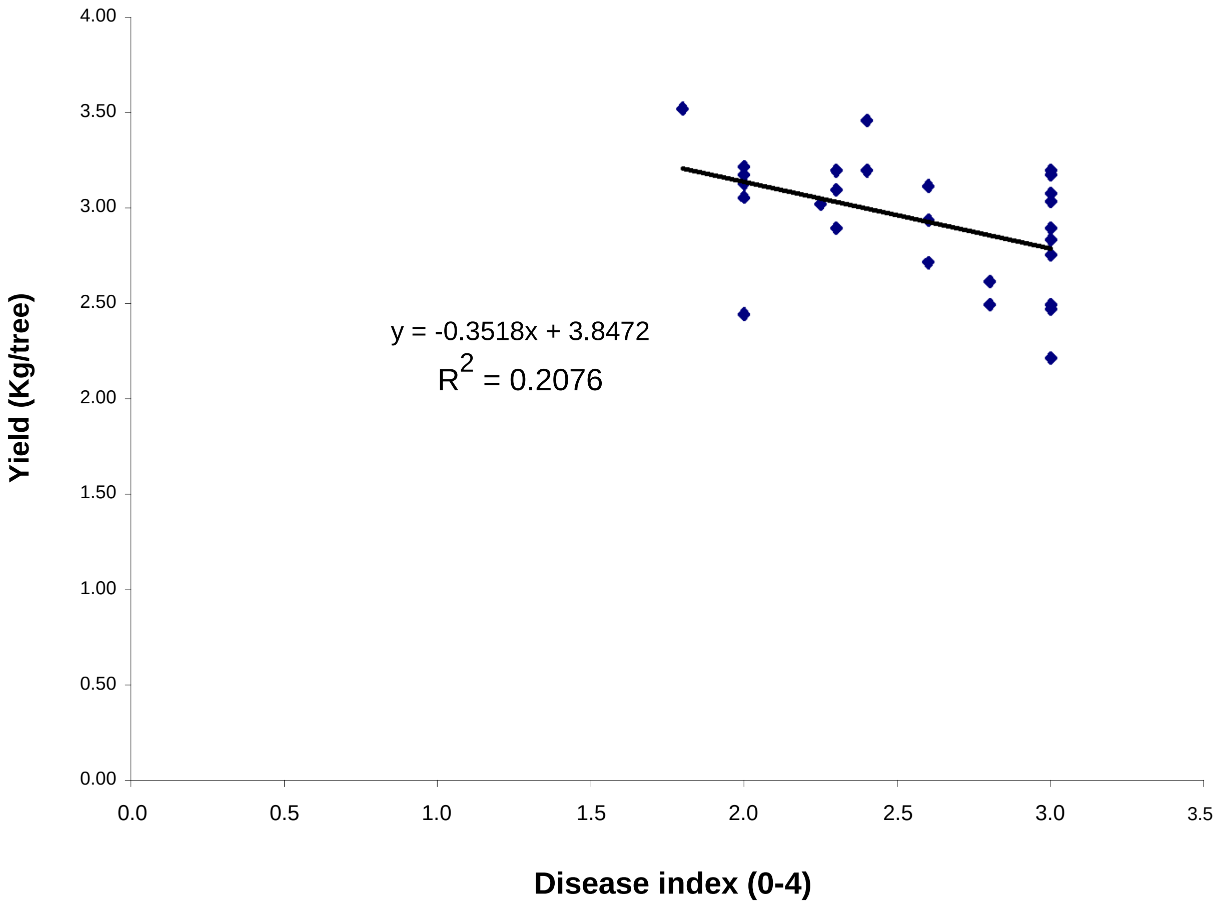

Figure 1. Correlation of inflorescence blight with yield for year 1.

were applied during the rainy seasons. Inflorescence infection was assessed on a disease rating scale of 0 to 4, where 0 = no floral infection, 1 = one to one hundred inflorescence panicles infec-ted (1 - 100), 2 = between one hundred and one to one hundred and fifty panicles infected (101 - 150), 3 = between one hundred and fifty one and two hundred inflorescences infected (151 - 200), while 4 = over two hundred and one inflorescence panicles infected.

Statistical analysis

The two-year data on disease index and yield were arcsine trans-formed and analyses of variance (ANOVA) were performed using Statistix 8.1 analytical software. Tukey HSD all-pair wise compare-sons test at 5% significance level was used to compare the means. Pearson correlation was used to evaluate the strength of the relationships between the disease index and cashew yield.

RESULTS

The results in Table 1 show the floral infection intensity and yield in relation to fertilizer application for years 1 and 2. For the first year, the data shows that only single application of potassium as muriate of potash (MOP) at 24 kg/ha showed slight increase in yield over the control, 3.22 kg/tree as against 3.19 kg/tree for control and 100 inflorescence panicles infected over 150 inflorescence panicles for control. The interaction of PK, NK, NP and NPK also showed increase in yield over the control as 3.20, 3.53, 3.20, and 3.46 kg per tree, respectively. Single application of MOP at 24 kg/tree and urea at 60 Kg/ha also showed a decrease in disease infection of inflorescence blight over the control (190 inflorescence panicles infected). The interaction of PK, NP, NK and NPK showed appreciable decrease in disease infection, with the least floral index of 1.8 (90 inflorescence panicles infected) when Urea at 120 kg/ha was combined with MOP at 48 kg/ha. It was observed that the highest yield of 3.53 kg/ha was obtained when the disease infection was the lowest (90 inflorescence panicles infected). Despite that increase in yield and reduction in disease infection of inflorescence blight was observed as a result of the fertilizer application, the differences were not significant.

The correlation coefficient (r) = 0.45 indicates that as cashew yield increases, disease infection decreases. Figure 1 shows the graph of correlation of disease index with yield for year 1 with R^2 value of 0.21. This means that 21% of the variance in disease index can be explained by variation in yield and vice versa, and that

Table 1. Results of Years 1 and 2 of infection of inflorescence blight disease and yield of cashew.

No.	Treatments	Year 1		Year 2	
		[1]Disease index (0 - 4)	Mean yield (kg/tree)	[1]Disease index (0 - 4)	Mean yield (kg/tree)
1	$N_0P_0 K_0$	4.0a	3.19	3.4 ab[3]	2.00 ab
2	$N_0P_0K_1$	2.0a	3.22	2.8 abcd	2.00 ab
3	$N_0P_0K_2$	3.0a	2.84	2.4 bcd	2.20 ab
4	$N_0P_1 K_0$	3.0a	2.76	2.6 abcd	2.50 ab
5	$N_0P_1K_1$	2.3a	3.20	2.6 abcd	2.50 ab
6	$N_0P_1 K_2$	2.0a	3.18	2.2 cd	1.80 ab
7	$N_0 P_2 K_0$	3.0a	3.04	2.0 d	2.30 ab
8	$N_0 P_2K_1$	3.0a	3.08	2.4 bcd	1.70 ab
9	$N_0 P_2 K_2$	2.8a	2.50	3.6 a	2.20 ab
10	$N_1 P_0 K_0$	2.0a	2.45	2.5 abcd	3.00 ab
11	$N_1 P_0K_1$	3.0a	2.48	3.0 abcd	2.20 ab
12	$N_1 P_0 K_2$	3.0a	3.18	2.6 abcd	2.20 ab
13	$N_1P_1 K_0$	3.0a	2.90	3.0 abcd	3.30 a
14	$N_1P_1K_1$	3.0a	2.22	2.8 abcd	2.30 ab
15	$N_1P_1 K_2$	2.3a	2.90	2.3 cd	2.30 ab
16	$N_1 P_2 K_0$	2.0a	3.06	2.6 abcd	1.60 ab
17	$N_1 P_2K_1$	2.3a	3.10	2.3 cd	3.60 a
18	$N_1 P_2 K_2$	2.0a	3.13	3.3 abc	2.10 ab
19	$N_2 P_0 K_0$	3.0a	2.50	2.8 abcd	2.60 ab
20	$N_2 P_0K_1$	2.6a	2.94	2.4 bcd	2.20 ab
21	$N_2 P_0 K_2$	1.8a	3.53	2.3 cd	2.96 ab
22	$N_2P_1K_0$	2.4a	3.20	3.6 a	2.56 ab
23	$N_2P_1K_1$	2.6a	2.72	2.8 abcd	1.84 ab
24	$N_2 P_1K_2$	2.8a	2.62	2.0 d	1.04 b
25	$N_2P_2 K_0$	2.6a	3.12	2.4 bcd	1.22 b
26	$N_2P_2K_1$	2.4a	3.46	2.2 cd	2.44 ab
27	$N_2P_2K_2$	2.3a	3.02	2.3 cd	2.32 ab
CV (%)		19.3	26.7	27.1	59.0
Error mean square		0.2526	0.6231	0.5016	1.7757

[1]Mean disease incidence (0 - 4) in five replications.
[2]Mean Yield (kg/tree) in five replications.
[3] The same letter(s) on each column are not significantly different at P = 0.05.
N levels in 3 × 3 factorial experiment: N_0 = 0 g, N_1= 500 g, N_2 = 1000 g Urea/ tree (0, 60 and 120 Kg/ha).
P levels in 3 × 3 factorial experiment: P_0 = 0 g, P_1= 600 g, P_2 = 1200 g SSP/ tree (0, 72 and 144 Kg/ha).

21% of the variance is shared between disease index of inflorescence blight and cashew yield. Results for the second year (Table 1) show that single and combined applications of fertilizer had significant effect on both the disease index and cashew yield. Single application of MOP at 48 kg/ha, SSP at both 72 kg/ha and 144 kg/ha, urea at both 60 and 120 kg/ha gave 2.20, 2.50, 2.30, 3.00 and 2.60 kg/tree, respectively.

This observed appreciable increase in yield over the control of 2.00 kg/tree was not significantly different at P = 0.05. However, a significantly different (reduced) floral infection of inflorescence blight (100 inflorescence panicles infected) was observed when SSP was applied singly at 144 kg/ha.

The interaction of PK (yield of 2.50 kg/tree and disease infection of 130 inflorescence panicles infected were obtained when SSP was applied at 72 kg/ha with MOP at 24 kg/ha), NK (urea at 120 kg/ha and MOP at 48 kg/ha), NP (urea at 60 kg/ha and SSP at 72 kg/ha) showed increase in yield and reduction in floral infection of inflorescence blight over the control. The highest yield of 3.60 kg/tree and reduction in floral infection of inflorescence blight was obtained when combined application (NPK) of Urea at 60 kg/ha, SSP at 144 kg/ha and MOP at 24 kg/ha were applied. At this fertilizer level, floral infection of inflorescence blight was significantly reduced to 115 inflorescence panicles infected at P = 0.05. Lowest floral infection of 100 inflorescence panicles infected was observed when SSP was applied singly at 144 kg/ha and combination of Urea at 120 kg/ha, SSP at 72 kg/ha and MOP at 48 kg/ha. However, the latter did not produce a corresponding increase in the yield of cashew.

DISCUSSION

Applications of nutrients to crops are to avoid plant stress, which may allow crops to better withstand pathogen attack, and to manipulate nutrients to the advantage of the plant and disadvantage of the pathogen (Palti, 1981). It is known that an understanding of disease interactions with each specific nutrient, the effects on the plant, pathogen and the environment can be effectively modified to improve disease control, enhance production efficiency and increase crop quality (Walters and Bingham, 2007).

Soils of the cashew growing areas in Ochaja, Kogi state, Nigeria have low levels of exchangeable bases, nitrogen and phosphorus (Falade, 1978) indicating that possible response to fertilizer by cashew crop was possible. The report in this experiment that urea at 120 kg/ha when combined with MOP at 48 Kg/ha gave the highest yield of 3.53 kg/tree and lowest disease infection (90 inflorescence panicles infected) for the first year agree with the report of Katan (2009) that NO_3 nutrition stimulates K uptake and vice versa promoting the synthesis of organic N compounds. The author highlighted that blast severity in rice was low when there was a high K:N ratio in leaf tissue, whereas a low K: N ratio increased the disease.

NPK fertilizer when applied as urea at 60 kg/ha, SSP at 144 Kg/ha and MOP at 24 kg/ha gave the highest yield for the second year and reduced disease infection (125 inflorescence panicles infected) significantly. This might be attributed to a balanced NPK nutrition, especially SSP at high concentrations. Mineral nutrients may reduce the incidence of diseases in certain cases or increase them in others, depending on the particular mineral nutrient, the host plant, the pathogen and other factors. Appropriate management which takes into account fertilizer form and rates, and time and mode of application, has the potential to achieve high crop productivity while reducing the incidence of diseases, or at least avoiding their increase (Katan, 2009). The observation of increased yield and reduced disease infection of single application of urea at 60 and 120 kg/ha and SSP at 72 and 144 kg/ha observed for the second year was not surprising. Nitrogen is the most commonly used fertilizer and is essential for the production of many cellular components (Huber and Thompson, 2007). The rapid rate of nitrification in cultivated soils provides nitrate (NO_3) for plant uptake which is internally reduced to amino acids prior to utilization by cells. The two forms of nitrogen absorbed by the plants in either a reduced or an oxidized form can have a profound effect on diseases.

The uptake and assimilation of nitrate leads to an increase in pH at the root/soil interface, the rhizosphere, whereas with ammonium (NH_4) nutrition, the rhizosphere is acidified. Phosphorus is an essential element of the building blocks of life, the ribonucleic acids (RNA), as well as being required for many additional biochemical and physiological processes including energy transfer, protein metabolism and other functions (Prabhu et al., 2007a). Addition of Phosphorus has been found to have predominantly beneficial effect on disease reduction. Phosphorus supplied in adequate amounts and in the appropriate form and methods of application has been reported to reduce disease incidence of some rusts and other foliar diseases, beneficial in counteracting high levels of nitrogen, suppressed *Fusarium* wilt in tomato at pH 7.0 and 7.5 and decreased severity of *Rhizoctonia* disease in soybean (Katan, 2009). Potassium application has been shown to reduce the incidence of both foliar and soil-borne diseases like *Verticillium* wilt; deficiency also pre-disposes cotton to *Fusarium* wilt (Prabbu et al., 2007b).

It was observed that there were decreased and increased disease infections on different fertilizer levels. This probably might be because of the inadequate methods of application of the fertilizers and limited knowledge of the nature of the interactions between the mineral nutrients and plant disease. Koike et al. (2000) reported that selection and application of fertilizers can influence disease development, while Huber and Thompson (2007) highlighted that contradictions in reports of the effects of mineral nutrients on diseases may result from failure to recognize the different effects of the various forms, rate of application, time of application and soil conditions. Although, excessive use of nitrogen fertilizers can result in leaf growth that is overly succulent and more susceptible to some diseases low yields were observed in the second year compared to the first year. This might be due to imbalanced nutrition, soil moisture and low fertilizer response due to early stoppage of rain during the second year. Tree crops are also known to show appreciable response to fertilizer application only after three years.

Fertilizer application has been used to control plant diseases of vegetables and crops. Woltz and Jones (1973) reported that tomato studies showed better *Fusarium* wilt control when nitrogen was used in soil with high pH. The nitrate nitrogen form also produced the lowest levels of *Fusarium* on chrysanthemum, king asters and carnations (Woltz and Ebgelhard, 1973).

This is the first available report of the use of fertilizers to reduce disease infection of cashew in Nigeria. Adequate crop nutrition makes plants to be more tolerant or resistant to disease, while the nutrient status of the soil, the use of particular fertilizers and amendments can have significant impact on the pathogen’s environment (NCAT, 2004). Regular application of major plant nutrients (nitrogen, potassium and phosphorus) is beneficial for healthy trees and increased yields in cashew (Fernandopulle, 2000; FAO, 2004) . Further research on the influence of fertilizers on plant diseases in nutrient deficient soils is therefore important; this is because this approach is more environmentally friendly than the use of costly and harmful pesticides to control the disease.

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