Ife Journal of Agriculture, 2024, Volume 36, Number 1

EFFECT OF FERTILIZER ON INCIDENCE AND SEVERITY OF *CERCOSPORA* LEAF SPOT AND YIELD-RELATED TRAITS OF KENAF (*HIBISCUS CANNABINUS* L.)

***ODUWAYE O. F. AND OLANIPEKUN S. O.**

Institute of Agricultural Research and Training, P. M. B. 5029, Obafemi Awolowo University, Moor plantation Ibadan.
**Corresponding author: bussyfa@gmail.com; +2348033234947*

ABSTRACT

Kenaf (Hibiscus cannabinus L.) is a herbaceous dicotyledonous with many industrial applications, however, its production is affected by several factors including soil nutrients and diseases. The use of fertilizer type and rate to minimize disease incidence is important. The experiment was carried out to evaluate the effect of organic and inorganic fertilizers on the incidence and severity of Cercospora leaf spot as well as yield-related traits of kenaf. Ifeken DI 400 was planted at the spacing of 0.2 m within the row and 0.5 m apart and commercially produced organic and inorganic fertiliser was applied each at 0, 70, 100, 130 and 170 kg/ha. The experiment was laid out in a randomized complete block design with three replicates. Data were collected on plant height, core yield bast yield, total yield, disease incidence and disease severity. Phytochemical analysis of the soil samples and fertilisers was carried out. Data collected were subjected to analysis of variance. means were separated using Duncan's multiple-range test. The highest core, bast and total yield of 133.97 kg/ha, 219.19 kg/ha and 353.14 kg/ha respectively were obtained from kenaf plants treated with 170kg/ha of organic fertiliser and plant height of 214.64 cm. The highest incidence of Cercospora leaf spot was observed with kenaf plants treated with 130kg/ha of NPK, while there was no correlation between the disease incidence and inorganic fertilizer. In conclusion, a higher rate of NPK above 130kg/ha only increased the disease incidence but did not increase the yield of the crop.

Keywords: ***Cercospora, Fertiliser, Incidence, Kenaf, Leaf spot.***

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is an annual dicotyledonous and herbaceous plant (Maganha *et al.,* 2010), it belongs to the Malvaceae family and the Hibiscus genus (Mussig, 2010), a family notable for both its economic and horticultural importance (Akinrotimi and Okocha, 2018). Kenaf (*Hibiscus cannabinus* L) is an indigenous African crop. It is one of the quick-growing plants, C3 plant (three carbon compound) and gaining world prominence because of its fibre which can be utilized as raw material in the pulp and paper industry and also in the sack manufacturing and cordage industries (Hossain *et al*., 2011).

Despite its industrial uses, kenaf cultivation in Africa has been constrained to small areas of production with attendant low yield per unit land area, as low as 0.04% of the global production is being recorded in Africa (FAO, 2022). This might be associated with the effect of diseases on the crop. *Cercospora* leaf spot disease is an important disease of kenaf (Park *et al*., 2017), occurring in areas with high humidity throughout the stages of its production, leaf defoliation as a result of the disease infestation results in leaf loss of between 25% and 43% which disrupt the photosynthetic process resulting in lower yield.

The poor fertility status due to continuous land cultivation which is a regular practice in most African countries affects plant growth adversely. Adequate mineral nutrition in the soil is of utmost importance in crop production. They are essential for the growth and development of plants as well as microorganisms and are important factors in plant-disease interactions. The influence of each nutrient on the response of plants to disease, whether positively or negatively, is unique to each plant-disease complex.

It is important to know how mineral nutrients in fertilisers affect disease incidence in plants to complement disease and pest control methods. Several disease control measures such as the use of synthetic and organic fungicides have been used to effectively control diseases (Gerken *et al*., 2001; Engindeniz and Ozturk, 2013). However, the use of synthetic fungicides is being discouraged because of their negative effect on the environment and human health (Engindeniz and Ozturk, 2013; Wagnitz, 2014; Zaker, 2016) this makes the adoption of organic means of disease control to spread widely. Organic means of disease control are eco-friendly posing no harm to human health and most of them are readily available. The use of fertiliser in disease management is being explored as organic control measure. This study is aimed at determining the effect of fertiliser type at varying rates on the incidence and severity of *Cercospora* leaf spot disease and related yield parameters of kenaf.

MATERIALS AND METHODS

Experimental sites

Field trials were carried out during the planting season of 2015 at the Experimental Farm of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Ibadan located at latitude 07^o 38` N and longitude $003^o$ 84` an altitude of 182 m above sea level within the Derived Savanna agro-ecological zone of Nigeria. The laboratory study was conducted at the Pathology Laboratory of the Institute.

Land preparation and experimental design

The experimental field was ploughed and harrowed. The treatments were arranged in split plots and fitted into a Randomized Complete Block Design with three replicates. The main plots were for the fertiliser types while subplots were for the fertiliser rates.

Soil sample analysis

Surface soil samples were randomly collected at a depth of 0-15 cm, bulked and sub-samples were taken for soil analysis before the commencement of the experiment. The samples were air-dried and sieved through a 2.0 mm mesh sieve and another part with a 0.5 mm mesh sieve (for organic carbon). The samples were then analyzed for total nitrogen, pH, organic carbon, available P, exchangeable Ca, K, Na and Mg. Total N and organic carbon in soil were determined by Kjedahl (Bremmer, 1965) and Walkey black procedure (Nelson and Sommer, 1982). Soil pH was measured using a 1:1 (W/V) soil/water suspension ratio. Available phosphorus was analyzed by the bray1 P- method (Bray and Kurtz, 1945). Potassium, Ca and Mg were first extracted using neutral normal NH4OAC pH 7. Thereafter K and Na were determined by flame photometry; Mg and Ca by atomic absorption spectrophotometry and Effective Cation Exchange Capacity (ECEC) was determined as the sum of the exchangeable bases and exchangeable acidity. All soil analyses were done using the standard analytical laboratory procedure of IITA (IITA, 1984).

Source and nutrient composition of the organic fertiliser used for the experiment

The organic fertiliser used for the experiment was sourced from a commercially produced organic fertiliser plant at the Aleshinloye Market (Grade B Paste setter fertiliser), Ibadan**.** It was composed of municipal waste and cow dung. Composting involves the conventional method where the process depends on the microorganism from the environment alone. This compost takes about three months to mature and the compost after preparation was bagged in 50 kg weight. The compost is kept in a dry but well-ventilated place away from moisture by arranging it on a raised platform. Samples were randomly taken from various bags of the organic fertiliser (OF), bulked and sub-sampled for chemical analysis. The OF material was digested with a mixture of perchloric, nitric and concentrated Sulphuric acids. P was determined from digest by vanado-molybdate yellow colour procedure (Olsen and Dean, 1965), while the bases; K, Ca, Mg and Na, as well as the micronutrients; Fe, Zn, Cu and Mn in the digest were read with the Atomic Absorption Spectrophotometer (Model Bulk Scientific NV 210/211).

Planting and field management

Kenaf variety seeds were sourced from the Kenaf and Jute Improvement program, IAR&T (Ifeken DI 400) and planted at a depth not deeper than 0.5 cm with a spacing of 0.2 m within the row and 0.5 m apart. The plants were later thinned to 2 plants per stand to give a total number of 60 plants per plot equivalent to a plant population of 277,000/ha. Planting was done after rain was established. Weeding was done twice at 3 and 6 weeks after sowing (WAS) while insect pest was controlled using Lambda-cyhalothrin applied as Laraforce.

Fertiliser treatments

The following quantities of organic fertiliser (OF) were applied 0, 6.36, 9.09, 11.82 and 14.55 kg per plot and thoroughly mixed with the soil two weeks before sowing. At two weeks after sowing, the following quantity of NPK 20-10-10: 0, 0.42, 0.60, 0.78 and 0.96 kg per plot were applied to the plots designated for inorganic fertiliser (IF). Both organic and inorganic fertilisers applied were expected to release 0, 70, 100, 130 and 160 kg N/ha.

Data collection and analysis

A total of ten plants per treatment were randomly selected per plot away from the borderline and tagged for data collection. Plant height (cm) was measured as the length of the plant from the soil surface to the tip of the stem using a meter rule. Stem diameter (cm) was measured at the middle of the plant using a vernier calliper. Fibre yield (g) was measured at harvest (10 weeks after sowing), when plants within 1 m^2 from each replicate were cut from the inner row of the plant in such a way as to avoid the border effect. The leaves were removed and whole stems were subjected to water retting. The plants were submerged in water for 14 days, after which the fibres were skinned from the core and then washed with running water, dried and weighed for bast.

Core yield (g) was measured by oven drying the core at 60°C until no further weight loss was observed. Weight was determined after the drying process as core yield measurement. Seed yield and yield components were recorded 150 days after sowing (when more than 80% of the capsules were already dried but before the seed started to shatter), the plants were cut at about 2 m above the ground and packed under the shed for further processes. The total seed weight (t ha^{-1}) was recorded per plot. Disease assessment was done at 8WAP by determining the disease incidence per treatment. Disease severity was also determined using the scale provided in Table 1 on three of the tagged plants and the mean was calculated. Symptomatic leaves were also collected for further work in the laboratory.

The data obtained were subjected to analysis of variance (ANOVA) and the means were separated using Duncan's multiple range test (DMRT) at a 5 % level of probability.

Laboratory experiment

Sterilisation of leaf samples and Preparation of Potato dextrose agar (PDA)

Symptomized leaves collected from the field were cut into small pieces about 2mm from the advancing margins of lesions and a healthy portion and surface were sterilized in 1% sodium hypochlorate, followed by five serial washing with sterile distilled water. The offcuts were placed on sterile blotter paper to dry.

Potato dextrose agar was used as a medium for the isolation. This was prepared by adding 3.9 g of PDA into a conical flask containing 100 ml of sterile distilled water. The flask was swirled gently to allow the PDA to dissolve, the mixture was sterilized in an autoclave for 15 min at a temperature of 121^0C and pressure of 15 lb. The PDA was augmented with 300 µg/l streptomycin after cooling and then dispensed into 90mm sterile Petri dishes for further use.

Table 1: Disease severity rating for leaf spot disease symptoms

Score	Observation	Severity description
0	No trace of infection	No disease
1	Small lesions on upper leaves	Trace infection
2	Small lesions on the upper and lower leaves	Slight infection
3	Advanced lesions on upper and or lower leaves, with or without new infections on the petiole	Moderate infection
4	Advanced lesions on upper and lower leaves, characterized by a dark to dark-brown spot with a whitish to straw-coloured or perforated centre;	Severe infection
5	Advanced lesions on upper and lower leaves, buds and petioles are characterized by a dark to dark-brown spot with a perforated centre.	Very severe infection

Anjorin *et al*. (2013) with modification

Isolation and identification of fungal isolates

The sterilized leaf samples were inoculated on streptomycin-modified PDA. Inoculated plates were incubated at 27 ± 1ºC for seven days. Developing fungal colonies were purified by the hyphal tip cut method to obtain a pure culture of the isolates. Colony size and texture, surface and reverse colour, zonation of furrow and pigmentation were observed and samples of conidia were mounted on glass and viewed under a compound microscope (Leica Microsystems) for the conidia shape. Identification guides by Watanabe (2002), Dugan (2008) and Barnett and Hunter (2010) were used to identify the fungal isolates.

Pathogenicity test of the fungal isolates

A pathogenicity test was carried out to confirm the causal pathogen of leaf spot disease of kenaf. The experiment was carried out in the screen house of IAR&T. Four weeks kenaf plants were sprayed with conidia of each fungus according to Oduwaye and Enikuomehin, (2013). After spraying, each plant was covered with a transparent polythene bag for 48 hours, all treatments were laid out in a complete randomized design with three replicates.

Disease assessment was carried out using visual observation for the presence or absence of symptoms. Symptomised portions were taken to the laboratory for re-isolation, a colony of the fungal isolates was compared with the original cultures of each fungal species.

RESULTS

The results of the soil analysis are presented in Table 2. The physical and chemical analyses showed that the soil pH (H_2O) is 6.08, and the organic carbon content in the soil is 14.9 g/kg. These values were considered medium to moderately high according to the soil fertility maps of Nigeria. The available P is 4.29 mg/kg. The soils used were generally low in P considering 7 mg/kg to 20 mg/kg as moderate. The exchangeable Ca is 2.50 mg/kg, exchangeable K is 0.62 cmol/kg and the effective cation exchange capacity is 4.66 cmol/kg. These values were low in the soil used. The soil was sandy loam with a high proportion of sand (766kg), Silt (69.2kg) and clay (164.8kg).

Nutrient content of the organic fertiliser used

The organic fertiliser used which was from a commercially produced organic plant at Aleshiloye market shows appreciable levels of various elements. The total nitrogen, available phosphorus and carbon content were 1.32 g/kg, 0.86 g/kg and 31.94 g/kg respectively. The exchangeable cations (Ca^{2+}, Mg^{2+} and K^{+}) were 2.34, 0.24 and 0.5 cmol/kg respectively with appreciable levels of micronutrients such as Na^{+}, Mn^{+}, Fe^{2+}, Cu^{+} and Zn^{+} present (Table 3)

Effect of fertiliser types and rates on kenaf yield parameters

Kenaf plants treated with 170kg of organic fertiliser gave a significantly high core yield, bast yield and seed yield. (Table 4). The tallest kenaf plants were also observed in the same plots however the yield observed in plots treated with NPK (170kg) though lower was not significantly different ($p \leq 0.05$) from the yield observed in plots treated with organic fertiliser at 170kg. A higher yield was observed in plants with organic fertiliser amendment.

Table 2: Physical and chemical properties of the soil of the experimental site

Parameters	Results
pH (H_2O)	6.08
Organic Carbon (g kg^{-1})	14.9
Total Nitrogen ((g kg^{-1})	1.3
Avail. P (mg kg^{-1})	4.29
Exchangeable cations (c mol kg^{-1})	
Ca^{++}	2.50
Mg^{++}	1.10
K^{+}	0.62
Na^{+}	0.34
Exchangeable acidity (c mol kg^{-1})	0.11
ECEC	4.66
Particle Size (g kg^{-1})	
Sand	766
Silt	69.2
Clay	164.8
Textural Class (USDA)	Sandy loam

Table 3: The nutrient analysis of the organic fertiliser used for the experiment

Parameter (%)	Value
N	1.32
P	0.86
C	31.94
Ca	2.34
Mg	0.24
K	0.5
Micronutrients (ppm)	
Na	29.61
Mn	106.67
Fe	891.39
Cu	16.98
Zn	1.99

Table 4. Effect of fertiliser type and rate on kenaf yield parameters

Fertiliser	Plant height (cm)	Core yield (kg/ha)	Bast yield (kg/ha)	Total Yield (kg/ha)
Control	177.52d	135.25d	77.63d	212.88f
NPK_70kg	190.63cd	175.9bcd	100.69bcd	257.59bcde
NPK_100kg	192.83bcd	166.26bcd	96.75bcd	263.01cdef
NPK_130kg	201.42ab	182.1abc	118.55ab	300.65abcd
NPK_170kg	212.19a	204.21ab	121.98ab	326.19ab
Org_70kg	210.4a	148.76cd	90.05d	238.81def
Org_100kg	213.2a	178.32abc	90.73cd	269.05bcdef
Org_130kg	209.02ab	201.17abc	116.59abc	317.75abc
Org_170kg	214.64a	219.17a	133.97a	353.14a

Means with the same alphabet along the columns are not significantly different (P<0.05) from each other.

Effect of fertiliser types and rates on leaf spot disease incidence and severity

Cercospora leaf spot disease of Kenaf is characterized by dark-red spots which later turn light brown to gray with a purplish border as the disease progresses with age (Plate 1). The pathogenicity test revealed *Cercospora* sp as the causal pathogen of the disease.

The disease incidence increased with an increase in the fertiliser quantity applied (Figure 1), as kenaf plants treated with 170kg of NPK and 170 kg of organic fertiliser showed a significantly ($p<0.05$) high incidence of the disease. The lowest incidence of leaf spot was observed in plots treated with 70kg of organic fertiliser.

DISCUSSION

The growth and yield of kenaf increase with an increased quantity of organic fertilizer applied. This observation is supported by the report of Ekhuemelo and Olatunji (2015) who reported an increase in the yield of pepper when poultry manure was applied. The significant increase in growth and yield of kenaf plants treated with organic fertilizer in the present study could be attributed to the ability of organic fertilizers to be retained in the soil compared with the chemical fertilizer (Ojo *et al*., 2014). Furthermore, Onunwa *et al*., (2021) reported that nutrients were more readily released by poultry manure hence achieving an increase in yield compared with other soil amendments.

The symptoms of the *Cercospora* leaf spot disease of kenaf observed in this study correlate with the report of Park *et al*., (2017), on the *Cercospora* leaf spot of kenaf in Korea. The report also confirmed *Cercopora* sp. as the causal pathogen, this corroborates the findings in this study that *Cercopora* sp. caused cercopora leaf spot disease of kenaf in southwest Nigeria.

The lowest incidence of leaf spot was observed in plots treated with 70kg of organic fertilizer. This observation is in line with the report of Ekhuemelo and Olatunji (2015) who reported that NPK fertilizer and poultry application significantly increased the incidence and severity of leaf spot on pepper plants in Makurdi. Furthermore, Ballini *et al*., (2013); Devadas *et al*., (2014); Huang *et al*., (2017) reported an increase in the incidence of downy mildew, powdery mildew and leaf rust of wheat and rice with an increase in Nitrogen. This might be because excessive use of N fertilization in plants promotes succulent tissue growth and alleviates apoplastic amino acid concentration along with improving the plant canopy, which ultimately favours the growth of pathogenic spores (Neumann *et al*., 2004; Dordas, 2008). However contrary results had been reported for gray mould of wheat and leaf spot of tomatoes (Krupinsky *et al*., 2007; Lecompte *et al*., 2010) in which the disease incidence decreased with an increase in NPK fertilizer.

Plate 1. Symptoms of *Cercospora* leaf spot disease of kenaf

The increase in kenaf yield despite the relatively high incidence observed could be attributed to the level of tolerance exhibited by the plant used in the study to leaf spot disease and nitrogen had been reported to allow greater tolerance of vegetative damage due to the slow release of the nitrogen to the plant (Echezona and Nganwuchu, 2006)

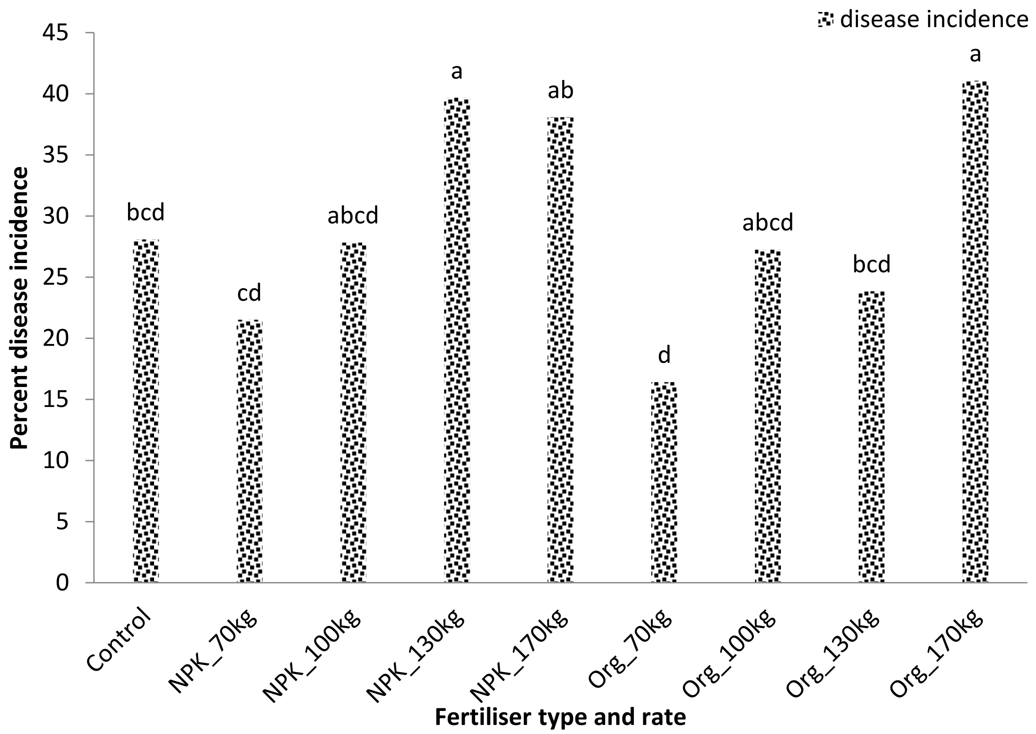

Figure 1. Effect of fertiliser types and fertiliser rates on leaf spot disease incidence of kenaf

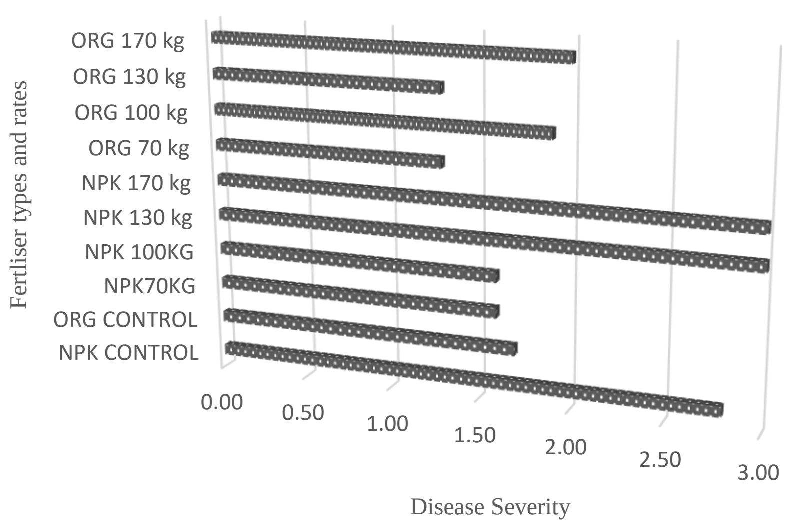

Figure 2. Effect of fertiliser type and fertiliser rates on severity of leaf spot disease of kenaf

CONCLUSION

A higher rate above 130 kg N/ha of inorganic fertiliser does not affect the yield of kenaf but increases the disease incidence hence, an additional increase in the quantity of fertiliser applied to the plant is of no benefit to the plant.

REFERENCES

Akinrotimi, C. A. and Okocha, P. I. (2018). Evaluation of genetic divergence in kenaf (*Hibiscus cannabinus* L.) genotypes using agro-morphological characteristics. *Journal of Plant Sciences and Agricultural Research*, 2(12): 1–10.

Anjorin, S. T., Jolaoso, M. A. and Golu, M. T. (2013). A Survey of incidence and severity of pests and diseases of okra (*Abelmoschus esculentus* L. Moench) and eggplant (*Solanum melongena* L.) in Abuja, Nigeria. *American Journal of Research Communication*, 1(11): 333-349.

Ballini, E., Nguyen, T. T., and Morel, J. B. (2013). Diversity and genetics of nitrogen-induced susceptibility to the blast fungus in rice and wheat. Rice 6:32. doi: 10.1186/1939-8433-6-32

Barnett, H. L. and Hunter, B. B. (2010). *Illustrated genera of imperfect fungi* 5th ed. Burgess Publishing Co. United States of America.

Bray, R. A. and L. T. Kurtz. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science*. 59:39-45

Bremmer, J. M. (1965). Total nitrogen in Method of Soil Analysis. Black, C. A. ed Agronomy 9. *American Society of Agronomy*. Madison. Wisconsin: 1141- 1174.

Devadas, R., Simpfendorfer, S., Backhouse, D., and Lamb, D. W. (2014). Effect of stripe rust on the yield response of wheat to nitrogen. *Crop Journal*, 2, 201–206.

Dordas, C.A., Lithourgidis, A.S., Matsi, T. and Barbayiannis, N. (2008) Application of Liquid Cattle Manure and Inorganic Fertilizers Affect Dry Matter, Nitrogen Accumulation, and Partitioning in Maize. *Nutrient Cycling in Agroecosystems*, 80, 283-296.

Dugan, F. M. (2008). The Identification of Fungi; an Illustrated introduction with keys, glossary, and guide to literature. Second printing, APS press.

Echezona, B. C. and Nganwuchu, O. G. (2006). Poultry manure application and varietal effects of chilli-pepper (Capsicum species) on insect pests and disease in a humid-tropical environment. Journal of Agriculture, Food, Environment and Extension 5(2): 49-58.

Ekhuemelo, C. and Olatunji, O. (2015). Effect of soil amendment on disease and yield of two pepper varieties in Makurdi, Benue State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 11: 75-81

Engindeniz, S. and Ozturk, G. C. (2013). An economic comparison of pesticide application for processing and table tomatoes, a case study for Turkey. *Journal of Plant Protection Research*, 53(3): 230-237.

Food and Agricultural Organization of United Nations (2022). Jute, kenaf, sisal, abaca, coir and allied fibres Statistical bulletin 2021. Rome.

(https://www.merriam-webster.com/dictionary/sawdust,https://en.wikipedia.org/wiki/Sawdust).

Gerken, A., Suglo, J. V. and Braun, M. (2001). Crop protection policy in Ghana. Pesticide Policy Project produced by Plant Protection and Regulatory Services Directorate of Ministry of Food and Agriculture, Accra, Ghana.

Hossain, M. D., Hanafi, H. J. and Hazandy, A. H. (2011). Growth yield and fibre morphology of kenaf (*Hibiscus cannanabinus* L.) grown on sandy bris soil as influenced by different levels of carbon. *African Journal of Biotechnology*, 10 (50): 10087–10094.

Huang, H., Nguyen Thi Thu, T., He, X., Gravot, A., Bernillon, S., Ballini, E., Morel J. B. (2017). Increase of fungal pathogenicity and role of plant glutamine in nitrogen-induced susceptibility (NIS) to rice blast. *Frontiers in Plant Science* 8:265. doi: 10.3389/fpls.2017.00265.

IITA. (1984). *Selected methods for Soil and Plant analysis* IITA Ibadan Nigeria.

Krupinsky, J. M., Halvorson, A. D., Tanaka, D. L., and Merrill, S. D. (2007). Nitrogen and tillage effects on wheat leaf spot diseases in the northern great plains. *Agronomy Journal* 99: 562–569.

Lecompte, F., Ali Abro, M., and Nicot, P. C. (2010). Contrasted responses of *Botrytis cinerea* isolates developing on tomato plants grown under different nitrogen nutrition regimes. *Plant Pathology*, 59: 891–899.

Maganha, E. G., Halmenschlager, R. C., Rosa, R. M., Henriques, J. A. P., Ramos, A. L. P. and Saffi, J. (2010). Pharmacological evidences for the extracts and secondary metabolites from plants of the genus *Hibiscus*. *Food Chemistry*, 118: 1–10.

Mussig, J. (2010). Industrial applications of natural fibers structure, properties and technical applications, 538. Bremen: John Wiley & Sons, Ltd, Amsterdam. University of Applied Science. 538pp.

Nelson, D.W. and Sommers, L.E. (1982). Organic carbon and soil extracts in: Methods of soil analysis. Part 2- Chemical and microbiological properties. Agronomy Monograph No. 9 (2^{nd} Edition). American society of Agronomy, *Soil Science Society of America*. Madison, WI, USA pp. 539-579.

Neumann S, Paveley N. D, Beed F. D. and Sylvester-Bradley R. (2004). Nitrogen per unit leaf area affects the upper asymptote of *Puccinia striiformis* f.sp *tritici* epidemics in winter wheat. *Plant Pathology* 53: 725–732.

Oduwaye, O. F. and Enikuomehin, O. A. (2013). Pathogenicity test of fungi associated with leaf spot disease of Sesame (*Sesamum indicum*) in Abeokuta South Western Nigeria. *Nigerian Journal of Plant Protection*, 27: 85-96.

Ojo, V. O. A., Dele, P. A., Olanite, J. A., Adeoye, S. A., Ajayi, S. O. and Idowu, O. M. O. (2013). Influence of manure type on the productivity of Pennisetum purpureum under different planting method and age.

Journal of Organic Agriculture and Environment 1 (1):71 -77.

Olsen, S.R. and L.A. Dean. (1965). Phosphorus. *Method of Soil Analysis*. Part 2. *Agronomy Monogram* 9, 2nd ed. Madison, Wisconsin: *Soil Science Society of America*. 1035-1049.

Onunwa A.O., Nwaiwu C.J., Nwankwor J.E., Emeh C.E., Madueke C.O. and Igwe C.A. (2021). Effects of four organic amendments on soil physiochemical properties and yield of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercrop in Awka, Southeastern Nigeria. *Agro-Science*. 20. 49-56.

Park, S., Choi, I., Lee, W., Lee, K., Galea, V. and Shin, H. (2017). Identification and characterization of *Cercospora malayensis* causing leaf spot on kenaf. *Mycobiology*, 45 (2): 114–118.

Wagnitz, J. J. (2014). Biopesticides use in IPM for low desert vegetable and fruit production, Paper AA13618603, Degree of Doctor of Plant Health, College of Agricultural Sciences and Natural Resources, ETD Collection for University of Nebraska, Lincoln.

Watanabe, T. (2002). Pictorial atlas of soil and seed fungi; morphologies of cultured fungi and key to species. Second Edition. CPC Press, pp 133-176.

Zaker, M. (2016). Natural plant products as eco-friendly fungicides for plant diseases control- A Review. *The Agriculturists*, 14 (1): 134-141.