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EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON FUNGAL DISEASES OF MAIZE IN A DERIVED SAVANNA

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Abstract
The effectiveness of fertilizer NPK 15:15:15 (NPK) and corresponding levels of an organic based fertilizer (OBD) on fungal diseases, growth and dry matter yields of maize (Zea mays) were compared in a pot experiment conducted at the University of Ibadan, Nigeria. The treatments were: 60, 120 and 180 kgN/ha from OBD fertilizer and NPK, and a control, arranged in a completely randomized design. Data collected on incidence, severity of fungal diseases and growth parameters were analysed with SAS 2004. The results showed that all the treatments had significant effects diseases severity at $P \leq 0.05$. Disease incidence increased with levels of OBD fertilizer; while increasing levels of NPK influenced the severity of attack by Curvularia leaf spot and anthracnose leaf blight disease with 180kgN/ha rate having the highest severity (3.50, 5.00). Increasing levels of OBD reduced the severity of Curvularia leaf spot and anthracnose leaf blight disease with 180kgN/ha of NPK having the lowest severity of Curvularia leaf spot (2.17). Plants treated with 60kgN/ha from NPK and 120kgN/ha of OBD had the highest total dry matter (58.5g/plant) and leaf area (4177cm^2/plant) respectively. OBD fertilizer could be considered as an alternative to inorganic fertilizer for good fungal disease prevention in maize production.
Keywords: NPK 15:15:15, OBD fertilizer, fungal diseases, severity, maize growth parameters

Introduction

Maize (*Zea mays* L.) is the most important cereal grown in sub-Saharan Africa, and Nigeria, and belongs to the grain producing monocotyledonous family, the *Poacea* (Campbell, 1985; Onuegbu and Oji- Isoma, 2000). It provides food and income to over 300 million resource-poor smallholders (IITA, 2010). In Nigeria, it is widely grown by peasant farmers because it is adaptable to various kinds of soil and climate, and has lots of uses as a staple food (Ogunbodede and Olakojo, 2001; Badmus and Ariyo, 2011). Presently small-scale farmers in Nigeria are faced with the challenge of low productivity due to several factors such as disease infestation and nutrient deficiencies; hence they manipulate the ecology of the soil by fertilizer addition to increase and improve the soil nutrient contents and equally increase yield (Osiname *et al*., 2000; Aduramigba-Modupe, 2017). Nutrient sources affect mineral balances and this could enhance or reduce host plant resistance by regulating the quality of food source for pathogens (Marschner, 1997). Likewise, certain physiological conditions increase the incidence and severity of disease, and can be mitigated by nutrient sources. Application of organic amendments which is one of the sources of nutrients improve soil functions such as infiltration, water holding capacity, nutrient retention and release, resistance to wind and water erosion (Brady and Weil, 2000) and suppress soil-borne diseases (Drinkwater *et al*., 1995). Disease suppression includes the reduction of both disease incidence and severity. High turn-over rates and relatively low residual mineral nutrients with minimal fluctuations is achieved following the application of organic amendments. Microbial community showed that the diversity of microorganisms, can be enhanced in soil fertilized with organic manure, as a result of nutrient enrichment of the soil by the manure (Chávez-Romero *et al*., 2016). Microbes perform important roles in the recycling processes and disease suppression in the soil (Enebe and Babalola, 2020). The excessive and insufficient nutrients supplied through fertilizer applications have been reported to affect the disease tolerance or resistance of plants to pathogens (Christos, 2008); the rate of growth, and the state of readiness of plants to defend themselves against pathogenic attack (Jahn, 2004). Therefore, this study was carried out to evaluate the effects of fertilizer rates (NPK and organic based fertilizer (OBD) on fungal diseases of maize in a Nigerian derived savanna.

Materials and Methods

The experiment was conducted as a pot trial in the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. Soil used for the pot experiment was collected at 0-15cm depth from the experimental farm (with the coordinates - N07^{O}27.048 and E003^{O}53.812, 225m above sea level) of the Department of Agronomy, University of Ibadan. The soil was characterized to be moderately acidic (with pH-H_2O 6.2); low in organic carbon (4.6g/kg) and total (N 1.51 g/kg). The test crop (maize variety, TZPB-SR-W, resistant to mosaic streak virus disease), the inorganic (NPK 15:15:15) and OBD-plus organic (manufactured by Gateway Organic Fertilizer Company, Abeokuta, Ogun State, Nigeria) fertilizers were obtained from the Institute of Agricultural Research and Training, Ibadan. Five kilogrammes each of the bulked air dried and sieved with 2cm-mesh top soil was measured into forty-two pots, after which the fertilizers were added. The soil and fertilizer were thoroughly mixed together and watered immediately to aid mineralization. The experiment was laid out in a completely randomized design, with six replications. The treatments were NPK 15:15:15 and OBD-plus at the rates of 60, 120 and 180 kg N/ha and an absolute control (no soil additive). The OBD treatments were applied two weeks before planting while the mineral fertilizer was applied one week before planting. Three seeds were sowed in the respective labeled pots and later thinned to two plants per pots at two weeks after sowing (WAS). The pots were watered frequently and weeds were rogued out as at when due. Data collected on incidence, severity of fungal diseases, growth parameters (3 to 9WAP) and total dry matter at 10WAP (2 plants per pot and oven dried at 60^{o}C), were analysed with SAS (2004).

Results and Discussion

Symptoms Expression of Fungal Diseases on Maize

The diseases assessed on maize were *Curvularia* leaf spot, anthracnose leaf blight. *Curvularia* leaf spot was associated with small chlorotic spots with a light-colored halo while anthracnose leaf spot was associated with dark brown, oval to spindle shaped lesions with yellow borders.

Effects of NPK 15:15:15 and OBD Fertilizer on Maize Disease Incidence (%)

Disease symptoms was observed on the plants as from 3WAP with only few plants infected; at 5WAP a high percentage of the plants were already infected (Table 1). The disease incidence increased gradually with time and increasing rate of fertilizer application; the percentage disease incidence was significantly higher on plants fertilized with different rates of OBD than NPK 15:15:15 fertilizer. The control and 180kgN/ha OBD treatments had the highest disease incidence at 3, 4 and 5 WAP respectively while 60kgN/ha from NPK 15:15:15 had the least.

Effects of NPK 15:15:15 and OBD Fertilizer on Maize Disease Severity (%)

The severity of *Curvularia* leaf spot presented in Table 2, showed that the effects of different NPK 15:15:15 and OBD fertilizer rates were not significantly different from one another; while maize fertilized with 180kgN/ha OBD have the lowest severity (2.17), the control treatment had the highest (4.00). Symptoms of leaf blight were observed on the plants at 5WAP and the result showed that the fertilizer rates had significant effect only at 10 WAP (Table 3). Statistical analysis ($P \leq 0.05$) showed that the disease severity increased with increasing NPK rates, although there were no significant differences between 60kgN/ha NPK and 120kgN/ha OBD fertilizers. The highest total leaf area infection was observed on plants treated with 180kgN/ha NPK 15:15:15 and
the control treatments (>76%).

Table 1: Effect of NPK 15:15:15 and OBD Fertilizer on Disease Incidence (%) On Maize

Fertilizer rates	3 WAP	4 WAP	5 WAP
Control	83.3^{c}	83.3^{d}	100^{a}
NPK 60kgN/ha	16.7^{a}	16.7^{a}	83.3^{a}
NPK 120kgN/ha	33.3^{ab}	50^{bc}	100^{a}
NPK 180kgN/ha	50^{b}	50^{bc}	100^{a}
OBD 60kgN/ha	33.3^{b}	33.3^{ab}	83.3^{a}
OBD 120kgN/ha	50^{b}	66.7^{cd}	83.3^{a}
OBD 180kgN/ha	83.3^{c}	83.3^{d}	100^{a}
SEM	32.22	34.15	18.10

SEM: standard error of means
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

Table 2: Effect of NPK 15:15:15 and OBD fertilizer on Severity of Curvularia Leaf Spot on Maize

Fertilizer rates	3 WAP	6 WAP	9 WAP
Control	0.00	1.50	4.00^{e}
NPK 60kgN/ha	0.00	1.00	3.00^{abc}
NPK 120kgN/ha	0.17	1.33	3.17^{ab}
NPK 180kgN/ha	0.00	1.17	3.50^{a}
OBD 60kgN/ha	0.33	1.33	2.67^{bcd}
OBD 120kgN/ha	0.00	1.00	2.50^{cd}
OBD 180kgN/ha	0.33	0.83	2.17^{d}
SEM	ns	ns	1.15

SEM: standard error of means
ns: not significant
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

The result obtained on the severity of *Curvularia* leaf spot and anthracnose leaf blight at days to 50% tasseling showed that the fertilizers had significant effects on the diseases (Table 4). The OBD fertilizer significantly suppressed the severity of the disease than NPK fertilizer and the control treatment. However, performance of the different rates of OBD fertilizer were not significantly different with one another and with 60 and 120kgN/ha of NPK fertilizer. More than 75% of the total leaf area of maize fertilized with 180kgN/ha of NPK and the control treatment were infected. Increased rates of NPK 15:15:15 fertilizer significantly influenced the severity of attack of the crops by *Curvularia* leaf spot and anthracnose leaf blight diseases. There were clear effects of NPK 15:15:15 fertilization from low to high severity of the diseases. This is partly inconsistent with Marschner's (1997) conclusion that plants with optimum nutrition have the maximum disease resistance. This also confirmed the report of Agrios (2005) that excessive N fertilization prolongs the vegetative growth of the plant and delayed maturity, making the plants susceptible to diseases. Similar observations had earlier been reported by Salawu and Afolabi, (1994) that N level beyond 80kgN/ha increases the severity of the diseases on sugarcane and corn blight. However, OBD fertilizer reduces the severity of the disease due to the slow release of nitrogen for the plant uptake which could have made the plant susceptible to disease and by the release of allelo-chemicals generated during product storage or by subsequent microbial decomposition (Bailey and Lazarovits, 2003). It is also known that organic fertilizer promotes increased populations of antagonistic microorganisms that interfere with the activities of pathogenic infection from fungi and many nonpathogenic soil micro-organisms which can effectively colonize foliage as well as roots in soil and allow protection of these tissues from infection (Nelson, 1992).

Table 3: Effect of NPK 15:15:15 and OBD fertilizer On Severity of Anthracnose Leaf Blight on Maize

Fertilizer rates	6WAP	8 WAP	10 WAP
Control	4.00	4.00	5.00[a]
NPK 60kgN/ha	3.83	4.00	4.00[b]
NPK 120kgN/ha	4.00	4.00	4.83[a]
NPK 180kgN/ha	3.67	4.00	5.00[a]
OBD 60kgN/ha	4.00	4.00	4.17[b]
OBD 120kgN/ha	3.83	4.00	4.00[b]
OBD 180kgN/ha	3.83	4.00	4.17[b]
SEM	ns	ns	0.99

SEM: standard error of means
ns: not significant
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

Organic fertilizers supply other nutrients such as micro-nutrients which are also essential and could be used by the plants to defend themselves against pathogenic fungi. The suppression of the diseases on the plants fertilized with OBD at days to 50% tasseling showed that the plants would perform better in terms of yield than those fertilized with NPK 15:15:15.

Table 4: Effects of NPK 15:15:15 and OBD fertilizer on The Severity of Curvularia Leaf Spot and Anthracnose Leaf Blight on Maize at Days To 50% tasseling

Fertilizer rates	*Curvularia* leaf spot	Anthracnose leaf blight
Control	2.83[a]	4.83[a]
NPK 60kgN/ha	2.50[ab]	4.17[b]
NPK 120kgN/ha	2.67[ab]	4.33[ab]
NPK 180kgN/ha	2.83[a]	4.67[a]
OBD 60kgN/ha	2.33[ab]	4.00[b]
OBD 120kgN/ha	2.17[bc]	4.00[b]
OBD 180kgN/ha	1.67[c]	4.17[b]
SEM	0.85	0.98

SEM: standard error of means
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

Effects of fertilizers on Growth Parameters

The effects of OBD and NPK 15:15:15 fertilizers on the growth parameters were not significantly different from one another at 3, 6 and 9WAP (Table 5). The plant height however increased with increasing fertilizer rates with the control treatment having the least, while at 9WAP, plants fertilized with 120kgN/ha NPK had the highest height (112.35cm). This showed large doses of NPK 15:15:15 fertilizer increased the plant growth and also the susceptibility of the plants to diseases. The data from 50% tasseling of maize crop as influenced by different fertilizer rates showed that the rates were not significantly different from each other in their effects on tasseling; likewise, the effects of 60kgN/ha and 120kgN/ha were not significantly different on leaf area and total dry matter (Table 6). However, plants fertilized with 120kgN/ha had the highest leaf area and total dry matter while unfertilized plants had the least. The increases in plant height, leaf area and total dry matter of maize plants may be due to physiological and metabolic activities of the plant following application of the fertilizers resulting in more photosynthetic activities and large leaf production.

Table 5: Effects of NPK 15:15:15 and OBD fertilizer on the plant height (cm) of maize

Fertilizer rates	3WAP	6WAP	9WAP
Control	23.73[b]	37.10[c]	57.98[d]
NPK 60kgN/ha	33.50[a]	58.60[a]	104.02[ab]
NPK 120kgN/ha	33.83[a]	57.47[a]	112.35[a]
NPK 180kgN/ha	35.00[a]	62.53[a]	108.18[a]
OBD 60kgN/ha	23.67[b]	43.08[bc]	74.68[c]
OBD 120kgN/ha	25.92[b]	42.22[bc]	87.72[bc]
OBD 180kgN/ha	25.67[b]	46.83[b]	77.73[c]
SEM	5.62	23.83	23.95

SEM: standard error of means
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

Similar result had earlier been obtained by Ihejirika and Nwufor (2001) that plant height and leaf production increased with plant age. However, increase in plant height even with an increase in the severity of *Curvularia* leaf spot, anthracnose leaf spot and leaf blight may be attributed to plant ageing process. Ameenal and Jacobus (2012) submitted that as the plant ages, the tissues become weak and the plant ability to withstand the attack of the pathogens becomes reduced leading to increased disease penetration and symptom manifestation and spread. Cooke (1982) argued that high levels of N increase the leaf area of the crops which could lead to increased transpiration and early onset of moisture stress thus increasing disease severity. The effects of nutrient deficiency in the control treatments reflected in the reduced total dry matter, leaf area and increase in disease severities. The total dry matter was significantly reduced in N- stressed plants. The decrease in leaf area obtained in the present study was also in agreement with the report of Radin and Boyer (1982) who found that low N caused substantial growth inhibition in sunflower plants by decreasing the turgor of expanding leaves during day time. Nitrogen deficiencies have been shown to inhibit the production of new leaves, decrease the area of individual leaves as observed in this study. Thus, the results of this study confirmed the critical importance of N nutrition. The untreated plants were almost stunted in growth as they had to rely on the native soil fertility which, from the result of chemical analysis was deficient in these nutrients. The different levels of fertilizer application showed that additional supply resulted in increased leaf area, plant height and total dry matter.

Table 6: Effects of NPK 15:15:15 and OBD Fertilizer on Days To 50% Tasseling, Leaf Area and Total Dry Matter

Fertilizer rates	Days to 50% tasseling	Leaf area/plant (cm^2)	Total dry matter (g/plant)
Control	64.33	2654.65^{d}	23.67^{d}
NPK 60kgN/ha	61.00	3806.30^{bc}	58.50^{ab}
NPK 120kgN/ha	61.67	5127.45^{a}	74.66^{a}
NPK 180kgN/ha	61.67	4596.49^{ab}	64.50^{a}
OBD 60kgN/ha	63.00	2680.63^{d}	27.00^{d}
OBD 120kgN/ha	62.33	4177.33^{abc}	45.50^{bc}
OBD 180kgN/ha	63.00	3065.12^{cd}	31.50^{cd}
SE	ns	1867.02	25.65

SEM: standard error of means
ns: not significant
Means with same letter (s) in a column are not significantly different at 5% level of probability by Duncan Multiple Range Test (DMRT)

Conclusion and Recommendation

The observation made from our study showed that application of fertilizers had profound effects on some of diseases of maize. The disease incidence on the plants increased with increasing rates of the NPK 15:15:15 applied over time. The results also showed that the effects of the different rates of NPK fertilizer on the diseases were not different from one another, and that excessive application of NPK 15:15:15 increased the growth of maize plants and their susceptibility to diseases. Since the performance of the different rates of OBD fertilizer were equal, 60kgN/ha of OBD fertilizer is thereby recommended as an alternative to inorganic fertilizer for good fungal disease prevention in maize production.

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