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Nutrient optimization for cucumber production using different fertilizer sources

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Abstract

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Determination of optimum amount of different fertilizer types for optimum growth and yield of cucumber is highly germane to avoid toxicity or malnutrition which will result in less expression of the real potential of the crop. This research was, therefore, conducted to determine the optimum rate of organic, inorganic and organo-mineral fertilizers for optimum growth and yield of cucumber. Five levels (0, 5, 10, 15 and 20 t/ha) of organic (poultry manure) fertilizer, five levels (0, 100, 200, 300 and 400 kg/hectare) of inorganic (NPK 15:15:15) fertilizer and five levels (0, 1, 2, 3 and 4 t/ha) of organo-mineral fertilizers were tested. Each of the fertilizer types was tested in separate experiments. The experiment was laid out in randomized complete block design (RCBD). Data were collected on vine length, number of leaves per plant, number of branches per plant, leaf area, fruit length, fruit girth, number of fruits per plant, individual fruit mass and dry matter per plant. The results showed that there was linearity in the increment of all the parameters used as the amount of each fertilizer type increased. So, the highest values for all the parameters tested were from 400 kg NPK/ha in inorganic fertilizer, 20 t/ha in organic (poultry manure) fertilizer and 4 t/ha in organo-mineral fertilizer. Therefore, the use of 400 kg NPK/ha fertilizer, 20 t/ha poultry manure and 4 t/ha in organo-mineral fertilizer is recommended for optimum cucumber production in Ilorin, a location southern guinea savannah ecological zone of Nigeria and places with similar edaphic and climatic conditions.

Key words: Cucumber, nutrient optimization, fertilizer sources, growth and yield

Introduction

Cucumber production in Nigeria has increased probably due to awareness being created by its market demand, economic returns, short duration in maturity, nutritional and medicinal values. Hence, the crop has become a popular vegetable crop in Nigeria. Both old and young people enjoy cucumber fruits of which many in their leisure time usually eat with fried groundnut in their offices, homes, market place and recreational areas. When the crop is given proper care and protection, cucumber tends to produce well. It is a crop that grows well in a well-drained fertile soil with good moisture retention ability. Cucumber requires high amount of soil nutrients from seedling stage to maturity. It is highly sensitive to excessive water and adequate soil tillage for its very fragile root penetration is required prior to planting (Nweke et al., 2014). Water logging usually causes or triggers off leaf problem in cucumber. Increase in cucumber production can be achieved by increasing soil nutrients or using improved varieties with appropriate cultural practices.

Mineral fertilizers supply nutrients to the soil at a faster rate unlike its organic counterpart. Despite that, inorganic fertilizer can only support growth on a short term basis due to its ease of loss through being washed away or leaching. Furthermore, the use of inorganic manures has been observed to cause destruction of soil texture and structure which often lead to soil erosion as well as acidity which results from leaching of mineral nutrients (Ojeniyi, 2000). All the mentioned effects give rise to reduced crop yields as a result of soil degradation and nutrient imbalance (Ojeniyi, 2009).

Application of poultry manure is one of the ways of improving soil fertility and final yield of crops. It has been indicated that poultry manure is not only cheap and effective but also essential for establishing and maintaining the optimum soil physical conditions for plant growth and yield (Enujeke et al., 2013)). As reported by DIPA (2006), nutrient composition of poultry manure is 1.0-1.8% N, 0.4-0.8% P, and 0.5-1.9% K. This high level of nutrients contained in it makes it suitable for soil amendment to increase growth and yield of crops. This poultry manure has long been used by ancient farmers as a source of plant nutrition and its benefits have been fully realised because of its ease of accessibility and cheapness (Wehner & Guner, 2004).

Improvement in environmental conditions with respect to public health has been observed as one of the major reasons for adoption of organic farming by farmers in the world (Eifediyi & Remison, 2010). The use of organic manures has been recommended for long term cropping in the tropics because slow mineralization of these manures promote crop yield for a long period of time (Gambo et al., 2008).

It should be noted that the most satisfactory method of increasing crop yields is by judicious use of organic manures in combination with little portions of the inorganic sources for nutrient use efficiency (Gambo et al., 2008). Several reports have thus proved that neither the sole use of organic fertilizer or inorganic fertilizer is a panacea for soil fertility management in Nigeria (Ayeni et al., 2012). This has, therefore, prompted the combined form of fertilizers (organo-mineral fertilizer) that would bridge the gap that exist between organic and inorganic fertilizers.

At present, cucumber is low in productivity as a result of several factors with nutrient availability being the most limiting factor (Ayatamuno et al., 2007). The use of inorganic fertilizers alone for increasing productivity of cucumber has been observed to cause the destruction of soil texture and structure which often lead to soil erosion and acidity resulting from leaching effects of mineral nutrients (Ojeniyi, 2000). Consequently, there will be reduced crop yield as a result of soil degradation and nutrient imbalance (Ojeniyi, 2000). However, the use of organic and organo-mineral fertilizers have been reported to significantly increase yields of maize and vegetables such as melon, pepper, tomato, okra, and Amaranths (Adeoye et al., 2008). Therefore, there is need to determine the optimum rate of different nutrient sources for optimum cucumber growth and yield. So, the objective of this study was to determine the optimum rate of organic, inorganic and organo-mineral fertilizers

for optimum growth and yield of cucumber.

Materials and Methods

Experimental Site

The experiment was carried out at the University of Ilorin Teaching and Research Farm, Ilorin located on latitude 8° 30'N and longitude 4° 33'E with an annual rainfall of 1186 mm. The mean annual temperature is 29° C while the average annual relative humidity is about 85%. We used cucumber variety Marketer

Nutrient Sources

Three different sources of nutrients used were NPK ((NPK 15:15:15) -15%N, 15%P and 15%K) fertilizer, poultry manure (4.58% N, 1.67 mg/kg P and 4.60 cmol/kg K) and organo-mineral fertilizer (10% N, 4% P and 4% K). The poultry manure used was obtained from Alao farms. It was dried and ground into powdered form. The organo-mineral fertilizer and the inorganic fertilizer were obtained from Aleshinloye market in Ibadan.

Field Preparation and Experimental Design

All the experiments were designed as a randomized complete block (RCB) with three replications. Five rates each of NPK fertilizer (0, 100, 200, 300, 400 kg/ha), Poultry manure (0, 5, 10, 15, 20 t/ha), and organo-mineral fertilizer (0, 1, 2, 3, 4 t/ha) were used. Each plot measured 3×2 m^2 with alleyway of 1 m between the plots.

Soil Sampling and Analysis

Soil samples were collected from individual plots and air-dried for three days, crushed and sieved using 2 mm aperture. The sieved samples were bulked together to obtain a composite sample. The composite sample was then analysed in the laboratory using the standard analytical procedures. From the composite soil sample, particle size distribution by hydrometer method (Gee & Bauder, 1986), soil pH determined using pH metre, total N content determined by Kjeldahl method (Bremner, 1966), available phosphorus determined using the modified Bray1 method and exchangeable bases determined by using 1N of Ammonium acetate were determined. The nutrient composition of the poultry manure used for the experiment was also determined using appropriate methods.

From the above analysis, it was found that the soil used was sandy loam. It was slightly acidic, high in organic matter and organic carbon, high in available phosphorus while the potassium and nitrogen were moderate. The poultry manure used was very high in nitrogen and potassium while the phosphorus is moderate (Table 1).

Planting

Two seeds of Marketer variety of cucumber were sown per hole at a spacing of 1 m x 1 m and depth of 2.5 cm. The resulting seedlings were then thinned to one plant per stand at three weeks after planting.

Fer*tilizer Treatments*

Poultry manure (organic fertilizer 4.58% N, 1.67 mg/kg P and 4.60 cmol/kg K) was incorporated into the soil one week before planting at the rates of 0, 5, 10, 15 and 20 t/ha. Organo-mineral fertilizer (10% N, 4% P and 4% K) was applied at three weeks after planting at the rate of 0, 1, 2, 3 and 4 t/ha. Inorganic fertilizer (NPK 15:15:15 - 15% N, 15% P and 15% K) was also applied to the soil at three weeks after planting at the rate of 0, 100, 200, 300 and 400 kg/hectare.

Weed and Pests Control

Weeds were manually removed using hoe every fortnight to avoid interspecific completion between the crop and weeds. The cucumber plants were sprayed every two weeks with Cypermethrin (insecticide) at 3, 5, and 7 WAP to free the plants of insect pests.

Data Collection

At 9 weeks after planting, the following parameters were taken. Vine length (measured from the ground level to the tip of the last leaf using a measuring tape), number of leaves (through individual leaf counting), number of branches (individual counting), leaf area (through the use of linear method: maximum length x maximum width x 0.4792 according to Sharma et al., 1987).

Dry Matter Measurement

Dry matter of the cucumber plants was assessed at 5 weeks after planting by uprooting cucumber plants, putting them in paper bags and placing them in an oven until a constant mass was recorded through a digital scale.

Harvesting and yield components Determina-

tion

Harvesting was done when fruit colour was deep green. Harvesting was done by handpicking. After harvesting, properly labelled fruits were then taken to the laboratory for the measurement of yield components. The yield parameters measured were fruit length (using a tape rule), fruit girth (using flexible rope), number of fruits per plot (through counting) and mass of fresh fruits (using a digital scale).

Data Analysis

All data collected were subjected to the analysis of variance (ANOVA) using Genstat Discovery 4 Software (2011). Significant means were separated using the least significant difference (LSD) at 5% probability level.

Results and Discussion

Results

The longest vine was produced when 400 kg NPK/ha was applied while the shortest vine was from the control. In branch production also, the highest number of branches was produced with the application of 400 kg NPK/ha while the lowest number of branches was produced by the control plants. In the same vein, the highest number of leaf per plant was produced by plants fertilized with 400 kg NPK/ha while the lowest number of leaf per plants was produced from control plants. Finally, total leaf area per plant also followed the trend of other parameters. The highest value of leaf was recorded from plants fertilized with 400 kg NPK/ha while the smallest leaf area was from the control plants (Table 2).

The longest vine was produced when 20 t/ha poultry manure was applied while the shortest vine was from the control. In branch production also, the highest number of branches was produced with the application of 20 t/ha poultry manure while the lowest number of branches was produced by the control plants. In the same vein, the highest number of leaf per plant was produced by plants fertilized with 20 t/ha poultry manure while the lowest number of leaf per plants was produced from control plants. Finally, total leaf area per plant also followed the trend of other parameters. The highest value of leaf was recorded from plants fertilized with 20 t/ha poultry manure while the smallest leaf area was from the control plants (Table 3).

The longest vine was produced when 4 t/ha organo-mineral fertilizer was applied while the shortest vine was from the control. In branch production also, the highest number of branches was produced with the application of 4 t/ha organo-mineral fertilizer while the lowest number of branches was produced by the control plants. In the same vein, the highest number of leaf per plant was produced by plants fertilized with 4 t/ha organo-mineral fertilizer while the lowest number of leaf per plants was produced from control plants. Finally, total leaf area per plant also followed the trend of other parameters. The highest value of leaf was recorded from plants fertilized with 4 t/ha organo-mineral fertilizer while the smallest leaf area was from the control plants (Table 4).

Yield parameters

The longest fruits were produced plants fertilized with 400 kg NPK/ha while the short fruits were produced by plants from the control plots. Similarly, the widest fruits were from fruits of plants fertilized with 400 kg NPK/ha while the narrowest fruits were from the control plots. In the same vein, the highest number of fruits was produced by plants fertilized with 400kg NPK/ha while the lowest number of fruits was realized from plants of the control plots. As for fruit mass, the same trend was equally followed. The heaviest fruits were produced by plants with 400 kg NPK/ha while the lightest fruits were from plants in the control plots. On overall dry matter production, the heaviest dry matter was realized from plants fertilized with 400 kg NPK/ha while the lightest dry matter was realized from the control plants (Table 5).

The longest fruits were produced plants fertilized with 20 t/ha poultry manure while the short fruits were produced by plants from the control plots. Similarly, the widest fruits were from fruits of plants fertilized with 20 t/ha poultry manure while the narrowest fruits were from the control plots. In the same vein, the highest number of fruits was

produced by plants fertilized with 20 t/ha poultry manure while the lowest number of fruits was realized from plants of the control plots. As for fruit mass, the same trend was equally followed. The heaviest fruits were produced by plants with 20 t/ha poultry manure while the lightest fruits were from plants in the control plots. On overall dry matter production, the heaviest dry matter was realized from plants fertilized with 20 t/ha poultry manure while the lightest dry matter was realized from the control plants (Table 6).

The longest fruits were produced plants fertilized with 4 t/ha organo-mineral fertilizer while the short fruits were produced by plants from the control plots. Similarly, the widest fruits were from fruits of plants fertilized with 4 t/ha organo-mineral fertilizer while the narrowest fruits were from the control plots. In the same vein, the highest number of fruits was produced by plants fertilized with 4 t/ha organo-mineral fertilizer while the lowest number of fruits was realized from plants of the control plots. As for fruit mass, the same trend was equally followed. The heaviest fruits were produced by plants with 4 t/ha organo-mineral fertilizer while the lightest fruits were from plants in the control plots. On overall dry matter production, the heaviest dry matter was realized from plants fertilized with 4 t/ha organo-mineral fertilizer while the lightest dry matter was realized from the control plants (Table 7).

Discussion

The longest vines were produced from application of 400 kg NPK/ha, 20 t/ha of poultry manure and 4 t/ha of organo-mineral fertilizer which were the highest application rates. Similar results with our findings were from the work of Jilani et al., (2009) who found that the longest vines resulted from highest application rate of NPK fertilizer. Similarly, Khan et al., (2017) found the longest vines with highest rate of poultry manure used in their work. In the same vein, Olaniyi et al., (2009) who tested three cucumber varieties (Ashley, Poinsett and Royal F1) discovered that the longest vines were from the highest application rate of organo-mineral fertilizer. They all found linearity in the relationship between application rates and vine length as found in this work. These results might be attributed to release of sufficient nutrient for enhancement of meristematic activities (Werner et al., 2001) at the shoot apices which are responsible for increase in vine length. The result could equally be linked to release of enough nutrients which aid betterment of physiological activities of the plants during morphogenesis (Igari et al., 2008). In the same vein, longer vines could result from better absorption of water and nutrients which are enhanced by development of efficient roots as a result better nutrient supply and this occurrence in turn led to luxuriant growth of the shoot and consequent longer vines.

Highest number of leaves produced was from the highest amount of fertilizer supply from all the nutrient sources tested. Similar results were got by Khan et al., (2017) who found that the highest application rate of poultry manure led to production of highest number of leaves per plant. Furthermore, Olaniyi et al., (2009) discovered that the highest number of leaves per plant stand was from highest rate of organo-mineral fertilizer applied in all the cucumber varieties (Ashley, Poinsett and Royal F1) tested. This trend was also found by Eifediyi and Remison (2010) who worked on effect of combined NPK and poultry manure on Asley variety of cucumber alone. However, Oga and Umekwe (2015) did not find the highest number of leaves per plant from the highest NPK fertilizer rate applied. Despite the fact that the number of leaves increased from the control treatment to application of 60 kgNPK/ha, there was a decline in number of leaves per plant as application of NPK reached 120 kg/ha which was the peak application rate in their work. This might have resulted from leaf dropping resulting from senescence. Our findings could be linked to optimum nitrogen supply in all the fertilizer types since nitrogen is responsible luxuriant vegetative growth of plants. It could equally be ascribed in part to longer vines produced by the plants because the longer the vines produced, the higher the number of leaves that will be attached to it under favourable and ideal conditions. Finally, the

nutrient supplied might have aided production of more nodes on the vines which resulted in more leaf production. The linearity experienced in vine and leaf production with increase in nutrient supply implies that increase in nutrient supply up to the highest rates used in this work did not result in toxicity in cucumber system.

There was increase in number of branches as the nutrient supply increased in all the nutrient sources tested. Khan et al., (2017) also found increase in number of branches with increase in rate of poultry manure application. This could be linked to the aid given by the fertilizers in production of more nodes as a result of multiplicity of cells aided by potassium nutrition from all the fertilizer sources. This is because potassium is responsible for normal cell division and meristematic growth.

Higher leaf area with increase nutrient supply from all the sources tested was found in this work. In the work of Khan et al., (2017), it was also found that increase in application rate of poultry manure resulted in increased leaf area of the concerned plants. This could be the result of higher nutrient supply which led to better cell production engineered by potassium nutrition. However, enlargement of leaves involves absorption of more nutrients and water. It could be said that increase in nutrient supply led to better water absorption as depicted in the result of this work. So, as the cells enlarge, the leaves also expand (increase in leaf area). Leaves produced by the control plants were less expanded because of low nutrient supply required for cell elongation and enlargement as well as low water absorption required for cell turgidity and enlargement. Furthermore, the supply of higher nutrient might have gingered the release of some hormones like auxins and gibberellin which are responsible for cell elongation and enlargement. However, the hormonal production should be inversely proportional to the nutrient release because hormones function in small quantities not in high quantities.

The improvement in fruit dimensions (length and girth) increased linearly with increase in fertilizer application in all the fertilizer sources used. Jilani et al., (2009) also found increase in fruit length with increase in NPK application. Combination of NPK and poultry manure was also found to increase fruit mass and yield (Eifediyi and Remison, 2010). Also, Ogaga and Kingsley (2012) found increase in fruit length, fruit mass and yield of cucumber with increase in rate of application of combined NPK and poultry manure. Khan et al., (2017) found increase in fruit length, diameter, number, average mass and final yield with increase in NPK application rate. These results might be attributed to increase in photo-assimilate production and judicious partitioning of the photo-assimilate produced. The influence of the applied nutrients was an indirect influence except in grain where potassium nutrition is responsible for grain filling. So, increase in photosynthetic source (leaves) as nutrient application increased led to increase in photosynthate production which was graced with better assimilate partitioning. Otherwise, there would have been luxuriant growth with small fruits and accompanied delay in transition from vegetative to reproductive stage. Furthermore, increase in nutrient supply might have aided boron absorption which is responsible for flowering and complete fruit development. In the same vein, florigen which is the hormone responsible for flowering might have been triggered as nutrient supply increased and the occurrence led to production of more flowers and consequently fruits. So, there was increase in the number of fruit per plant as well the mass of individual fruits. The luxuriant vegetative growth resulted from better root development that assisted in absorption of water and supplied nutrient. This root development also aided absorption and transportation of water to the fruits to have appreciable weight. The rate of water absorption and supply to the fruits was directly proportional to the application rates in all the fertilizer types used. It could be deduced that the aid given to the vegetative parts of the plants with better nutrient supply led to better assimilate production and better yield with increase in nutrient supply from all the fertilizer sources used.

Table 1. Soil properties of the experimental site and poultry manure analysis

Properties	Soil	Poultry manure
pH	6.80	
Clay (%)	6.20	
Silt (%)	8.20	
Sand (%)	85.40	
Textural class	Sandy loam	
Zinc (mg/g)	1.18	
Carbon %	1.82	
Organic matter %	3.18	
Nitrogen %	0.30	4.58
Phosphorus (mg/kg)	10.21	1.67
Potassium (cmol/kg)	1.03	4.60
Calcium (cmol/kg)	6.45	
Mg (cmol/kg)	0.28	
Na (cmol/kg)	0.52	

Table 2. Effect of NPK fertilizer on vine length, number of branches, number of leaves and leaf area of cucumber plants

Fertilizer Rate (kg/ha)	Vine Length(cm)	Number of Branches (no/plant)	Number of Leaves (no/plant)	Leaf Area (cm^2)
0	45.00	33.00	66.00	9802.49
100	89.40	43.00	83.00	10049.93
200	108.20	50.00	134.00	12352.22
300	121.80	60.00	149.00	15241.57
400	129.50	71.00	170.00	15498.15
LSD (0.05)	2.622	2.584	6.264	ns

Table 3. Effect of poultry manure on vine length, number of branches, number of leaves and leaf area of cucumber plants

Fertilizer Rate (t/ha)	Vine Length(cm)	Number of Branches (no/plant)	Number of Leaves (no/plant)	Leaf Area (cm^2)
0	46.00	37.00	74.00	7758.40
5	97.90	53.00	124.00	11289.40
10	101.20	56.00	153.00	14707.37
15	121.20	76.00	174.00	16810.08
20	133.20	81.00	202.00	17528.86
LSD (0.05)	5.401	3.342	10.85	4603.0

Table 4. Effect of organo-mineral fertilizer on vine length, number of branches, number of leaves and leaf area of cucumber plants

Fertilizer Rate (t/ha)	Vine Length(cm)	Number of Branches (no/plant)	Number of Leaves (no/plant)	Leaf Area (cm^2)
0	42.10	34.00	66.00	7088.88
1	97.10	53.00	121.00	9674.92
2	100.50	55.00	132.00	12232.62
3	115.80	73.00	173.00	14076.19
4	131.00	82.00	191.00	15989.43
LSD (0.05)	4.713	2.947	6.178	3454.1

Table 5. Effect of NPK fertilizer on fruit length, fruit girth, number of fruits, mass of fruit per plant and dry matter per stand of cucumber plants

Fertilizer Rate (t/ha)	Fruit length (cm)	Fruit girth (cm)	Number of Fruit per plant	Fruit mass (kg/plant)	Dry matter (g/plant)
0	7.30	4.20	3.00	0.34	4.41
100	10.70	7.30	5.00	0.55	6.07
200	12.10	8.90	10.00	1.02	8.37
300	14.10	9.30	10.00	1.19	10.86
400	16.20	10.20	11.00	1.25	13.05
LSD (0.05)	1.29	0.90	2.62	0.23	0.71

Table 6. Effect of poultry manure on fruit length, fruit girth, number of fruits, mass of fruit per plant and dry matter per stand of cucumber plants

Fertilizer Rate (t/ha)	Fruit length (cm)	Fruit girth (cm)	Number of Fruit per plant	Fruit mass (kg/plant)	Dry matter (g/plant)
0	6.80	4.00	3.00	0.31	4.06
5	11.40	8.20	7.00	0.66	6.20
10	14.00	10.10	11.00	1.21	9.32
15	16.20	10.50	13.00	1.43	11.88
20	18.20	11.30	15.00	1.45	15.46
LSD (0.05)	1.049	0.59	2.62	0.17	1.55

Table 7. Effect of organo-mineral fertilizer on fruit length, fruit girth, number of fruits, mass of fruit per plant and dry matter per plant of cucumber

Fertilizer Rate (t/ha)	Fruit length (cm)	Fruit girth (cm)	Number of Fruit per plant	Fruit mass (kg/plant)	Dry matter (g/plant)
0	6.10	3.60	2.00	0.25	3.78
1	10.70	6.20	6.00	0.57	5.66
2	13.10	9.90	10.00	1.18	8.63
3	15.40	10.50	11.00	1.30	12.28
4	17.00	11.40	13.00	1.39	15.01
LSD (0.05)	1.193	1.11	1.19	0.13	0.43

Conclusion

From the results of this work, it was found that all the vegetative and yield parameters used in assessing the strength and efficacy of each of organic, inorganic and organo-mineral fertilizers increased with increase in the application rates of all those fertilizer sources. Therefore, the use of 400 kg NPK/ha fertilizer, 20 t/ha poultry manure and 4 t/ha in organo-mineral fertilizer is recommended as the optimum for better yield in cucumber production in Ilorin, a location southern guinea savannah ecological zone of Nigeria and places with similar edaphic and climatic conditions.

However, the limitation of this research is that the effects of increasing the fertilizer rates beyond those used in this work could not be ascertained. It is not known whether further increase in the application rates will lead to toxicity of the plants and law of diminishing return would set in or the plants will be completely killed by eventuality of toxicity of the nutrient supplied. This aspect constitutes the limitation of this work and further research is required to be embarked upon in furtherance of the findings of this work.

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