Evaluation of Proportionate Combinations of Indigenous Rice Bran and Mineral Fertilizer for Improved Performance of Tomato (*Lycopersicon lycopersicum)* Under Low Fertile Soil conditions

ABSTRACT

Under tropical soil conditions, where soils are mostly marginal and deliberate fallowing of farmlands is very uncommon, integration of two or more different fertilizer materials, at pre-determined proportions, may be beneficial to soil quality improvement and enhanced crop productivity. Field experiment was carried out in the year 2015, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, to determine the complementary effect of organic and inorganic fertilizer at different rates on the performance of tomato, under low fertile soil conditions. Six treatments including the control were used: No fertilizer application, 100% N.P.K, 75% N.P.K + 25% Rice bran, 50% N.P.K +50% Rice bran, 25% N.P.K+ 75% Rice bran and 100% Rice bran arranged in randomized complete block design (RCBD), replicated three times. Data were collected on growth and yield parameters, and analysed using Analysis of variance (ANOVA). Means were separated using Duncan multiple range test (DMRT) at 5% level of probability. Results showed that amended plots significantly enhanced tomato growth, yields and nutrient uptakes higher, compared to the control. Sole application of 100% NPK and Rice bran significantly improved fruit yield by 831.5% and 597.1% respectively, while their combinations significantly enhanced tomato fruit yield ranging from 819% to 1127%. These indicate that combined application of organic and inorganic fertilizer is better than sole application. Also, significantly prolonged leaf production was observed (which equally promoted prolonged flowering and fruiting), in tomato plants which received Rice bran applications at 50% level and above. Therefore, since there is an increasing awareness nowadays, on the environment friendly benefits of applying organic materials to farmlands, application of either 75% or 100% NPK fertilizer should be totally discouraged. Hence, 75% Rice Bran + 25% NPK could be recommended or alternatively 50% Rice Bran + 50% NPK, for tomato production in the study area. This will improve soil organic matter content, reduce soil chemical fertilizer loads or inputs and alleviate the residual effects of synthetic fertilizer, for improved soil quality and tomato production, in the study area.

Keywords: Tomato, Iindigenous Rice Bran, Mineral Fertilizer, Soil Fertility, Crop Performance

1.0. INTRODUCTION

Tomato (*Lycopersicon lycopersicum* L. Mill) is an arable fruit vegetable. It belongs to the solanaceae family. Tomato ranks first amongst the common fruit vegetable crops in Nigeria and dominates the largest of the estimated vegetable crops production areas [1]. Tomatoes are normally propagated by seeds. Plants may be established by either sowing directly on the field or by transplanting of seedlings obtained from the nursery. Although tomato is grown throughout the year, the best period for tomato production in Nigerian Savanna is the dry season, when the weather is cooler and the incidence of pests and diseases is minimal [2]. Many varieties are now widely grown, sometimes in greenhouses in cooler climates. The plants typically grow up to 1-3 meters in height (when supported by stakes), and have a weak stem that often sprawls over the ground and may vine over other plants. More so, the dietary significance as well as the considerable versatility of tomato cannot be over-emphasized. The fruit is a berry type, and ripped fruits could be eaten fresh or raw (e.g. salad), could be cooked or processed, as in soup, stew, ketchup, paste, juice, powdered or canned tomatoes etc. [3, 4]. Tomatoes have been reported to be important sources of nutrient anti-oxidants such as lycopene and vitamin C in human diet [5]. Lycopene, the most important anti-oxidant has been linked with reduced risk of prostrate and other forms of cancer as well as heart diseases [6]. The fruits are highly perishable and are commonly sliced and dried (due to poor storage facilities), to await future uses or sales [7].

Soil fertility is a major constraint to achieving sustainable vegetable crop production in the tropics [8,9]. However, due to scarcity and high cost of purchasing synthetic fertilizer, farmers are now advancing their interests toward using organic and low technology fertilizer inputs as soil amendments, particularly for improving the growth and yield of common and indispensable vegetables like tomato, pepper, onion etc. Wasteful plant and animal residues are now commonly exploited for improving soil productivity ([10, 8]. In addition, exploration and exploitation of commonly available and relatively cheap agro-industrial wastes by vegetable farmers in peri-urban areas may promote and encourage sustainable crop production, as well as ensuring more balanced crop nutrition and effective environmental sanitation [11]. Although, cases of successful utilization of some agro-wastes such as livestock manures and composted plant materials were reported for improved tomato production, hence, exploitation of agro-industrial wastes such as sorghum husk, rice bran and sawdust for improved vegetable production under tropical soil conditions, had not been adequately studied and reported [12,13,11]. Meanwhile, since sole application of both organic or inorganic fertilizer had been reported to have some notable defects, integration of two or more fertilizer from different sources (at the recommended rates, in varying proportions), may be desirable for reducing chemical fertilizer loads on tropical soils, apart from improving growth and yield of arable crops [14,4].

Rice bran is obtained from rice processing (i.e. de-hulling). Rice bran is also referred to rice husk or rice hull. It is thereby regarded as a rice-mill waste. Although it is used for feeding livestock magnitudes, hence, magnitudes of this material are found wastefully deposited in many rice processing villages in Nigeria. However, if properly managed, rice bran is a potential fertilizer material, which is relatively high in Nitrogen, and could be used as a sole soil amendment or for organic fortification of chemical fertilizer materials, suitable for arable crop production. Nitrogen is an essential nutrient element required in photosynthesis and was also reported to support luxuriant and vigorous plant growth [2,15,16]. Inappropriate use of fertilizer greatly reduces fertilizer efficiency and imposes negative effects on soil productivity [17,8]. Both organic and inorganic fertilizer should be applied to match nutrient needs of crops [14,8]. Hence, in cases of desiring a combined application of organic and inorganic fertilizer materials, it is important to pre-determine the accurate proportions (in percentage) of either of the fertilizer to be applied. Therefore, this research was conducted to evaluate the performance of tomato at varying combination rates of organic and chemical N-fertilizer, so as to reasonably recommend the most suitable for optimum performance of tomato in the study area.

2.0 MATERIALS AND METHODS

2.1. Experimental site

The experiment was conducted in the year 2015 (between April and July), at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria, to evaluate the response of tomato to sole and combined applications of different organic and inorganic fertilizer materials.

2.2. Land preparation and collection of soil samples

The land was manually cleared of all existing vegetation. Each plot size was 2.1m × 2.7m = 5.67 m^2 with plant spacing of 30cm × 90cm (0.3 m x 0.9 m). Soil samples were collected from 0-15 cm depth at different points in the experimental site with soil auger and later mixed together to get a composite sample.

2.3. Soil samples analysis

The composite auger sample was ground and sieved through 2mm mesh to remove stones and other large particles, for determination of soil physico-chemical properties [i.e. total nitrogen, available phosphorus, exchangeable cations (Ca, Mg, Na and K), and percentages of sand, silt and clay].

2.4. Propagation / nursery technique and agronomic practices of tomato

The seeds of Roma VF variety were sown in the raised nursery bed made up of bamboo trees and shaded with palm-fronds. The seedlings were nurtured for four (4) weeks before transplanting to the field. A water tank of 300 Litre capacities (connected to the Faculty of Agriculture bore hole), was placed at the centre of the experimental plot to ensure regular watering, using watering cans. Although the experiment was not a dry season research (i.e. carried out between April –_July, 2015), but the tank of water was placed to ensure regular water supply, in case of rain failure. However, watering to saturation was done once throughout the experiment in the late July. Manual weeding was carried out with the aid of weeding hoes on every fortnight basis.

2.5. Treatments and experimental design

There were six (6) treatments including the control employed in the study: the control or zero fertilizer application, 100% NPK 15-15-15 fertilizer (equivalent to 200 kgha^{-1}), 75% NPK + 25% Rice bran, 50% NPK + 50% Rice bran, 25% NPK + 75% Rice bran, and 100% Rice bran (equivalent to 3.0 tons ha^{-1}). All treatments were applied at recommended rate of 200 kgNha^{-1} [11]. The treatments were laid out in a randomised complete block design (RCBD), replicated three times.

2.6. Data collection

Data collection commenced at four (4) weeks after transplanting (4WAT). The growth parameters determined at the early boom of flowering were: plant height (by using measuring tape), stem girth (by using venier callipers which first gave the value of the diameter, converted later to circumference, using a fomular: πD (i.e. 3.142 multiplied by the original diameter (D) value measured with calipers), number of leaves, number of branches (determined by direct counting of all well-developed branches per plant) and leaf area [by graph method as described by [13]. After each harvesting, number of ripe fruits per plant was determined (by direct counting) and weighed; using Mp 600H Electronic Weighing balance. Fruit diameter was also determined (using callipers). Moreso, from multiple harvestings spanning up to eight (8) weeks, the cumulative fruit weight values per plant per treatment were determined, which were later converted to fruit yield (tonnes per hectare).

2.7. Plant sampling and analysis

At the termination of the experiment, the N, P and K concentrations and uptakes by plants were determined by careful packing of all the plants per treatment into giant-brown envelopes

(30 cm by 65 cm). These plant materials were oven-dried at 80^{0}C for 72 hours to a constant weight according to the procedure as described by [18]; [16]. Total N was determined by micro-Kjeldahl method. The P was determined using vanadomolybdate colorimetry, and K by flame photometry. The nutrients accumulated in plant parts were then calculated as; Nutrient uptakes i.e. % Nutrient content X sample dry weight.

2.8. Data analysis

All data collected were analyzed using analysis of variance (ANOVA) according to the procedure for randomized complete block design (RCBD). Duncan's Multiple Range Test (DMRT), was used to compare differences between the treatment means at 5% level of probability, using Statistical Analysis System [19].

3.0 RESULTS AND DISCUSSION

3.1. Initial soil physico-chemical properties of the study area

The soil's pre-cropping physico-chemical analysis results showed that the soil was slightly acidic with pH (H_20) value of 6.1 (Table1), and that it was very low in essential nutrient concentrations particularly N = 0.19 gkg^{-1}, P = 3.57 mgkg^{-1} and K = 0.21cmolkg-1. These results corroborated the earlier research findings of [7] and [16], which indicated that the soils in the study area were grossly low in essential nutrients and mildly acidic in nature.

Table 1: Results of the physico-chemical analysis of the soil sample used

Soil Characteristics	Value
pH (H_2O)	6.10
Organic Carbon(g kg^{-1})	4.42
Total N (g kg^{-1})	0.19
Available P (mg kg^{-1})	3.57
Fe (mg kg^{-1})	1.10
Cu (mg kg^{-1})	2.36
Zn (mg kg^{-1})	2.87
Exchangeable K (cmol kg^{-1})	0.21
Exchangeable Na (cmol kg^{-1})	0.22
Exchangeable Ca (cmol kg^{-1})	0.19
Exchangeable Mg (cmol kg^{-1})	3.11

Sand (%)	**75.03**
Silt (%)	**14.15**
Clay (%)	**10.82**
Textural class	**Sandy loam**

3.2 Nutrient compositions of fertilizer materials used

As indicated in Table 2, the values of nutrient concentrations in the chemical fertilizer materials used were already indicated on the bag containing the fertilizer as 15 Kg each for N, P and K i.e. NPK 15-15-15 fertilizer grade, while those of the rice bran were analysed in the laboratory [18], and the results were 1.0%, 1.2% and 1.7% for N, P and K respectively. These values were relatively higher than N, P and K concentrations in some common weeds and wasteful plant residues [8].

Table 2: Nutrient compositions of fertilizer materials used

	NUTRIENT CONCENTRATIONS		
FERTILIZER MATERIALS	**N**	**P**	**K**
NPK FERTILIZER	**15.0 %**	**15.0 %**	**15.0 %**
RICE BRAN	**1.0 %**	**1.2 %**	**1.7 %**

3.1.3 Growth parameters of tomato (*Lycopersicon lycopersicum* L. Mill) under combined fertilizer applications

Application of different fertilizer and their combinations significantly ($p < 0.05$) enhanced growth of tomato (Table 3). Application of 50% NPK + 50% Rice bran had significantly higher plant height (98.2cm), but the value was not significantly different from those obtained from applications of 100% NPK and other fertilizer treatments studied (except 100% Rice bran), but significantly higher than the control. Also, application of 75% Rice bran + 25% NPK produced the plant with significantly wider stem girth value. Although the value was statistically similar to those produced by other fertilizer treatments, it was significantly higher than the control (Table 3). The highest values of both the leaf area and number of branches of tomato were observed in plots applied with 50% NPK + 50% Rice bran. Generally, the result (Table 3) indicated that all the amended plots significantly ($p < 0.05$) increased both the leaf area and number of branches higher relative to the control. Application of 75% Rice bran + 25% NPK produced the highest significant number of leaves, though significantly same with those from 50% NPK + 50% Rice bran and 100% Rice bran treated plots, (Table 3). This result implies that the higher the level of NPK integration, the higher the possibility of leaf shedding. Also, as the level of organic fertilizer application or integration increased, delayed leaf shedding increased, and this may possibly promote indeterminate growth of tomato (Table 3). All these are in support of the research reports of [8], who related improved sesame growth (and even prolonged leaf formation), to improved and continuous flow of soil nutrients from applied fertilizer. Also, the results were in line with research findings of [15], who reported improved growth of okra and maize, as induced by improved applications of both organic and inorganic fertilizer.

Table 3: Effects of combining organic and inorganic fertilizer materials on growth parameters of tomato (*Lycopersicon lycopersicum*)

Treatments	Plant height (cm)	Stem Circumference (cm)	Leaf Area (cm^2)	Number of Leaves	Number of Branches
Control	42.1c	0.7c	16.2b	101.0c	4.0b
100% NPK	91.3a	2.9a	34.6a	186.3b	19.2a
75% NPK + 25 % Rice Bran	90.1a	2.8a	33.2a	201.4b	18.4a
50 % NPK + 50 % Rice Bran	98.2a	2.9a	36.6a	236.5a	20.2a
25 % NPK + 75 % Rice Bran	96.6a	3.3a	35.2a	242.3a	18.2a
100% Rice Bran	82.5b	2.5ab	31.2a	232.5a	16.3a

Means followed by the same letters are not significantly different at p=0.05, using DMRT.

3.1.4 Fruit yield and fruit yield parameters of tomato (*Lycopersicon lycopersicum* L. Mill) under combined fertilizer applications

Sole application of fertilizer and their different integrations significantly ($p < 0.05$) influenced fruit yield and fruit yield parameters of tomato (Table 4), compared to the control. Applications 50% NPK + 50% Rice bran and 75% Rice bran + 25% NPK produced significantly higher and statistically similar values of fruit diameter (5.4cm and 5.3cm respectively). Application of other fertilizer treatments (75% NPK + 25% Rice bran, 100% NPK and 100% Rice bran) produced significantly lesser fruit diameters than those of 50% NPK + 50% Rice bran and 75% Rice bran + 25% NPK, but higher than the control (Table 4). Significantly earlier days to 50% flowering were observed in plants which received application of 50% NPK + 50% Rice bran. It was obtained that amended plots showed earlier days to 50% flowering significantly higher than the control. Hence, it could be deduced that fertilizer application irrespective of the sources may possibly promote early flowering and fruiting, compared to the control. Earlier studies agreed with these results [7,15], which indicated improved crop yield parameters via improved organic and inorganic fertilizer applications. Application of 75% Rice bran + 25% NPK produced the highest number of fruits (47.0). Application of 25 % NPK + 75 % rice bran produced the highest number of fruits (47.0). This value was not significantly higher than the number obtained in 50 % NPK + 50 % rice bran treatment. The control had the least value. Fruit weight value was significantly higher in plants which received 50% NPK + 50% Rice bran. This value was not significantly different from those obtained from other fertilizer investigated, but significantly higher than the control. Integration of 50% NPK with 50% Rice bran produced the highest fruit yield (82.3 tons ha^{-1}). This value was not significantly different from other fertilizer studied (except 100% Rice bran and the control (Table 4). All these results corroborated earlier research findings that enhanced crop yield is influenced by improved soil nutrition of [4, 10, 14].

Table 4: Influence of combined application of organic and inorganic fertilizer materials on fruit attributes and fruit yield of tomato (*Lycopersicon lycopersicum*)

Treatments	Days to 50% flowering	Fruit Diameter (cm)	Cumulative Number of Fruits	Cumulative Fruit Weight (gplant^{-1})	Fruit Yield (tonnes per hectare)
Control	92.2b	1.6c	15.0c	13.1b	7.3c
100% NPK	68.1a	4.0b	38.0ab	43.1a	60.7a
75% NPK + 25 % Rice Bran	67.6a	4.2b	39.0ab	41.4a	59.8a
50 % NPK + 50 % Rice Bran	60.4a	5.4a	46.0a	48.3a	82.3a
25 % NPK + 75 % Rice Bran	60.6a	5.3a	47.0a	45.1a	78.5a
100% Rice Bran	71.2a	3.8b	30.0b	39.2a	43.6b

Means followed by the same letters are not significantly different at p=0.05, using DMRT.

3.1.5 Biomass production of tomato (*Lycopersicon lycopersicum* L. Mill) as influenced by combined fertilizer applications

Fertilizer applications significantly improved biomass production (Table 5). The fresh below ground biomass of tomato was significantly ($p < 0.05$) enhanced by application of 100% NPK fertilizer. This value was not significantly different from those obtained from 75% NPK + 25% Rice bran and 50% NPK + 50% Rice bran, but significantly higher than other fertilizer treatments and the control. The dry below ground biomass production was significantly higher with application of 100% NPK. This value was not significantly different from those plants which obtained from 50% NPK + 50% Rice bran and 25% NPK + 75% Rice bran applications, but the value was significantly higher than other fertilizer materials assayed, and the control (Table 5). Similarly, 100% NPK fertilizer application produced the highest values of fresh and dry above ground biomass. The result revealed that plots treated with 100% NPK fertilizer application statistically performed alike with plots amended with 50% NPK + 50% rice bran and 25% NPK + 75% rice bran in the fresh above ground biomass weight. The value of dry tomato biomass obtained from NPK fertilizer application was not significantly different from those obtained from75% NPK + 25% Rice bran and 50% NPK + 50% Rice bran, but significantly higher than other fertilizer tested and the control. (Table 5). These enhanced crop yield and biomass production, as influenced by application of different fertilizer materials is in agreement with earlier research findings that improved biomass accumulation and crop yield under tropical climate, are connected to improved soil nutrition through application of either organic or inorganic fertilizer or both [8, 12,13].

Table 5: Effects of organic and inorganic fertilizer combinations on biomass yield of tomato (*Lycopersicon lycopersicum*)

Treatments	Above- ground Biomass Fresh Weight (g plant^{-1})	Above-ground Biomass Dry Weight (g plant^{-1})	Below-ground Biomass Fresh Weight (g plant^{-1})	Below-ground Biomass Dry Weight (g plant^{-1})
Control	116.1c	28.7d	12.8c	5.1cd
100% NPK	240.1a	78.3a	30.0a	9.8a
75% NPK + 25 % Rice Bran	196.1b	67.2ab	25.0a	6.4bc
50 % NPK + 50 % Rice Bran	204.6ab	68.1ab	24.7a	7.1ab
25 % NPK + 75 % Rice Bran	200.8ab	59.5bc	22.1bc	8.6ab
100% Rice Bran	162.2b	49.4c	15.6bc	6.0bc

Means followed by the same letters are not significantly different at p=0.05, using DMRT.

3.1.6 Effects of combined fertilizer applications on N, P and P uptakes of tomato (*Lycopersicon lycopersicum* L. Mill)

Application of different fertilizer and their combinations significantly ($p < 0.05$) influenced nutrient uptakes of tomato, compared to the control (Table 6). Generally, significantly higher improvements were observed in the N, P and K uptakes, particularly on application of 25% NPK + 75% Rice bran. The values obtained were not significantly different from other fertilizer treatments (both soles and their combinations) investigated, except the control (Table 6). A number of studies have shown that improved nutrient uptakes by crops via both sole fertilizer applications and their combinations, under varying agro-ecological zones and soil fertility conditions [4, 9].

Table 6: Nutrient uptakes of tomato (*Lycopersicon lycopersicum*) as influenced by organic and inorganic fertilizer combinations

	NUTRIENT UPTAKES (gkg^{-1})		
TREATMENTS	N	P	K
Control	12.4c	1.1c	1.1d
100% NPK	46.7b	9.2b	14.6c
75% NPK + 25 % Rice Bran	57.3ab	21.5a	18.6b

50 % NPK + 50 % Rice Bran	**65.4a**	**21.2a**	**20.6ab**
25 % NPK + 75 % Rice Bran	**63.9a**	**24.1a**	**22.7a**
100% Rice Bran	**61.7a**	**22.3a**	**22.6a**

Means followed by the same letters are not significantly different at p=0.05, using DMRT.

4.0 CONCLUSION AND RECOMMENDATION

All fertilizer materials applied significantly enhanced tomato growth, yields and nutrient uptakes, compared to the control. Locally produced rice bran is a potential fertilizer material, which could be used for efficient arable crop production. Integration of rice bran with chemical fertilizer may be more effective and efficient in inducing better crop performance than its sole application, particularly under low fertile soil conditions. Significantly delayed leaf shedding and prolonged leaf production observed in tomato plants which received rice bran applications at 50% level and above, is a good indicator of possible enhancement of prolonged flowering and fruiting, as also manifested in significantly higher fruit yields. Therefore, since there is an increasing awareness on the environment friendly benefits of organic fertilizer production and usage, application of only NPK fertilizer without using organic manure should be totally discouraged.

Hence, 75% Rice Bran + 25% NPK could be recommended or alternatively 50% Rice Bran + 50% NPK, for tomato production in the study area. This will alleviate the problems associated with the use of chemical fertilizer, as well as their residual effects established in soils of the study area.

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