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Nitrogen and Phosphorus use Efficiency by Tomato (*Solanum lycopersicum* L.) in Dadin Kowa, Gombe State

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ABSTRACT

The research was conducted at the Teaching and Research farm of the Federal College of Horticulture Dadin Kowa during 2014 and 2015 cropping seasons the trial was to determine Nitrogen (N) and Phosphorus (P) Use Efficiency by Tomato (*Solanum lycopersicum* L.). The experiment consisted of fifteen (15) treatments combinations laid out in a split plot design, replicated three times, with five (5) levels of N as the main plot treatments and three P levels as the sub-plot treatments. All the treatments levels of N and P applied gave higher results on growth and yield parameters such as plant height, number of branches plant^{-1}, number of fruits plant^{-1}, yield of fresh fruits and dry weight of fruits in tons Ha^{-1}, they all increased with increase in N and P levels than the controls (0 Kg Ha^{-1}) in the two cropping seasons. However 120 Kg Ha^{-1} of N and 26 Kg Ha^{-1} of P significantly ($P \leq 0.05$) enhanced growth and yield of fresh fruits of tomato producing the highest yields of 118.1 and 124.5 tons Ha^{-1} of fresh fruits of tomato in the two cropping seasons, respectively. There were high significant interacts ($P \leq 0.01$) between the N and P on the growth and yield of the tomato in both the two cropping seasons. The N and P levels of 120 Kg Ha^{-1} of N and 26 Kg Ha^{-1} recorded the highest uptake efficiency of N and P, respectively, than the control levels. But, there was no statistical difference ($P \leq 0.05$) between N levels of 90 Kg Ha^{-1} and 120 Kg Ha^{-1}. Therefore, the above results indicated that N and P treatments contributed to the growth, yield and nutrient uptake of tomato plants attaining optimum status at 90 Kg N Ha^{-1} and 26 Kg P Ha^{-1} on the sandy loam soils of Dadin Kowa. The interaction of N and P gives striking evidence of their complimentary effects on growth and nutrition of tomato plants.

INTRODUCTION

Tomato (*Solanum lycopersicum* L. is one of the most popular and widely grown plants in the world as well as in Africa (Osemwegie, *et al.,* 2010).

It is the second most important vegetable worldwide, in terms of the amount of vitamins and minerals it contributes to the diet (Enrique and Eduardo, 2006). Although tomato origin and early history of its domestication are obscure, the weight for evidence suggested that Mexico was probable centre of origin (Ojo *et al.,* 2009). African tomato varieties were introduced to Africa and Nigeria in particular at the end of the 19th century (Bangambuola *et al.,* 2004).

Tomato is perhaps the most important popular vegetable crop grown all over the country, both the wet and dry season cropping systems contribute immensely to the national requirement, but the bulk production is from the dry season cropping system grown yearly under irrigation in southern states (Ojo *et al.,* 2009). Tomatoes are considered to be one of the most economically important crops of all those that exist in the world (Rahman *et al.,* 2003). They also constitute the main ingredients in hundreds of dishes and productions that are sold in supermarkets throughout the developed world, this means that the demand of tomatoes from countries will be extremely high (Mourvaki *et al.,* 2005).

Fertilization system that optimizes plant growth and productivity by optimizing nutrient utilization and minimizing fertilizer loss would decrease the amount of fertilizer applied. This in turn provides cost saving to the growers and minimizes environmental hazards. As such, increasing nutrient use efficiency is an economic and environmental need (Valenzuela *et al.*1992; Hedge, 1997; and Agbabiaze and Bodunde, 2002). How much nutrients plants need depends on the plant growth rate and nutrient use efficiency (NUE), as such, nutrient analysis of the plant biomass provide an estimate of the crop performance (Thompson *et al.,* 2003). A study conducted by Afolabi and Ayinde (2001), show that tomato production is a profitable venture, but the level of resource use with respect to fertilizer, land and seed are below optimum. The subsistence farmers often with very low yield grow most of the tomatoes cultivated in Nigeria, especially in the Northern part of the country on small scale. There are indications that farmers apply different amounts of fertilizer to the crop, which are often too low satisfying the crop plant nutrients demand.

However, krusekopt *et al.,* (2002) indicated that not more than 100 kg N ha^{-1} was necessary to maximize tomato yield or fruit quality in any field, indicating that differing field conditions justified little of the variability in grower N rates. But then, the amount of nutrients required for the efficient growth and quality of any crops depends on the types of crop, soil conditions, and the environmental factors (Valenzuela *et al.*1992, and Thompson *et al.,* 2003). It is obvious that farmers themselves lack knowledge on appropriate combination of inputs and proper levels of the resources for optimum growth and yield of the crops. This research work was thus, conceived to determine the most efficient N and P levels for growth, yield and quality of tomato in the area under study.

MATERIALS AND METHODS

Field experiments were conducted during the 2014 and 2015 cropping seasons at the Federal College of Horticultural Research Farm, Dadin Kowa, Gombe, located on 10° 18" N and 11° 31" E in the Sudan savannah ecological zone of Nigeria (Kowal and Knabe, 1972), with a mean annual rainfall of 850 mm. The mean daily temperature ranges from 30-32 °C. The soil at the experimental site is classified texturally as sandy loam. The experiment was laid out in a Split-Plot Design with three replications. The treatments consisted of five levels of nitrogen (0, 30, 60, 90 and 120 kg N/ha) from urea (46 % N), which were assigned as main treatments, and three levels of phosphorus (0, 13 and 26 kg P/ha) from single super phosphate (7.8 % P), which were the sub- treatments. Twenty centimeters raised beds of 1.5 m width and 4.0 m long were prepared for raising the tomato seedling on 1st June, 2014 and 10 June 2015, respectively. Normal cultural practices such as weeding, pest and diseases control were done to ensure proper growth and development.

The seedlings were transplanted into the field four weeks after sowing at a spacing of 60 cm by 40 cm. The plot size was 6 m by 2.5 m giving 63 plants $plot^{-1}$. First spray of the farm with insecticides was done 3 WAT; the plots were sprayed fortnightly with Dimethionate (75 ml/15l) using a knapsack sprayer to control pest and diseases. Destructive sampling was conducted using five plants samples at 2 weeks interval from 24 to 44 days after transplanting (DAT).These samples were washed, dried at 60 °C, weighed, ground to < 0.6 mm, and extracted. The total nitrogen and phosphorus contents of all above ground biomass sampled were determined by the micro –kjeldahl method. Five out of 63 plants in each plot were randomly selected and tagged for sampling data. The number of branches $plant^{-1}$ at 2 weeks interval from 30-60 days (DAT), Plant height at 2 weeks interval, single fruit weight, and length of fully matured fruit were observed on tagged plants. The fruit yield (t ha^{-1}) were also recorded.

The N and P use efficiency was calculated as

$$NUE\ of\ N = \frac{PNi - PNo}{FNi}.$$ Where PNi represent the total aboveground crop N uptake in plot i, PNo equals the aboveground crop N uptake in control plot and FNi is fertilizer N applied to Plot i.

Similarly, $$PUE\ for\ P = \frac{NP_i - NPo_o}{FPi}.$$

Where NP_i represent the available P in the aboveground crop p uptake in plot i, NP_o equals the aboveground crop P uptake in control plot and FP_i is the fertilizer P applied to plot i (Thompson *et al.,* 2003). It was assumed that: (i) the fate of indigenous N and P in control and fertilized plot was the same, (ii) There was no other source of unaccounted N and P, and (iii) There was no net change in organic matter or microbial biomass of N and P. Therefore, any differences in N and P losses observed between fertilized and control plots were assumed to be the result of the treatments or their effects on tomato growth and N and P recovery in plant biomass. Data collected were subjected to analysis of variance, and comparison of means with control was made according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

The result in Table 2 indicated that there were significant differences ($P \leq 0.01$) among the nitrogen (N) levels on growth parameters. The 120 kg N/ha significantly had the highest plant heights of 47.33 cm and 36 87 cm in 2014 and 2015 respectively. Again, it also had the highest number of branches of 4.31 and 8.21 per plant at 4 and 6 WAT respectively, in 2014. But, the highest number of branches of 6.22 and 9.89 were recorded by 60 kg N/ha in 2015. The highest lengths of matured fruit (cm) in both 2014 and 2015 cropping seasons were obtained by 120kg N/ha recorded as 6.53 cm and 5.48 cm respectively.

Again, significant difference ($P \leq 0.01$) was observed among the phosphorus (P) levels on growth parameters (Table 2). 26 kg P/ha produced the highest plant height (cm) at 2, 4 and 6 WAT, highest length of matured fruit (cm) and the highest number of branches per plant at 2,4, and 6 WAT in the two cropping seasons. The number of branches and plant height increase with a corresponding increase in the levels of nitrogen and phosphorus from the zero levels (control) to the highest levels of the N and P between 2 WAT to 6 WAT. This could be as a result of initial low levels of N and P available to the plant, which was considered very low to support the good performance of the crop, and may be due to the fact that most of the soil phosphorus is fixed due to its fixation by organic matter or clay minerals and may be due to PH changes (Table 1)(Brady and Neil, 1999).

The results as indicated in Table 3 are that the highest mean value of fresh tomato fruits was achieved by the treatment of 120 kg N ha^{-1}. This N level produced the highest mean value of 98.8 t ha^{-1} of fresh tomato fruits, in 2014, though not statistically different from that obtained from 90 kg N ha^{-1}. Highly significant difference was equally observed among

P levels, with respects to yield of fresh fruits of tomato. In 2015 the P level of 26 kg P ha^{-1} produced the highest mean value of 103.8 t ha^{-1} of fresh tomato fruits.

The results therefore, indicated that yield of fresh fruits of tomato, number of fruits per plant, single fruit weight and the fruit dry weight increase with increase in the levels of nitrogen and phosphorus in both the two cropping seasons. The highest number of fruits per plant was obtain by 120 kg N/ha at 6 and 8 WAT. This treatment level also had the highest single fruit weight (g) and the highest yield of fresh fruit of tomato in 2014 and 2015 cropping seasons (Table 3). However, the highest fruit dry weight was obtained by 90 kg N/ha. Similarly, 26 kg P/ha had the highest number of fruits per plant at 4, 6 and 8 WAT, the highest single fruit weight (g) highest fruit dry weight(g), and the highest yield of fresh fruits of tomato in the two cropping seasons. These yield advantages may be attributed to better use of the nutrients when the nutrients were at their optimum levels. This agree with the findings of Alamu *et al.* (2002) and Thompson *et al.* (2003), who stressed the importance of high fertility level for getting higher yield of tomato.

Table 4 shows that, there were significant differences ($P \leq 0.001$) among the phosphorus levels with respect to available P in tomato plant biomass measured in both 2014 and 2015 cropping seasons. In 2014, the highest mean value of P uptake was observed from the treatment level of 26 kg P/ha which recorded 0.620 % at 6 WAT. While the lowest mean value of P uptake of 0.117 % was observed from 0 kg P/ha at 2 WAT. 13 kg P/ha recorded the mean P uptake of 0.450 % at 6 WAT, and 0.233 % at 2 WAT. However at 4 WAT, the mean values of p uptake recorded by the 0, 13 and 26 kg P/ha were 0.33 %, 0.323 % and 0.417 % respectively. In 2015, the lowest mean value of P uptake of 0.111 % was observed from 0 kg P/ha at 2 WAT, while the highest mean P uptake of 0.594 % was obtained by application of 26 kg P/ha at 6 WAT. The 13 kg P/ha had its highest mean P uptake of 0.468 % at 6 WAT and lowest P uptake of

0.193 % at 2 WAT in 2015. At 4 WAT in 2015, the mean P uptakes obtained by 0, 13 and 26 kg P/ha were 0.240 %, 0.339 % and 0.409 % respectively. However the highest N and P uptake was obtained at 6 WAT which coincided with the fruiting period than at 2 WAT that is the early growing period of the crops in the two cropping seasons. This result tends to agree with the report of Hedge (1997) who reported that about 50 % of the total nutrient uptake takes place during the peak fruit development due to high level of nutrients demand at that stage. The highest N uptake in tomato was obtained in combination with fertilizer P. likewise P uptake in tomato increased significantly ($P \leq 0.05$) with increase in N and P levels in both the 2014 and 2015 cropping seasons. Similar report was made by Havlin *et al.* (1999) that great effectiveness of fertilizer P can occur when fertilizer application system place P in close association with NH_4^+ N source due to their complimentary effects. Significant interactions ($P \leq 0.05$) were also observed among N and P levels on most of the measured parameters. Although, Havlin *et al.* (1999) reported that the effects of interactions between N and P doses were not found to be very significant on the uptake of nitrogen, phosphorus, magnesium and zinc. The result of this study indicated that P uptake is influenced by the presence of fertilizer N. Thus, it could be that N promotes P uptake by the plant.

This study, therefore indicated that N and P applications contributed to the growth, yield and efficient nutrient uptake by tomato plants, attaining maximum status at 90 kg N/ha and 26 kg P/ha on the sandy loams of Dadin-kowa. The interaction of N and P confirmed their complimentary effect on growth and nutrition of tomato plants.

Table I: Chemical and Physical Properties of the Soil of the Experimental Site before the Two Cropping Seasons at Dadin-Kowa

	2014	2015
Soil Characteristics	**0-30 cm Soil depth**	**0-30 cm Soil depth**
Chemical properties of soil		
P^H in water (1.2.5)	6.40	6.50
P^H in $CaCl_2$ (1.2.4)	5.50	5.80
Organic carbon (%)	0.58	0.50
Total Nitrogen (%)	0.50	0.46
Available Phosphorus (Ppm)	4.86	6.72
Exchangeable Bases (Meg/100g)		
Ca	4.35	3.30
Mg	0.82	0.78
K	0.45	0.31
Na	0.35	0.30
CEC	5.50	5.33
Particle size distribution		
Sand (%)	51.2	49.7
Silt (%)	33.0	31.3
Clay (%)	14.8	16.0
Textural Class	Sandy-Loam	Sand-Loam

Table 2: The Effects of Nitrogen (N) and Phosphorus (P) Levels on Plant Height, Length of Fully Matured Fruit and Number of Branches/Plant of Tomato Measured in 2014 and 2015 Cropping Season

Treatments N levels	Number of Branches/Plant						Length of fully matured fruit (cm)		Plant height (cm)					
(Kg/ha)	2014			2015			2014	2015	2014			2015		
	2 WAT	4 WAT	6 WAT	2WAT	4WAT	6WAT			2 WAT	4WAT	6WAT	2 WAT	4 WAT	6WAT
0	0.56	2.44	3.67	0.22	1.67	3.22	3.944	3.511	16.89	23.11	31.49	13.49	22.61	26.14
30	1.44	3.22	5.67	1.67	4.89	7.22	4.889	4.144	21.22	27.78	37.11	14.79	24.46	32.47
60	1.89	3.44	6.00	2.8	6.2	9.89	5.222	4.778	22.67	28.78	39.56	18.46	30.47	38.87
90	1.33	3.56	6.00	2.11	5.22	8.11	5.222	4.922	22.11	30.78	43.22	16.28	25.50	32.29
120	1.89	4.31	8.21	2.22	5.11	7.56	6.533	5.489	22.67	33.22	47.33	18.40	27.93	36.87
LSD	0.531	0.371	0.857	0.760	2.11	2.102	0.510	0.545	2.127	2.516	2.548	0.901	4.73	6.035
P Levels														
(Kg/ha)														
0	20.13	28.07	38.47	15.85	21.65	27.29	4.620	3.013	1.00	3.00	5.20	0.93	2.60	4.606
13	21.33	28.93	40.07	15.61	28.18	36.00	5.100	4.440	1.41	3.33	5.73	2.20	6.07	8.80
26	21.87	29.20	40.80	17.39	28.7	36.69	5.167	5.653	1.80	3.73	6.73	2.33	5.20	8.20
LSD	0.417	0.350	0.774	3.150	4.384	3.695	0.432	0.298	0.359	0.254	0.533	1.241	1.590	1.519

Table 3: The Effects of Nitrogen (N) and Phosphorus (P) Levels on Number of Fruits/Plant, Average Fruit Weight, Fruit Dry Weight and Yield of Fresh Fruit of Tomato

Treatments	Number of fruit/Plant						Average fruit weight (g)		Fruit dry weight (g)		Yield of fresh Fruit (t/ha)	
N Levels (Kg/ha)	2014			2015			2014	2015	2014	2015	2014	2015
	4WAT	6WAT	8WAT	4WAT	6WAT	8WAT						
0	1.78	10.78	25.11	0.78	3.89	7.44	3.78	2.44	2.37	1.30	4.85	0.79
30	2.78	15.11	38.33	2.67	14.22	26.44	4.33	3.11	2.97	1.72	10.59	4.70
60	4.56	16.00	41.44	4.33	17.56	36.11	5.11	3.33	3.70	2.56	10.54	6.94
90	4.56	17.56	46.67	4.56	17.56	37.22	5.22	3.44	3.73	3.60	11.06	9.36
120	4.56	18.00	46.67	5.22	21.67	39.78	5.22	3.67	3.52	3.21	11.8	9.23
LSD	1.223	3.058	12.773	0.606	2.083	6.442	0.948	0.806	0.628	0.287	4.476	4.869
P Levels (Kg/ha)												
0	3.13	13.00	29.00	2.67	12.13	23.80	3.80	1.73	3.11	1.81	7.99	0.83
13	3.47	16.73	42.60	3.40	14.80	29.20	5.13	3.40	3.21	2.54	11.21	5.33
26	4.33	16.73	43.13	4.47	18.00	35.20	5.27	4.47	3.45	3.07	10.10	12.45
LSD	0.967	1.876	4.583	0.501	0.819	1.914	0.454	3.679	0.237	0.150	3.555	2.765

Table 4: Available Nitrogen (N) and Phosphorus (P) in Tomato Plant Biomass Measured in 2014 and 2015 Cropping Seasons

Treatment Available N and P in Tomato Plant Biomass (%)

N levels (kg/ha)	2 WAT		4 WAT		6 WAT		NUE
	2014	**2015**	**2014**	**2015**	**2014**	**2015**	
0	2.434	2.094	2.773	2.610	2.372	2.890	11.2
30	3.266	2.541	2.929	2.980	2.518	3.420	17.1
60	2.879	2.441	2.743	2.770	3.866	3.400	67.0
90	2.489	2.604	2.643	3.110	4.008	3.580	70.0
120	2.824	2.971	3.367	3.540	3.634	4.030	73.0
LSD	0.437	1.150	0.430	1.380	1.010	1.309	6.430
P levels(Kg/ha)							
0	0.117	0.111	0.233	0.240	0.317	0.356	17.0
13	0.223	0.193	0.323	0.339	0.450	0.468	22.4
26	0.243	0.226	0.417	0.409	0.620	0.594	51.0
LSD	0.169	0.0595	1.170	0.0602	0.001	0.070	6.706

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