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acta SATECH **3**(1): 35 - 41 (2009)

Effect of P-fertilizer sources and rates on growth, dry matter accumulation and fruit yield of Bell Pepper (*Capsicum Frutescens*)

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ABSTRACT

Bell pepper (Capsicum frutescens) requires phosphorus (P) for optimum growth and high quality fruit production. This study was carried out at National Horticultural Research Institute, Ibadan to assess growth, dry matter and fruit yield of bell pepper in response to P-fertilizer types and their rates. The treatments studied were three P-fertilizer types {Single Super Phosphate (SSP); Ogun Rock Phosphate (ORP) and Organic Fertilizer (OGF)} and four levels of each fertilizer sources (0, 30, 60 and 90 kg P /h) in a Randomized Complete Block Design (RCBD) experiment with three replications. Data were collected on growth and yield attributes as well as dry matter accumulation. The data collected were subjected to analysis of variance and significant means compared using DMRT at 5% probability level. The main and interactive effects of fertilizer P- sources and rates were significant in most of the growth parameters considered. SSP at 60 kg /ha significantly enhanced growth parameters and dry matter accumulation over other sources and rates. ORP produced the highest number of marketable fruits (269 / plant). The 60 kg /ha rate produced both the highest marketable and fresh fruit weight/plant whereas the least of the two parameters were obtained with 0 kg/ha fertilizer treatment. The interaction of fertilizer sources and rates were significant on all parameters considered. In most cases results obtained with 60 and 90 kg / ha of P-fertilizer were not significant. It was concluded that optimum production of bell pepper required up to 60 kg /ha P. This could best be supplied through the use of ORP fertilizer.

***Key words**: Dry matter, fruit yield, pepper, rock phosphate fertilizer.*

INTRODUCTION

Pepper belongs to the family *Solanaceae* and the Genius *Capsicum.* It originated in the tropical America, probably Mexico (Tindall, 1988; Bosland, 1989). It is cultivated mostly in the East Amazon but is has also spread to Africa (Pickersgill, 1989). In Nigeria, it is ranked among the top 5% of the most important spices consumed (Denton and Makinde, 1993). Nigeria is the largest producer of pepper in Africa. Pepper contributes substantially to the diet of Nigerian populace as condiments in soup and stew. It is also a reliable source vitamins A and C. Fresh fruit yield is between 1000 and 1250 kg /ha (Rice *et al*., 1990), and the dry fruits weight of between 8501200 kg /ha (Alegbejo *et al*., 1999) have been reported.

It is generally believed that solanaceous group of vegetables and spices take up large amount of nutrient from the soil. . Pepper needs P nutrient even up to fruit ripening (Hedge, 1997). It has been reported that optimum supply of N and P to pepper increases dry matter, fruit yield (Grattan and Grieve, 1993) and nutrient uptake in pepper (Hedge, 1989). Information available on pepper P requirement varied from 20 kg P /ha to as much as 140 kg P /ha (Fagbayide, 1997). P has been implicated as an essential nutrient to plants for it is requires for tissue respiration and as components of an important plant organic compounds (Robert and Andrew, 1989).

Pepper yield could be as high as 12 t./ha under experimental condition as against 1.2 t /ha realizable on farmers' field (Grattan and Grieve, 1993). One of the major causes of low yield of pepper obtained by the farmers is poor soil nutrients. The fragile nature of the soil, couple with overuse of most arable crop lands as a result of continuous cropping in Nigeria has made it mandatory to apply fertilizer to the crops. However, despite indispensability of fertilizer to crop production in Nigeria, its source and cost are still problems to very many peasant farmers. Fertilizer is any materials, of organic or inorganic origin, that is added to the soil to supply needed nutrients to the crop grown on it (FPDD; 1990). Natural deposits of phosphate rock are available in Nigeria in large quantity. They are relatively cheaper than synthetic P source and their residual effects last longer. Some of these P sources are Ogun Rock Phosphate (ORP) and Sokoto rock Phosphate. Despite the fact that these P sources are readily available, research is still required on them to ascertain the nutrient contents and crop requirement of them. The objectives of this work therefore is to determine the effectiveness of different P fertilizers as indicated by the growth, dry matter accumulation and fruit yield of bell pepper.

MATERIALS AND METHOD

Experimental site: Field experiments were conducted at National Horticultural Research Institute, Ibadan, Nigeria between 2003 and 2005. Ibadan is on latitude 40^0N and longitude 60^0 E with annual rainfall of about 1290 mm. The soil of the experimental plot had 0.03 % N; 4.69 ppm available P; 0.58 % organic carbon and 0.11 meg 100^{-1} exchangeable acidity. From the analysis, it was discovered that the soil is low in essential nutrients (notably N and P) required for optimum growth and fruit yield of pepper.

Field establishment and crop management: The seeds of the bell pepper cultivar'tantase'were sown in a nursery beds contained 1:3 top soil: compost proportion by weight (Akanbi et al 2002). The seedlings were allowed to grow for a period of six weeks. The experimental land was ploughed and harrowed once each. Thereafter it was divided into blocks and plots. A plot dimension 2.5 m x 2.5m and contained 36 plants spaced out at 50 cm x 50 cm. At transplanting, healthy seedlings were selected and transplanted into well prepared plots on 20^{th} of April, 2003 and 16^{th} of April, for 2003 and 2005 experiment, respectively. Supplying of vacant stand was done a week after transplanting (WAT). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The treatments tested were three P types {Ogun Rock Phosphate (ORP), Single Super Phosphate (SSP) and Organic Fertilizer (OGF) and four rates of application (0, 30, 60 and 90 kg / ha P_2O_5). The Ogun Rock phosphate is from P deposit in Ogun state and contains about 14 % P_2O_5 while OGF is an organic fertilizer produced by Pacesetter fertilizer firm own by Oyo State government. The chemical analysis of OGF fertilizer material shows 5.24 % N and 0.95 % P. The P types were grinded into powder before application. This increases their surface area. The P treatments were applied a week before transplanting (NIHORT, 1989) to make them readily available to the plants. At 2WAT, there was uniform application of Nitrogen at 80 kg N /ha, (inform of Urea, 46 % N) as basal treatment to the entire plots. Manual weeding was done thrice starting from 2WAT and repeated every (3) weeks interval by hoeing. Insect pests were controlled by spraying the crops with karate at the rate of 20 ml /20L water at two weeks interval starting from 2 WAT.

Data Collection: Six plants were randomly tagged per plot for data collection. The growth parameters measured at 8 WAT were per plant number of functional leaves and branches, plant height, stem girth, leaf area and dry matter yield. The fruit yield components taken were number of marketable and unmarketable fruit, weight of marketable and unmarketable fruit, and fruit yield.

Data analysis: All data collected over two years were pooled together and averaged before subjected to Analysis of Variance (ANOVA), and significant means were compared using DMRT at P = 0.05.

RESULTS

Effects of P Fertilizer on Vegetative growth of Pepper.

P source and rate significantly affected pepper vegetative growth parameters (Tables 1 and 2). The main effect of P source was significant pepper stem girth, plant height, number of branches and leaves and leaf area. The girth ranges from 2.54cm in ORP to 3.01 cm in SSP. For all the growth parameters assessed, crop performance under SSP and OGF were similar. P- rates also had significant effects on all the growth parameters recorded. Except in leaf area development and number of branches per plant, application rate of 60 kg P /ha consistently produced higher values compared to others. The leaf production was highest with application of 90 kg P/ha. This is similar to what was obtained with the use of 60 kg P /ha. Incase of number of branches/plant,application of 90 kg P/ha gave the

highest values, followed by non fertilized plant while the least was observed with 30 kg P/ha application rate.

The Interactive effects of P source and rate was significant on all the growth parameters measured. Stem girth ranges from plants that were fertilized with 30 kg /ha ORP to that of 60 kg /ha SSP. Number of branches gave similar trends. In this parameter, application of 60 kg /ha SSP outperformed other treatments. The highest leaf number per plant (195 leaves /plant) was obtained with plants fertilized with 60 kg /ha SSP and was significantly higher than values obtained with other treatments. On the average, OGF produced leaves that were 25.2 and 31.2% higher than what was obtained with SSP and ORP, respectively. Plant leaf area production was significantly influenced by P-source and rates. This parameter varied from 773.0 cm^2 in 90 kg /ha OGF to a situation where 30 kg /ha ORP was applied.

Table 1: Main effects of sources and rates of P-fertilizer on vegetative growth of pepper at 8WAT

Treatment	Stem girth (cm)	Plant height (cm)	No. of branches / plant	No. of leaves / plant	Leaf area / plant (cm^2
Fertilizer P-source					
SSP	3.01a	44.1a	3.6a	155.9a	658.9a
ORP	2.54b	40.1b	3.2a	120.2b	592.0b
OGF	2.96a	44.3a	3.4a	158.6a	721.8a
Fertilizer P- rate (kg /ha)					
0	2.76ab	43.0a	3.3ab	149.9a	691.4a
30	2.64b	42.2b	2.4b	130.0b	571.9b
60	3.05a	43.7a	3.1b	156.1a	628.8ab
90	2.83a	42.3b	4.7a	143.6a	771.2a

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; and OGF = Organic Fertilizer

Table 2: Effects of different sources and rates of P-fertilizer on vegetative growth of pepper at 8WAT

P-Source	P-Rate (kg/ha)	Stem girth (cm)	Plant height (cm)	No of branches / plant	No of leaves / plant	Leaf area / plant (cm^2
SSP	0	2.9ab	42.4b	3.7ab	154.2b	521.5c
	30	2.7b	42.5b	2.4c	120.3cd	608.1b
	60	3.5a	42.3b	3.1b	195.0a	545.6c
	90	3.1a	49.1a	5.3a	54.1b	580.4c
ORP	0	2.6c	41.9c	2.4c	125.6c	537.7c
	30	2.2d	41.7bc	2.1c	132.1c	520.8c
	60	2.4cd	41.3c	3.4b	111.7d	649.3b
	90	2.8b	35.5d	4.7a	111.4d	660.2b
OGF	0	2.7b	44.9ab	3.8ab	169.9b	535.9c
	30	2.8b	42.4b	2.7bc	137.5bc	586.7bc
	60	3.2a	47.6a	2.7b	161.7b	691.6ab
	90	2.7b	42.2b	4.2a	165.4b	773.0a

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; and OGF = Organic Fertilizer

Dry Matter Accumulation in Pepper at 8WAT

Dry matter partitioning in pepper in response to P rate and source is presented in Tables 3 and 5. The main effect of P source was significant only on the stem and fruit parts. In stem, dry matter accumulation varied with 3.91 g/plant in SSP to 3.65g/plant in ORP. The value obtained with ORP and OGF were not significant but both were significantly lower than the value obtained with SSP. Fertilizer rate influenced pepper dry matter partitioning into leaf, root, stem and fruit. In all these parameters, 60 kg/ha application rate consistently produced highest dry matter irrespective of the parts of part in which the materials was accumulated. The interactive effects of P source and rate were significant on leaf, root, stem and fruit dry matter. The highest stem dry matter was obtained with 30 kg ORP. This was similar to what was obtained with 60 and 90 kg/ha SSP and 60 kg OGF.

Table 3: Main effects of source and rate of P-fertilizer on dry matter accumulation in pepper

Treatment	Dry matter (g)			
	Leaf	Root	Stem	Fruit
Fertilizer P-source				
SSP	1.17a	1.86a	3.91a	3.8a
ORP	1.25a	1.74a	3.65b	4.4a
OGF	1.30a	1.81a	3.67b	4.2a
Fertilizer P-rate (kg /ha)				
0	1.19b	1.69ab	3.62ab	3.7b
30	1.15b	1.63b	3.53b	3.5b
60	1.44a	2.07a	4.16a	4.5a
90	1.17b	1.81a	3.64ab	4.8a

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; and OGF = Organic Fertilizer

Table 4: Dry matter accumulation in pepper in respond to different P fertilizer sources and rates at 8 WAT

Fertilizer		Dry weight (g)			
P-Source	P-Rate (kg /ha)	Leaf	Root	Stem	Fruit
SSP	0	0.68c	1.56b	2.49bc	3.0c
	30	0.79bc	1.22cd	2.33c	3.1c
	60	1.57a	2.25a	4.93a	5.0b
	90	1.62a	2.39a	5.87a	4.1b
ORP	0	1.29ab	1.58b	3.47b	4.1b
	30	1.67a	2.29a	5.05a	6.0ab
	60	1.22ab	1.90b	4.03ab	4.2b
	90	0.80b	1.20d	2.04c	5.1b
OGF	0	1.59b	1.94b	4.90ab	2.1d
	30	0.98b	1.39c	3.21b	3.3bc
	60	1.53a	2.07a	3.53b	3.4bc
	90	1.08ab	1.85b	3.02b	8.1a

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; and OGF = Organic Fertilizer

Table 5: Main effects of source and rate of P-fertilizer on fruit yield of pepper

Treatment	Number			Weight (g/plant)		
	MF	UMF	TOTAL	MF	UMF	TOTAL
Fertilizer P-source						
SSP	223b	38a	261	829.3b	146.5b	985.8
ORP	269a	34b	303	855.1b	136.0c	1115.2
OGF	2496	39a	287	954.5a	160.7a	991.1
Fertilizer P-rate (kg /ha)						
0	161a	47a	208	752.8b	158.9a	911.7
30	271a	33a	304	969.0a	149.7a	1118.7
60	290a	35a	325	928.4a	137.8b	1066.2
90	269a	31b	300	881.8ab	145.1ab	1026.9

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; and OGF = Organic Fertilizer
MF = Marketable fruit; UMF = Unmarketable fruit

Effect of P fertilizer source and rate on Fruit Yield and yield components of b ell Pepper

Fruit yield attributes of pepper varied significantly with P source and rate (Tables 5 and 6). Variations exist among and within treatments. ORP at 30kg/ha produced the highest number of fruit whereas SSP at 0kg/ha produced least. Though there were significant differences in the number of unmarketable Fruits (nUMFs), 0 kg /ha of the three sources produced UMFs that are not different. They were in the order of 44, 47 and 49 for SSP, ORP and OGF respectively. Both the nMFs and nUMFs produced were affected by the fertilizer sources. ORP yielded more than either SSP or OGF except at 60kg/ha ORP, but there were no differences in respect of fertilizer rates. The fruit weight per plant varied across the P rate and

source. Weight of MFs from ORP was highest and varied very significantly from those from SSP and OGF that are almost similar in weight. ORP outperformed other P source in the total nFs produced but total wF/plant was significantly higher in OGF than any of the two other sources. There was no significant difference in the nMF produced based on the fertilizer rate but 90 kg/ha produced least nUMF and was significantly different from the other rates. MF weight/plant was lowest at 90kg/ha though not significantly different.

Bell pepper fruit yield varied significantly with P-source and rates. Fig. 1 shows the main effects of P-source and rate on pepper fruit yield. Ogun Rock Phosphate produced fruit yield that is 26 and 32 % higher than that of SSP and OGF, respectively. Fruit production was highest in 30 kg /ha application rate. The fruit yield obtained with this treatment was similar to that of 60 kg P/ha and was 43% and 24% significantly higher than what was obtained with 0 (control) and 90 kg application rate, respectively. Table 7 presented the interactive effects of P-source and P-rate on fruit yield. The fruit yield was highest with the use of 60 kg/ha OGF while the least was obtained with application of 0 kg /ha OGF. On the average, fruit yield was highest with 60 kg /ha application rate when the fertilizer materials was ORP.

Table 6: Effects of different sources and rates of P-fertilizer on fruit yield of pepper

P-Source	P-Rate (kg/ha)	Number of			Weight (g/plant)		
		MF	**UMF**	**TOTAL**	**MF**	**UMF**	**TOTAL**
SSP	0	140d	44a	184	845.5b	150.4b	995.9
	30	213bc	32c	245	832.9b	149.2bc	982.1
	60	323ab	40b	363	862.6ab	170.1a	1032.7
	90	216bc	37b	253	813.0b	117.7d	930.7
ORP	0	179c	47a	226	740.3bc	142.9c	883.2
	30	365a	31cd	396	1033.2a	145.9c	1179.1
	60	225bc	30cd	255	802.4b	120.3d	922.7
	90	306ab	26d	332	846.1b	135.1c	981.2
OGF	0	163c	49a	212	672.6c	123.3cd	795.9
	30	226bc	37b	263	1040.8a	153.9b	1194.7
	60	321ab	36b	357	1120.1a	183.1a	1303.2
	90	284b	31cd	315	986.3a	182.5	1168.8

Mean with same letter(s) along the column are not significantly different (DMRT= 0.05)
ORP = Ogun Rock Phosphate; SSP = Single Super Phosphate; andOGF = Organic Fertilizer
MF = Marketable fruit; UMF = Unmarketable fruit

Table 7: Interactive effects of P-source and their rates on bell pepper fruit yield (t./ha)

P- source	**P – rate (kg / ha)**				
	0	**30**	**60**	**90**	**Mean**
Single Super Phosphate	0.99	0.98	1.03	0.93	**0.99b**
Ogun Rock Phosphate	0.88	1.18	0.92	0.98	**1.12a**
Organic fertilizer	0.80	1.19	1.30	1.17	**0.99b**
Mean	**0.91b**	**1.12a**	**1.07a**	**1.03ab**	
LSD 5%: P-source x P-rate			0.02		

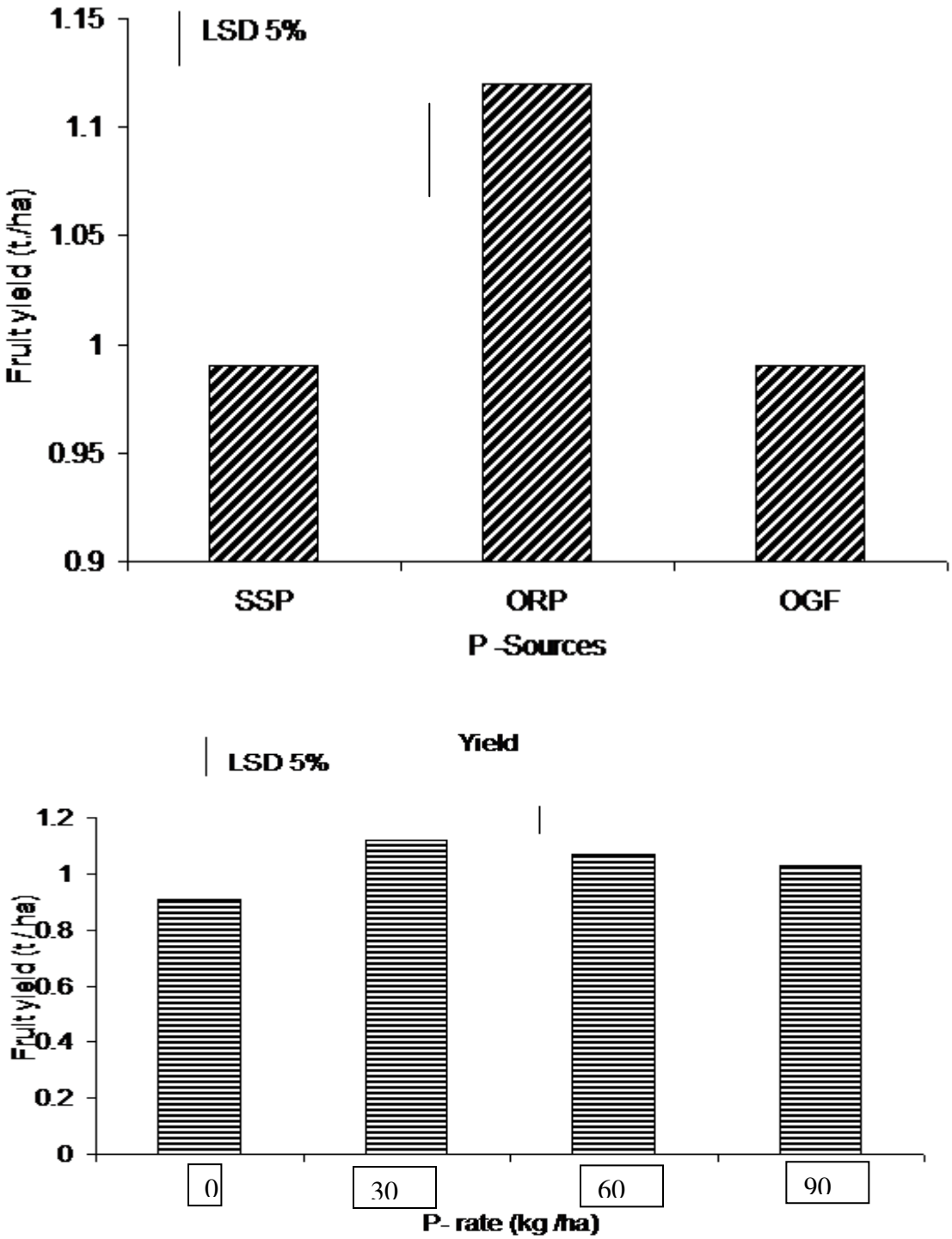

Fig. 1: Main effect of P-fertilizer source and rate on bell pepper fruit yield

DISCUSSION

Phosphorus (P) application influenced the growth, fruit yield and dry matter partitioning in pepper. Though at a lesser extent, at 60 kg /ha OGF SSP also favoured stem enlongation. OGF is required at between 30 and 60 kg /ha only. Plant height increased as the stem girth with SSP and OGF better than ORP. It has also been shown that higher rates of P fertilizer increased stem girth considerably. Rock Phosphate (RP) is bulky and so more expensive at the point of application particularly if transported over a long distance. That higher rate of RP is required for growth of the crop, and it is therefore not economical to apply ORP.

This result also signifies that ORP is not a good source of P for pepper vegetative growth. Fertilizer might not be applied or be applied at any of the three rates because sources of P fertilizer are not so important in pepper for branching. This clearly shows that P fertilizer does not have significant difference on branching in pepper. Fagbayide (1997) also observed this type of relationship between P-fertilizer and pepper. Though there is difference between the effects of the rate of application on the branching, highest rate still share a common feature with no P-fertilizer applied.

ORP did not enhance the growth of stem girth and plant height. But if it is readily available at relatively cheaper price, it can be applied between 60 and 90kg/ha because more branches are produced in this range. OGF at 90kg/ha also favoured branching to disadvantage of both plant stem and height. This may be so because the nutrient elements have been directed to branching at the expense of stem and height.

SSP at 60kg/ha produced more leaves though branching and leaf area are moderate. Generally OGF improves leaf production and followed by SSP which was not significantly different from OGF. For leaf production, general application rate at 90kg/ha is the best. It can also be applied at 60kg/ha or not applied at all. It is good to note that applcation at 60kg/ha had the largest stem girth, plant height and the number of branches was moderate. This feature coupled with number of leaves and leaf area will position the sun loving crop to photosynthesize adequately.

Leaf area is particularly favoured by both OGF and SSP. A soil deficient of nutrient from OGF may not produce large leaves. The total number and weight of fruits produced were highest with ORP. This perhaps is due to the fact that fruits production is a function of many factors among which are number of leaves per plant and leaf area.

CONCLUSION

Phosphorus application enhanced pepper growth, dry matter partitioning and fruit yield in this trial. In most of the parameters considered, and irrespective of P source application of 60 and 90 kg / ha performed similarly. It could be concluded that optimum production of bell pepper required up to 60 kg /ha P. This could best be supplied through the use of ORP fertilizer.

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