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Comparative Yield Of Bell Pepper (*Capsicum annuum L.*) On Different Soil Series In Ibadan, Southwestern Nigeria

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ABSTRACT

Climatic change and its accompanying adverse effects on the cultivation of crops such as bell pepper - an important fruit vegetable requires adaptable technology strategy at low or no cost to poor resource farmers. Growing bell pepper on soils considered less suitable could be an adaptation strategy to mitigate the effect of climate change on bell pepper production. Field trials were conducted at Ibadan, a derived savannah agro-ecological zone of Nigeria to determine the productivity of Bell Pepper (*Capsicum annuum* L.) on three different soil series at varying rates of Phosphorus (P) and Potassium (K) fertilizers over three seasons. Phosphorus and Potassium fertilizers were applied at four different rates of 0, 30, 45 and 60 kg P/ha and 0, 15, 30 and 45 kg K/ha respectively on Egbeda, Apomu and Jago soil series. Fertilizer source for P was Single Super Phosphate (SSP) while for K it was Murate of Potash (MOP). There were significant differences ($P < 0.05$) between the yields of Bell Pepper at different fertilizer rates and between different soil series. In the wet season of 2011, highest Bell Pepper yield of 15.34 t/ha was observed on Apomu soil series while the highest yield of 16.70 t/ha was observed on Egbeda soil series in the wet season of 2012. The highest yield of 15.05 t/ha was found on Apomu soil series in the dry season of 2012 followed by Egbeda (13.34 t/ha) and Jago (8.36 t/ha) soil series respectively. Highest P fertilizer rate for bell pepper on the soils was 45 kg P/ha while for K it was 30 kg K/ha. The trend of Bell Pepper yield on different soil series were Apomu > Egbeda > Jago, Egbeda > Apomu > Jago and Apomu > Egbeda > Jago in the raining seasons of 2011 and 2012 and dry season of 2012 respectively.

1. Introduction

Soil physical and chemical properties are essential in the profitable production of crops such as bell pepper. Also, the response of plants to applied nutrients is determined by intrinsic soil characteristics such as the soil series they belong. Soil series is a group of soils formed from the same parent rock material having similar chemical properties but different texture. Bell Pepper is well adapted to a wide range of soil texture but yields higher in sandy soils because of the warmth of such soils (Hartz et al. 2008). Bell Pepper requires an adequate application of P and K for stimulation of flowering, seed and fruit development and improvement of fruit quality. The average yield of pepper is about 13.4t/ha (FAO, 2001). Sweet pepper may yield up to 30t/ha in the field and up to 100t/ha in protected cultivation. Aliyu et al. (1996) recorded maximum economic yield at 140kg N/ha and 24kg P/ha on Pepper cultivar while Olanrewaju and Sowemimo (2003), obtained the highest yield at 24.2kg N and P/ha on a Sandy Loam Alfisol. Although Bell Pepper is grown across most of the agro-ecological zones of Nigeria with different soil types, the main production comes from Southern and Northern Guinea savannahs. Ensuring food security against increasing desertification and the menace of climate change requires investigation and manipulation of alternative arable lands. It is therefore imperative to study the yield on different soil types in a derived savannah

area such as Ibadan. The objective of this trial is to investigate the yield of Bell Pepper (*Capsicum annuum* L.) on 3 different soil series in Ibadan and at varying rates of P and K.

2. Materials and Methods

Field trials were conducted at Ibadan, a derived savannah agro-ecological zone of Nigeria to determine productivity of Bell Pepper (Capsicum annuum L.) on 3 different soil series – Egbeda, Apomu and Jago (Smyth and Montgomery, 1962) and at different Phosphorus (P) and Potassium (K) fertilizers over three seasons years. The soil series belong to Alfisols class (Soil Survey, 1990). Phosphorus and Potassium fertilizers were applied at 4 different rates of 0, 30, 45 and 60 kg P/ ha and 0, 15, 30 and 45 kg K/ha respectively on Egbeda, Apomu and Jago soil series. Ibadan is located at 7^0 30`N, $3^0$ 54`E and 168m above sea level with an annual rainfall of 1300mm. As shown in Table 1, the sites were formed from different parent rock materials situated at different altitudes with a different mode of formation and drainage classes (Askira, 2000). Jago series, a poorly drained hill wash soil was formed from Alluvial situated at the lowest altitude while Egbeda at the highest altitude formed from sedimentary Precambrian basement complex was well drained. Apomu soil series – a colluvial-alluvial was also a hillwash and well drained. Jago series was adjacent to a perennial stream which had been under fallow for more than 2 years while Apomu and Egbeda have been cropped annually for experimental purpose and been grown with leafy and fruit vegetables such as Pepper Cabbage and others as shown in

Table 1 Site and soil description of experimental sites

Soil Series	Elevation (m)	Parent Material	Mode of Formation	Drainage class
Jago	168m	Alluvium	Hill Wash	Poorly drained to swampy
Apomu	173m	Colluvial-alluvial materials derived from the basement Complex	Hill Wash	Well-drained class 4
Egbeda	185m	Precambrian Basement Complex comprising mainly granite and Gneisses Biotite Gneisses and Quartz Schist	Sedimentary	Well-drained class 4

Source: Adapted from Askira (2000)

Table 2. Routine chemical soil tests such as pH, textural classification, effective cation exchange capacity, total N, available P, exchangeable K, and organic carbon were carried out on the composite soil samples (0 – 30cm) taken from the sites before planting. Routine soil analyses were carried out on the soil samples. pH was determined in 1:1 soil-water suspension (Black, 1965), while textural classification was determined by Bouyoucos hydrometer method (Bouyoucos, 1951). K was determined in 1N Ammonium Acetate at 7.0 pH extract with Flame Photometer. Effective Cation Exchange Capacity (ECEC) was determined by the summation method while total nitrogen from concentrated Sulphuric acid digest was by colorimetric method. Phosphorus was determined in Bray P1 extract and organic carbon by colorimetric complete oxidation method. (Heanes, 1984). Bell Pepper (*Capsicum annuum L.*) seedlings were raised in the nursery for 4 weeks before transplanting into the field at a spacing of 30cm within rows and 50cm (66,666 plants/ha) between rows on plot size 0.9 x 1.5m. Granular Single Superphosphate (SSP, 18% P) was the source of Phosphorus and was applied at 0, 30, 45 and 60 kg P/ha in a single dose at two weeks after transplanting (2 WAT). Granular Murate of Potash (MOP, 60 % K) was the source of Potassium (K) fertilizer applied at the same time interval as for P in a single dose at 0, 15, 30 and 45 kg K/ha to the plants by banding. Nitrogen fertilizer in the form of granular Urea (46% N) at 40kg N/ha was applied in two equal split doses at 2 WAT and at flowering by banding. The experiment was laid out in a 4 x 4 split plot in a randomized complete block design replicated three times where Potassium was assigned to the main plot and Phosphorus to the subplot.

Table 2 Cropping history of sites used for the study.

Site	Elevation(m)	Bearing	Site History
Jago	168	N7.40211^0, E3.84562^0	Adjacent to a river. On fallow for up to 2 years
Apomu	173	N7.40173^0, E3.84774^0	Cultivated with annual leafy and fruit vegetables
Egbeda	185	N7.40721^0, E3.84833^0	Cultivated with annual leafy and fruit vegetables.

Fruits were harvested green as they mature, counted and weighed at weekly intervals. The experiments were carried out in the raining seasons of 2011, 2012 and the dry season of 2012. Supplementary watering was carried out in the dry season of 2012. Analysis of variance was done to determine significant differences between the yields of Bell Pepper at different fertilizer combination rates and means separated by Duncan Multiple Range Test. Furthermore, for easy comparison, relative yield of Bell Pepper among soil series was determined for each season as the yield of a treatment divided by the highest yield in that season expressed in percent.

3.0 Results and Discussion

The particle size and chemical properties of the soils are presented in Table 3. The soils are acidic with Apomu and Egbeda more acidic than Jago. pH in distilled water were 5.8, 5.2 and 5.2 in Jago, Apomu and Egbeda series respectively. Textural classes of the soils range from Loamy sand in Jago and Apomu series to sandy loam in Egbeda. There was variability within the organic carbon content of the soils which could be described as low to medium. Nitrogen (N) level of the soils are low to medium (0.60, 0.50 1.40 g/kg) with available P following the same trend as in N which was low to medium. Exchangeable K levels in two of the locations (Jago and Apomu) were low but adequate in Egbeda . Highest ECEC value (4.46cmol/kg) was obtained on Egbeda soils series while the percent base saturation was generally high. The soils are considered suitable for Bell Pepper production with appropriate fertilizer application and good management practices.

Table 3 Pre-cropping soil textural classification and chemical properties.

Soil Series	pH in H_2O	N g/kg	Av. P mg/kg	K cmol/kg	ECEC cmol/kg	Base Saturation %	Org. C g/kg	Soil Textural Classes
Jago	5.8	0.60	13.76	0.20	2.42	91.74	6.9	Loamy Sand
Apomu	5.2	0.50	13.44	0.18	2.35	92.34	6.0	Loamy Sand
Egbeda	5.2	1.40	4.30	0.53	4.46	88.12	16.9	Sandy Loam

2.1 The yield of Bell Pepper

There were significant differences in the yield of Bell Pepper among the soils series in all the three seasons. Although there were significant differences in Bell Pepper yield among soil series in the raining season of 2011 as shown in Table 4, highest yields observed in Egbeda and Apomu soil series were not significantly different with a yield of 14.82 and 15.0 t/ha respectively while Jago soil series yields were the lowest. Yields range of 1.06 – 14.82, 0.59 – 15.0 and 0.46 – 5.46 t/ha were observed on Egbeda, Apomu, and Jago soil series respectively. In the raining season of 2012 (Table 5), the highest yield of 16.7 t/ha was observed on Egbeda soil series followed by Apomu (12.83 t/ha) and lastly by Jago (11.86 t/ha) soil series. However, in the dry season of 2012 (Table 6), the first four highest yield ranking were observed in Apomu soil series with yields of 16.43, 15.05, 14.03 and 12.91 t/ha while the fifth highest yield ranking was observed in Egbeda soil series with a yield of 10.0 t/ha. Relatively, Bell Pepper yield was highest in Apomu soil series when compared to Egbeda and Jago soil series. Fig. 3 shows an increase Bell Pepper yield in Apomu soil series of 14, 7 and 17 times of over the control treatments of Egbeda, Apomu, and Jago soil series. Bell Pepper

Table 4 Effect of P and K fertilizer interactions on the yield (t/ha) of Bell Pepper (Capsicum annuum L) on different soil series in 2011.

Treatment	Egbeda	Apomu	Jago
P0K0	1.060pqrst	0.598st	0.459t
P1K0	8.389c	4.100fg	1.000qrst
P2K0	14.820a	1.530mnopq	5.460d
P3K0	8.937bc	3.427hi	0.820erst
P0K1	3.614ghi	2.560jk	0.611dst
P1K1	3.050ij	2.408kl	3.320hi
P2K1	1.681mnop	3.910fgh	3.281hi
P3K1	3.589ghi	1.191pqrs	2.400kl
P0K2	2.160klm	1.471nopqr	0.401t
P1K2	0.460t	4.380ef	1.000qrst
P2K2	2.370kl	15.007a	0.930qrst
P3K2	1.539mnopq	1.899lmn	0.847rst
P0K3	1.222opqrs	3.360hi	0.720dst
P1K3	3.512ghi	9.071b	0.831rst
P2K3	1.049gpqrst	1.410nopqr	0.731st
P3K3	4.759e	1.840lmno	2.111klm

Means with the same letters are not significantly different (P<0.05)

P rates – 0, 30, 45, 60 kg P/ha
P0, P1, P2, P3

K rates - 0, 15, 30, 45 kg K/ha
K0, K1, K2, K3

Table 5 Effect of P and K fertilizer interactions on the yield (t/ha) of Bell Pepper (Capsicum annuum L) on different soil series in the raining season of 2012.

Treatment	Egbeda	Apomu	Jago
P0K0	2.010vwyx	1.288y	0.548z
P1K0	3.822lmn	2.861pqrst	3.630lmnop
P2K0	11.620c	1.773vwyx	2.760qrstu
P3K0	16.700a	2.189tuvwx	1.969uvwyx
P0K1	5.020ghij	4.900hij	2.400dstuv
P1K1	5.715g	7.586e	1.500wyx
P2K1	2.451rstuv	4.719ijk	1.3601yx
P3K1	6.621f	3.720lmno	1.360yx
P0K2	5.781gh	12.828b	2.199tuvw
P1K2	2.537lmnopq	4.351jkl	0.531z
P2K2	2.259stuvw	8.308d	4.051klm
P3K2	1.850vwyx	3.720lmno	3.499mnopq
P0K3	2.216uvwt	3.051nopqrs	0.439z
P1K3	5.037ghij	4.351jkl	0.508z
P2K3	3.999klm	3.088nopqrs	3.270bmnopqr
P3K3	2.917opqrst	5.341ghi	11.861c

Means with the same letters are not significantly different (P<0.05)

P rates – 0, 30, 45, 60 kg P/ha
P0, P1, P2, P3

K rates - 0, 15, 30, 45 kg K/ha
K0, K1, K2, K3

Table 6 Effect of P and K fertilizer interactions on the yield (t/ha) of Bell Pepper (Capsicum annuum L) on different soil series in the

Treatment	Egbeda	Apomu	Jago
P0K0	1.170t	2.491qrs	0.960t
P1K0	5.546jk	9.490ef	3.860mno
P2K0	13.341cd	12.910d	4.740klm
P3K0	2.269rs	16.428a	1.681t
P0K1	2.820pqr	9.591ef	1.571st
P1K1	4.010lmno	7.250ghi	3.349opq
P2K1	8.674fg	15.049b	6.359ij
P3K1	9.998e	8.140gh	4.921kl
P0K2	1.190t	7.909gh	3.260pq
P1K2	2.211rs	8.770fg	2.218rs
P2K2	5.558jk	14.028c	3.801no
P3K2	1.221t	7.020i	0.928t
P0K3	3.611nop	4.952kl	4.948kl
P1K3	4.821kl	8.000gh	1.660st
P2K3	4.865kl	6.850i	6.919i
P3K3	9.330ef	4.501lmn	8.360g

Means with the same letters are not significantly different (P<0.05) P rates – PO = 0, P1 = 30, P2 = 45, P3 = 60 kg P/ha
K rates— KO = 0, K1 = 15, K2 = 30, K3 = 45 kg K/ha

2.2 Relative Yield

The yield of Bell Pepper among soil series in the raining season of 2011 was highest in Apomu soil series relative to other soil series as shown in Fig. 1. An increase of 14, 26 and 33 times over the control treatments in Egbeda, Apomu, and Jago were observed. In the raining season of 2012, highest Bell Pepper yield was obtained in Egbeda soil series relative to other soil series which translates to an increase of 8, 13 and 30 times over the control treatments of Egbeda, Apomu and Jago soil series as shown in Fig. 2.

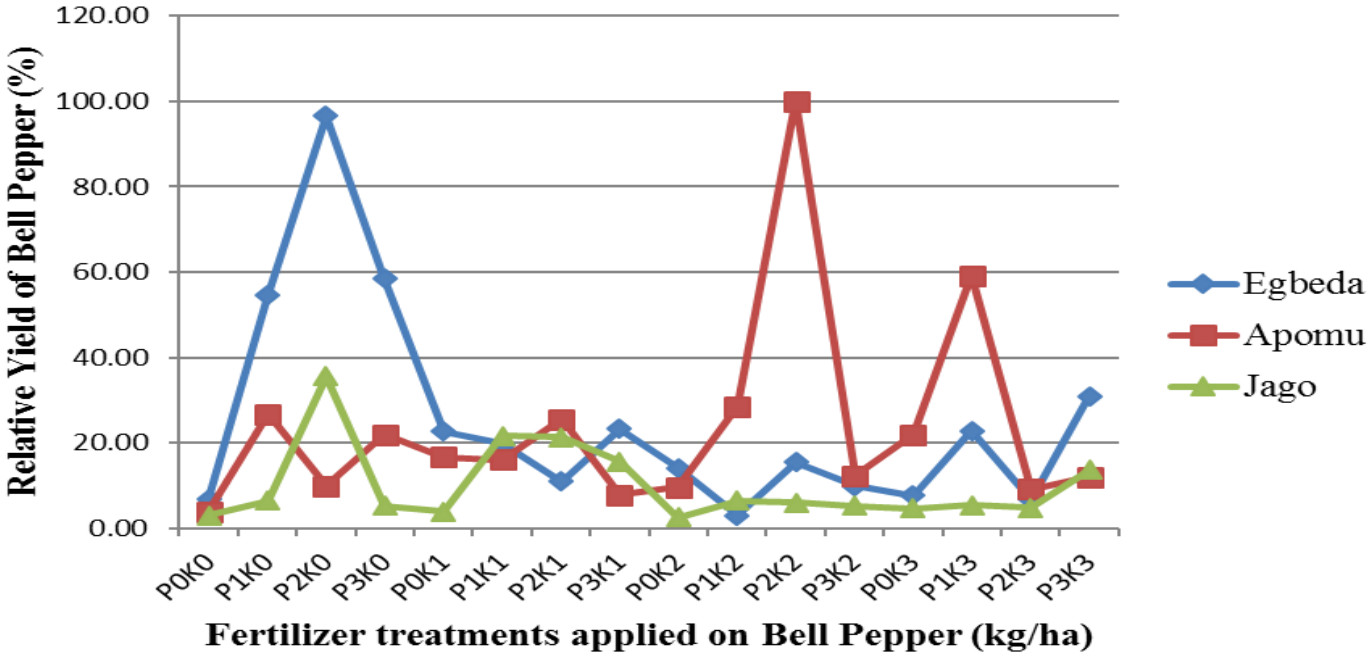

Fig. 1 Relative Yield of Bell Pepper in response to fertilizer application on different soil series in 2011.

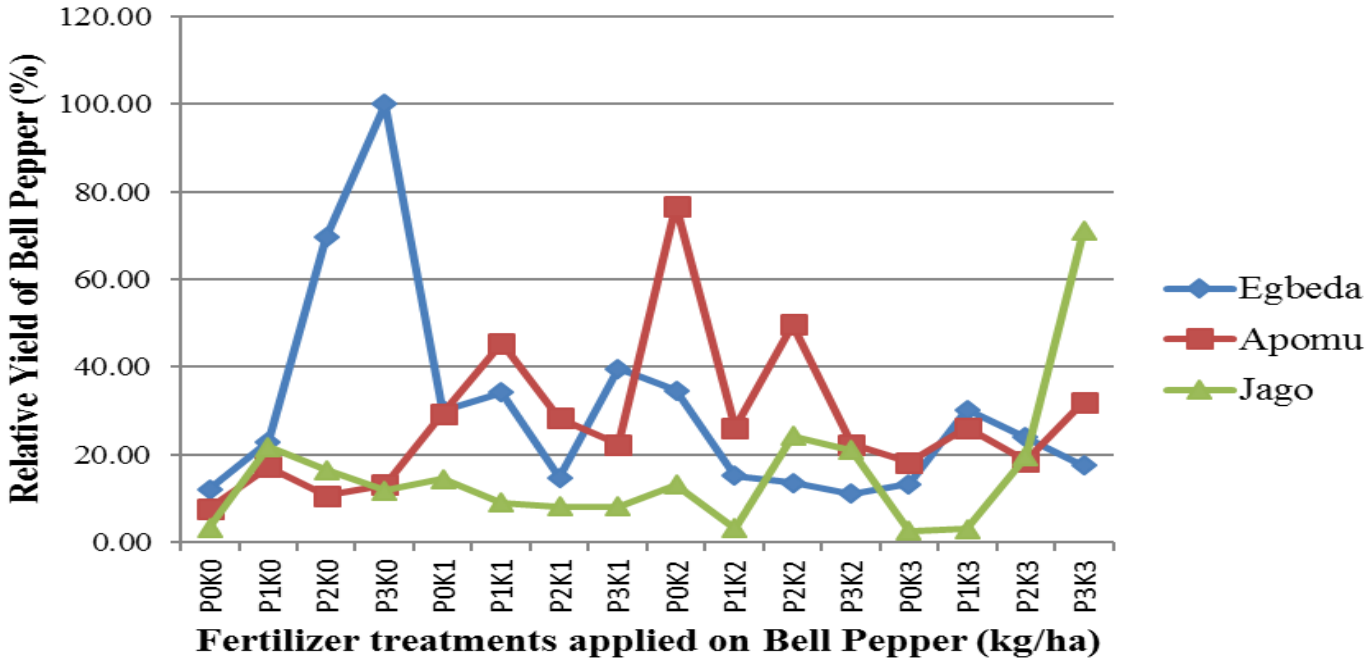

Fig. 2 Relative Yield of Bell Pepper in response to fertilizer application on different soil series in the raining season of 2012.

yields of 14.82, 16.70 and 10 t/ha observed in Egbeda soil series and 15.01, 12.83 and 16.43 t/ha in Apomu soil series in the three seasons indicates increased productivity of Bell Pepper on these soil series over Jago. FAO (2001) put the average yield of Pepper at 13.4 t/ha. Results obtained in the three consecutive seasons revealed that Bell Pepper production is better in Egbeda and Apomu soil series in the raining season while it is advisable to plant in Apomu soil series in the dry season. The relative difference in the yield of Bell Pepper in different soil series could be attributed to the intrinsic properties of the soils series, especially the drainage and textural class they belong as shown in Tables 1 and 3. Egbeda and Apomu soil series are well-drained loam sand, whereas Jago soil is poorly drained and sandy loam. Although Egbeda and Apomu soil series are well drained, Apomu retains more water than Egbeda which was likely what made Apomu more productive in the dry season. Conversely, Jago soil series was poorly drained and caked during the dry season. These soil conditions were probably responsible for relatively low yield of Bell Pepper observed on Jago soil series. Caked soil is a problem to root development and consequently poor crop development and low yield.

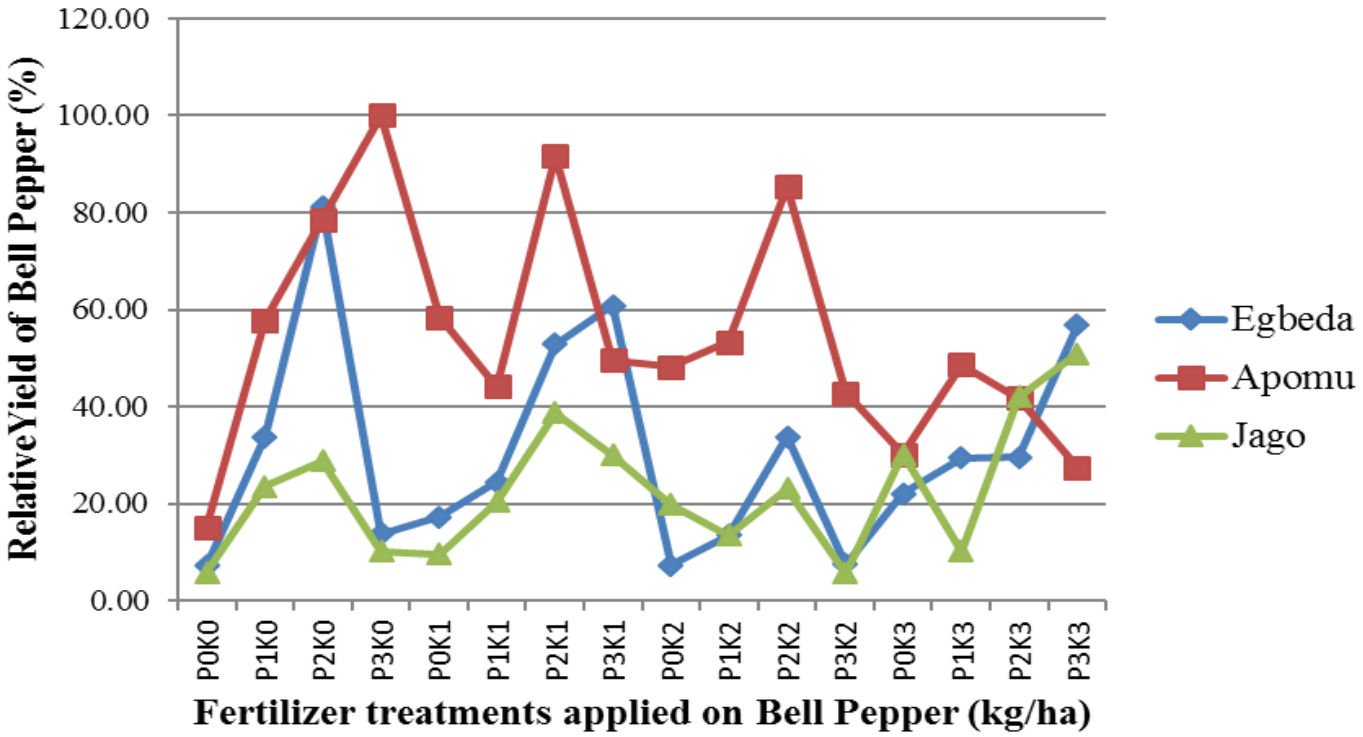

Fig. 3 Relative Yield of Bell Pepper in response to fertilizer application on different soil series in the dry season of 2012.

3. Conclusions

Egbeda and Apomu soil series yield comparatively higher than Jago soil series in both raining and dry seasons while Apomu soil series yield relatively higher than Egbeda soil series. The trend of Bell Pepper yield on different soil series were Apomu > Egbeda > Jago, Egbeda > Apomu > Jago and Apomu > Egbeda > in the raining seasons of 2011 and 2012 and dry season of 2012 respectively. Bell Pepper is recommended in Egbeda and Apomu soil series in raining season production while Apomu is recommended in dry season.

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