Effect of Cropping System and Mineral Fertilizer on Root Yield of Cassava

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Resumé

Issaka, Nuhu Roland, Buri, Moro Mohammed, Asare, Daniel, Senayah, Kofi James & , Essien, Ato Martin. *L'effet du Système de la Culture et L'engrais Minèral sur le Rendement Racinaire du Manioc.* L'objeclif de cette étude était pour évaluer l'effet du système de la culture et l'engrais sur le rendement racinaire de trios nouvelles variétés du manioc qui possèdent le rendement élevé. Les variétés sont (Afisiafi, Abasafitaa et Tekbankye) et deux variétés locales (Tuakentenma et Akosua tumtum). Deux systèmes de la culture (manioc unique, l'intercalaire du manioc maïs et cinq régimes d'engrais (0 - 0 - 0, 30 - 30 - 30, 60 - 60 - 60, 90 - 90 - 90 et 120 - 120 - 120 kg ha^{-1} N-P_2O_5-K_2O) étaient étudiés en 2000 et 2001. Un déssein de deux parcelles avec quatre réplications était utilisé lors de la première étude et un déssein d'une parcelle lors de la deuxième étude. L'intercalaire du manioc - maïs a réduit considérablement le rendement racinaire à Mampong (2000) et Asuansi (2001) mais pas à Wenchi (2001). Afisiafi et Abasafitaa ont fonctionné mieux que les variétés locales ou Tekbankye. À Asuansi et Kpeve, Afisiafi a fait mieux que Abasafitaa en ce qui concerne le rendement racinaire. Le rendement racinaire était pourtant similaire à Mampong et Wenchi en 2000. À Wenchi (2001) Abasafitaa a fait mieux que Afisiafi. À Mampong (2000) et Wenchi (2001) Afisiafi a produit plus de racines par parcelle que les variétés locales. De la même manière, Abasafitaa a produit plus de racines que les variétés locales. À tous les quatre sites, l'engrais minéral a résulté en plus élevé sur contrôle. À Asuansi (2001) Kpeve (2001) et Mampong (2000) 60 - 60 - 60 kg ha^{-1} N-$P_2O_5K_2O$ a donné un rendement plus grand que le 30 - 30 - 30 kg N-$P_2O_5K_2O$ ha^{-1} mais similaire au 90 - 90 - 90 et 120 - 120 - 120 kg ha^{-1} - $P_2O_5K_2O$. À Wenchi (2001) tous les niveaux ont donné un similaire rendement. À travers les localisations, Afisiafi et Abasafitaa ont produit des rendements plus élevés que les variétés locales et Tekbankye. L'engrais minéral à 60 - 60 - 60 kg ha^{-1} N-$P_2O_5K_2O$ était le niveau optimum pour les rendements racinaires.

Mots clés: Variétés de manioc, système de la culture, fertilization, rendement racinaire.

Abstract

The objective of this study was to evaluate the effect of cropping system and fertilizer on the root yield of three introduced high yielding cassava varieties (Afisiafi, Abasafitaa and

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Tekbankye) and two local varieties (Tuakentenma and Akosuatumtum). Two cropping systems (sole cassava and cassava-maize intercrop and five fertilizer regimes (0-0-0, 30-30-30, 60-60-60, 90-90-90 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O) were studied in 2000 and 2001. A split-split plot design with four replications was used in the first study and a split-plot design for the second. Cassava-maize intercrop significantly reduced root yield at Mampong (2000) and Asuansi (2001) but not at Wenchi (2001). Afisiafi and Abasafitaa performed better than the local varieties or Tekbankye. At Asuansi and Kpeve, Afisiafi gave significantly greater root yield than Abasafitaa. Root yields of Afisiafi and Abasafita were, however, similar at Mampong and Wenchi in 2000. At Wenchi (2001), Abasafitaa gave significantly greater root yield than Afisiafi. At Mampong (2000) and Wenchi (2001), Afisiafi produced significantly more roots per stand than the local varieties and Abasafitaa gave significantly greater root yield per stand than the local variety. At all the four sites mineral fertilizer resulted in significantly greater root yield over control. At Asuansi (2001), Kpeve (2001) and Mampong (2000), 60-60-60 kg ha^{-1} N-P_2O_5-K_2O gave significantly greater root yield than the 30-30-30 kg N-P_2O_5-K_2O ha^{-1} but similar to the 90-90-90 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O. At Wenchi (2001) all the rates gave similar root yield. Across locations, Afisiafi and Abasafitaa produced greater root yield than the local varieties and Tekbankye. Mineral fertilizer at 60-60-60 kg ha^{-1} N-P_2O_5-K_2O was the optimum level for root yields.

Keywords: Cassava varieties, cropping system, fertilization, root yield.

Introduction

Root and tuber crops play a major role in ensuring food security in Ghana. They are generally heavy feeders hence their production is sustained through the use of fallow lands. Cassava is a major source of dietary energy for low income consumers in many parts of tropical Africa, including major urban areas (Berry, 1993). Cassava is more tolerant to poor soil conditions. However, yields are generally low under marginal lands or under continuous cultivation. Cassava-maize intercrop is a common cropping system in many parts of the country. Under this system the maize crop is sometimes fertilized with a possible residual effect on cassava. Shading of young cassava plants when intercropped with maize usually delay growth of the young cassava plants resulting in smaller root yield (Ikeorgu and Iioka, 1992 and Gondwe and Sauti, 1992). Cassava response positively to fertilizer application (Cong, 2001, Lahai *et al.,* 1992, Odwuke and Oji, 1994, Osiname and Landu, 1989). Lahai *et al.* (1992) obtained 27 - 36% increase in root yield due to fertilization while Osiname and Landu (1989) observed reduction in root loss due to leaf harvest when fertilizer was applied at 50-50-50 NPK. In Vietnam, Cong obtained maximum root yield when fertilizer was applied at 60-60-120 NPK.

Root yield of local varieties are generally low ranging between 6 - 10 t ha^{-1} (Jones, 1959). The introduction of high yielding cassava varieties (root

yield range of 25 - 40 t ha^{-1}) into the country and the need to produce more of the crop for industries clearly signify the need to look at various options regarding sustainable production of the crop. While sole cropping may be necessary under mechanization or large scale farming, cassava-maize intercrop is a usual practice under small holdings.

In this study, the performance of three newly introduced high yielding cassava varities (Afisiafi, Abasafitaa and Tekbankye) and two local varities (Tuakentema and Akosuatumtum) were evaluated.

Materials and methods

Experimental area and design

The experiments were conducted at Mampong (2000), Wenchi (2000 and 2001), Asuansi (2001) and Kpeve (2001) at Ministry of Food and Agriculture (MoFA) Root and Tuber multiplication centres. Selected soil characteristics of these areas are presented in Table 1.

At Mampong (2000), Wenchi (2001) and Asuansi (2001) a split-split plot design with four replications was used. Sole cassava and cassava-maize intercrop (Cropping system) were the main plot treatments. Three cassava varieties (Abasafitaa, Afisiafi and one of the following (Akosuatumtum, Tuakentema or Tekbankye), were the subplot treatments. Five rates of fertilization 0-0-0, 30-30-30, 60-60-60, 90-90-90 and 120-120-120 kg ha^{-1} N-

Table 1. Soil characteristics (0-20cm) at the sites of the experiments.

	Mampong (2000)	*Wenchi (2000)*	*Wenchi (2001)*	*Asuansi (2001)*	*Kpeve (2001)*
Soil pH	5.6	5.5	5.3	5.8	6.1
Avail. P (mg kg^{-1})	1.5	1.2	3.5	6.4	4.5
Bray Exch. K	25.6	20.0	40.6	55.5	45.8
Organic Matter (g kg^{-1})	36.0	15.0	22.0	32.0	18.0
Dominant soil type	Eutric Leptosol	Plinthic Lixisol	Plinthic Lixisol	Ferric Lixisol	Haplic Lixisol
Soil Texture	Sandy Loam	Sandy Loam	Sandy Loam	Loam	Sandy Loam
Soil depth (cm)	20-30	30-35	25-35	30-40	25-35

P_2O_5-K_2O constituted the sub-subplot treatments.

At Wenchi (2000) and Kpeve (2001) a split plot design with four replications was used. Three cassava varieties (Abasafitaa, Afisiafi and Tuakentema or Tekbankye) were the main plot treatments. Five rates of mineral fertilizer 0-0-0, 30-30-30, 60-60-60, 90-90-90 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O constituted the subplot treatments. Only cassava was planted.

Agronomic practices

At all the sites and for all the cassava varieties, planting distances were 1m x 1m. For maize-cassava intercrop, maize (*Obatanpa*: local name) was used and planted at 1m x 0.4m with two (2) plants per hill.

For 30-30-30 and 60-60-60 kg ha^{-1} N-P_2O_5-K_2O rates, all the P and K and two-thirds of the N were applied two weeks after the maize was planted. For the 90-90-90 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O rates, half of the required amount of fertilizer was applied two weeks after the maize was planted. For all the rates, the remaining fertilizer was applied six weeks after planting of the maize. Soil samples (0-20cm) were initially taken before planting at all the sites.

Soil analysis

Air-dried soil samples were ground and passed through 2 mm sieve. Soil pH was measured using a glass electrode (pH meter) in a soil: water ratio of 1:2.5 according to the method recommended by IITA (1979) and Mclean (1982). Organic matter was determined by the wet combustion method (Walkley and Black, 1934). Available phosphorus was determined by the method of Bray and Kurtz (1945). Mechanical analysis was by the pipette method as described by Gee and Bauder (1986).

Results and Discussion

Effect of cropping system on root yield

Effect of cropping system on yield characteristics and root yield of cassava at Mampong (2000), Wenchi (2001) and Asuansi (2001) are in Table 2. At Mampong (2000), number of roots per stand and weight of roots per stand was significantly greater for sole cassava than cassava-maize intercrop (Table 2A). This resulted in significantly greater root yield per hectare under sole cassava over cassava-maize intercrop (Table 2B). These observations support the findings of Ikeorgu and Iioka (1992) and Gondwe and Sauti (1992) who observed smaller tuber yield when cassava was intercropped with maize. According to Gondwe and Sauti (1992), shading is a major factor when maize is intercropped with cassava. At Wenchi (2001) sole cassava and cassava-maize intercrop gave similar number of roots per stand, weight of roots per stand and root yield ha^{-1}. Rainfall at Wenchi (2001) was erratic and maize growth was generally very poor, hence intercropped cassava did not experience much shading, this partly explains why

Table 2. Effect of cropping system and varieties on the number and weight of roots of cassava at Mampong, Wenchi and Asuansi.

	No. of roots per stand		*Weight of roots per stand (kg)*	
	Mampong (2000)	*Wenchi (2001)*	*Mampong (2000)*	*Wenchi (2001)*
A. Cropping system				
Sole cassava	5.8 b	4.5 a	4.1 b	3.2 a
Cassava-maize	5.2 a	4.3 a	3.5 a	3.0 a
B. Variety				
Local •	5.0 a	3.3 a	2.7 a (0.54 a)	2.3 a (0.70.b)
Abasafitaa	4.6 a	3.8 a	3.8 b (0.84 b)	3.9 c (1.03 c)
Afisiafi	7.0 b	6.1 c	4.2 b (0.60 a)	3.3 b (0.54 a)

Mean weight of root (kg) in parenthesis.
• Mampong :-Akosuatuntum; Wenchi:- Tuakentema.
Figures within a column followed by the same letter(s) are not significantly different at the 5% level of DMRT.

there was no significant difference between the cropping systems.

Root yield of cassava varieties

Yield characteristic of the three cassava varieties at Mampong (2000) and Wenchi (2001) are in Table 3A. At Mampong (2000) and Wenchi (2001) the local cassava varieties and Abasafitaa gave similar number of roots per stand which was significantly smaller than that of Afisiafi. Weight of roots per stand was similar for Abasafitaa and Afisiafi but significantly greater than the local varieties. Abasafitaa produced significantly bigger roots than the local varieties at Mampong (2000) and Wenchi (2001) (Table 3A).

At Mampong and Wenchi in 2000 Afisiafi and Abasafitaa gave similar root yield which were significantly greater than the local varieties (Table 3B). In 2001 Afisiafi gave significantly greater root followed by Abasafitaa and then Tekbankye at Asuansi and Kpeve. Abasafitaa gave better root yield only at Wenchi (2001).

In general Afisiafi and Abasafitaa performed better than the local varieties and Tekbankye.

Effect of mineral fertilizer on root yield

Soil fertility levels for all the sites was low. Soil pH was within the range conducive for cassava growth. Available phosphorus and exchangeable potassium were very low for all the site except at Asuansi which was low and moderate respectively (Table 1). Organic matter status at Mampong and

Table 3. Root yield of cassava at Mampong, Wenchi, Asuansi and Kpeve.

	Root yield (t ha^{-1})				
	Mampong (2000)		*Wenchi (2001)*	*Asuansi (2001)*	
A. Cropping system					
Sole cassava	40.6b		32.1 a	33.4 b	
Cassava-maize	34.6a		30.9 a	27.7 a	
B. Variety					
	Mampong (2000)	*Wenchi (2000)*	*Wenchi (2001)*	*Asuansi (2001)*	*Kpeve (2001)*
Local/Akosuatuntum	27.0 a	-	-	-	-
Local/Tuakentema	-	16.4 a	22.9 a	-	-
Tekbankye	-	-	-	25.4 a	24.2 a
Abasafitaa	38.0 b	29.0 b	38.7 c	30.b b	29.6 b
Afisiafi	41.8 b	30.4 b	32.9 b	35.9 c	33.2 c

Figures within a column followed by the same letter(s) are not significantly different at the 5% level of DMRT.

Asuansi was good.

The effect of fertilization on yield parameters of cassava at the four sites is given in Table 4. At Mampong (2000) number of roots per stand was significantly greater for the 90-90-90 kg ha^{-1} rate than all the treatments except the 60-60-60 kg ha^{-1} rate (Table 4A). At Wenchi (2001), number of roots per stand was greatest for the 60-60-60 treatment, which was significantly greater than that of 30-30-30 and 90-90-90 rates. At both Mampong (2000) and Wenchi (2000), weight of roots per stand was significantly greater for all treatments that received fertilizer than the control. At Mampong in 2000, 90-90-90 kg ha^{-1} N-P_2O_5-K_2O gave the greatest weight of roots per stand which was similar to 60-60-60 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O.

Heavier root weight per stand for the fertilized treatments resulted in significantly greater root yield (t ha^{-1}) over the control (Table 4B). At Mampong (2000), root yield (t ha^{-1}) increased with increasing rates of fertilization to 90-90-90 kg ha^{-1} N-P_2O_5-K_2O before falling at 120-120-120 kg ha^{-1} N-P_2O_5-K_2O. This fall in root yield supports the findings of Tshiunza (1996) who observed a fall in root yield when nitrogen rate exceeded 100 kg ha^{-1}. High amount of nitrogen (120 kg ha^{-1}) might have resulted in the production of more

leaves and branches to the detriment of root production. At Wenchi (2000 and 2001) root yield increased and stabilized at 30-30-30 kg ha^{-1} $N-P_2O_5-K_2O$. In 2001 at both Asuansi and Kpeve, root yield increased significantly and stabilized at 60-60-60 kg ha^{-1} $N-P_2O_5-K_2O$. Other scientists have reported the positive influence of fertilization on cassava root yield. Osiname and Landu (1989) observed that application of 50-50-50 kg ha^{-1} NPK significantly reduced root loss caused by leaf harvest also Lahai *et al.* (1992) found that fertilization also resulted in 27 - 36% increase in root yield.

Effect of mineral fertilizer on root yield of cassava varieties

Cassava varieties responded differently to mineral fertilizer. Root yield generally increased when mineral fertilizer was applied (Figure 1). At Mampong in 2000, 90-90-90 kg ha^{-1} $N-P_2O_5-K_2O$ gave the largest root yield for both Abasafitaa and Afisiafi. For the local varieties, 60-60-60 and 90-90-90 kg ha^{-1} $N-P_2O_5-K_2O$ gave the same root

Table 4. Effect of mineral fertilizer (kg ha^{-1} $N-P_2O_5-K_2O$) on root yield of cassava.

A. Number of roots per stand and weight of roots per stand

	No. of root per stand		*Weight of root per stand (kg)*	
	Mampong (2000)	*Wenchi (2001)*	*Mampong (2000)*	*Wenchi (2001)*
Control	5.0 a	4.6 ba	2.5 a	1.4 a
30-30-30	5.0 a	4.4 a	3.4 b	2.4 b
60-60-60	5.9 ab	5.8 b	3.9 bc	3.2 b
90-90-90	6.3 b	4.4 a	4.5 c	3.1 b
120-120-120	5.0 a	5.3 ab	3.8 bc	2.7 b

B. Root yield (t ha^{-1})

	Mampong (2000)	*Wenchi (2000)*	*Wenchi (2001)*	*Asuansi (2001)*	*Kpeve (2001)*
Control	23.5 a	13.3 a	24.9 a	19.1 a	19.4 a
30-30-30	33.5 b	24.3 b	30.3 b	26.0 b	26.7 b
60-60-60	38.7 bc	31.6 b	32.4 b	36.5 c	32.5 c
90-90-90	44.6 c	30.6 b	35.5 b	36.3 c	32.7 c
120-120-120	37.5 bc	26.8 b	34.5 b	34.7 c	33.6 c

Figures within a column followed by the same letter(s) are not significantly different at the 5% level of DMRT.

yield (Figure 1A). The situation was different at Wenchi (2000). For Afisiafi the largest root yield was observed at 60-60-60 kg ha^{-1} N-P_2O_5-K_2O, while 90-90-90 kg ha^{-1} N-P_2O_5-K_2O gave the largest root yield for the local varieties 60-60-60 and 90-90-90 kg ha^{-1} N-P_2O_5-K_2O gave similar root yield for Abasafitaa (Figure 1B). At Wenchi in 2001, Afisiafi did not show any response to mineral fertilizer. Abasafitaa and the local variety showed a significant yield increase at 90-90-90 kg ha^{-1} N-P_2O_5-K_2O which was similar to 60-60-60 and 120-120-120 kg ha^{-1} N-P_2O_5-K_2O (Figure 2). Root yield increased significantly to 60-60-60 kg ha^{-1} N-P_2O_5-K_2O for all the varieties at Asuansi (2001) and Kpeve (2001) (Figures 3A and B).

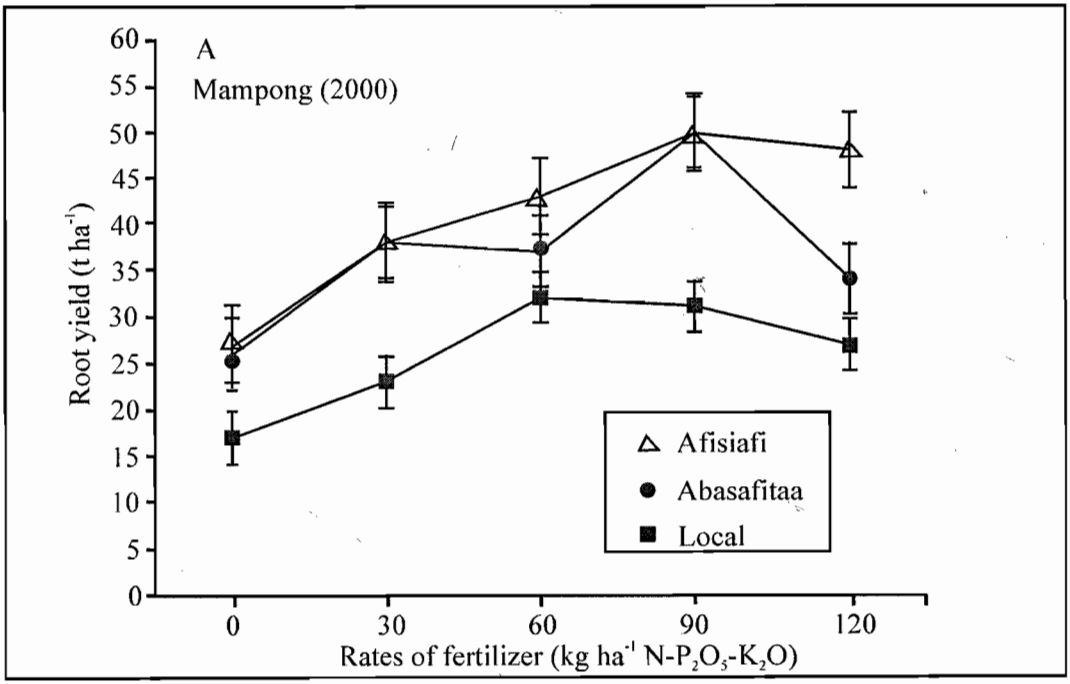

Figure 1A. Effect of rates of fertilizer on root yield of cassava varieties at Mampong (2000).

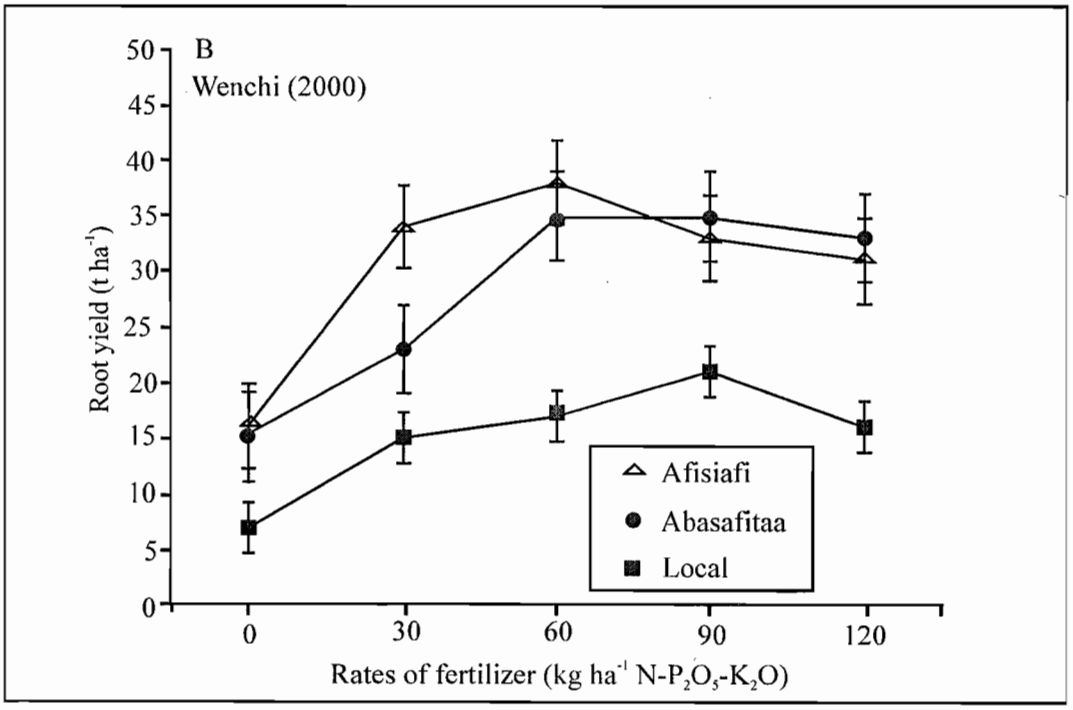

Figure 1B. Effect of rates of fertilizer on root yield of cassava varieties at Wenchi (2000).

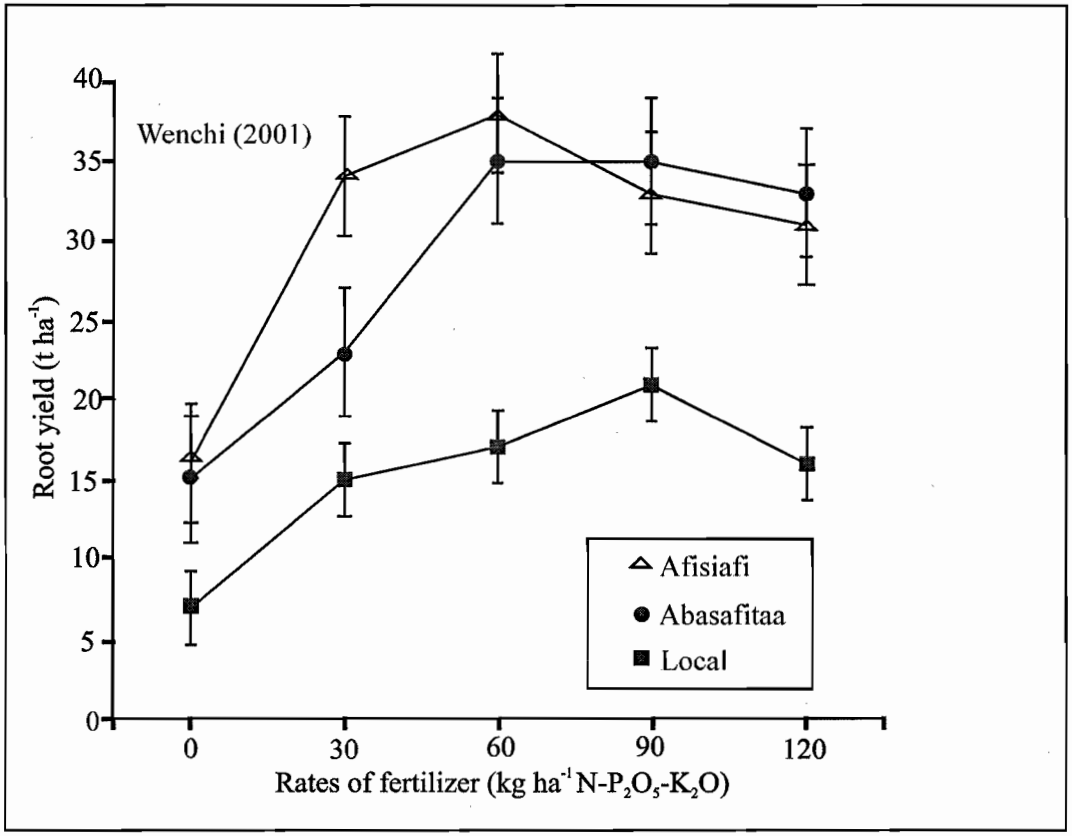

Figure 2. Effect of rates of fertilizer on root yield of cassava varieties at Wenchi (2001).

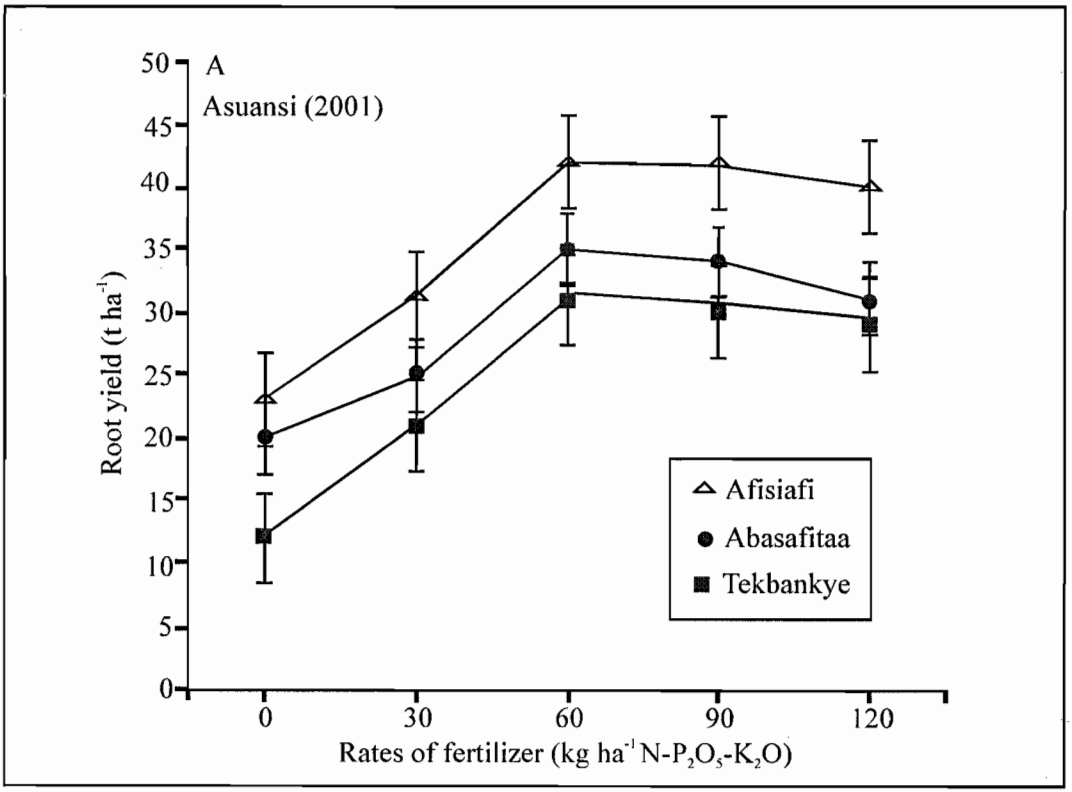

Figure 3A. Effect of rates of fertilizer on root yield of cassava varieties at Asuansi (2001).

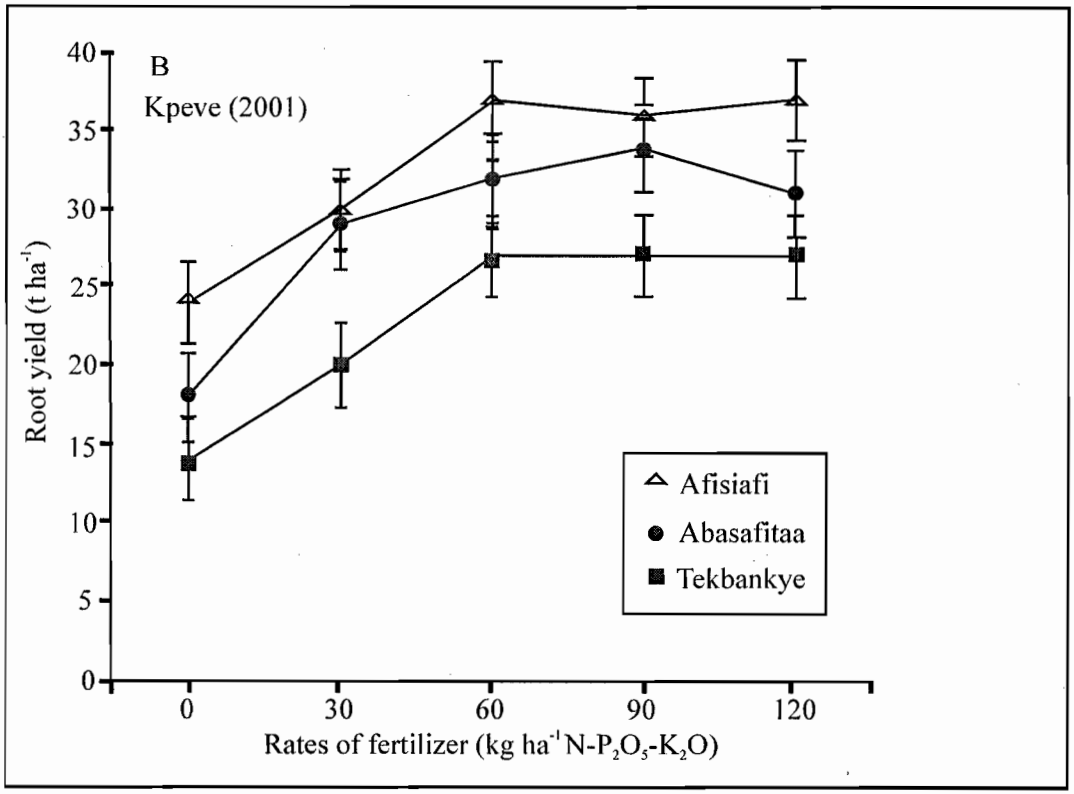

Figure 3B. Effect of rates of fertilizer on root yield of cassava varieties at Kpeve (2001).

Conclusions

Intercropping cassava with maize decreases root yield of cassava. The introduced varieties, Afisiafi and Abasafitaa, gave better root yield per hectare than the local varieties (Akosuatumtum and Tuakentema). All the cassava varieties responded to mineral fertilizer. From this study, 60-60-60 kg ha^{-1} $N\text{-}P_2O_5\text{-}K_2O$ was observed to be the optimum rate of mineral fertilizer.

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