EFFECT OF SOIL TYPE, FERTILIZATION AND MYCORRHIZAL INOCULATION ON NPK UPTAKE OF CASSAVA

Angela S. Almendras, Reynaldo E. dela Cruz and Ireneo J. Manguiat

Instructor, Department of Agronomy and Soil Science, Visayas State College of Agriculture, ViSCA, Leyte; and Associate Professors, U.P. at Los Baños, College, Laguna, Philippines.

Portion of M.S. thesis conducted by the senior author in U.P. at Los Baños.

Funded by Philippine Council for Agriculture and Resources Research.

ABSTRACT

The response of cassava (cv. Lakan) to NPK fertilization and mycorrhizal inoculation was evaluated through a pot experiment using unsterilized soil (Lipa clay loam and Luisiana clay). Application of 45-60-60 and 90-60-60 in Lipa clay loam and Luisiana clay, respectively, resulted in significantly higher P uptake than with 0-60-60 treatment in both soil types. Nitrogen and potassium uptakes were not significantly affected by NPK levels in both soil types. Irrespective of soil type and fertilizer treatments, inoculation significantly increased shoot phosphorus concentration and uptake.

Ann. Trop. Res. 4: 118-126.

KEY WORDS: Mycorrhizal inoculation. Fertilization. Soil type. Cassava. NPK uptake. Pot experiment.

INTRODUCTION

Cassava is one of the most promising root crops with good potential for multiple utility such as food, feed and as material for textile, paper and adhesive, and furniture industries. Hence, research on the improvement of its cultural management has been intensified with the hope of increasing its yield.

A number of researches along this line are primarily concentrated on supplementing the soil with fertilizers. Improved yields were observed with fertilizer application (PCARR, 1977; Obigbesan, 1977; Mohan Kumar, 1978; Cotejo and Talatala, 1978). Molinyawe (1968) recommended 600 kg/ha application of 12-12-12 for cassava. However, these findings on cassava's high fertility requirement are not compatible with the plant's ability to thrive well on acidic and infertile soils (Howeler, Cadavid and Calvo, 1976). From this incompatibility, Howeler (1977) postulated that an efficient mycorrhizal association under field conditions must exist.

Several workers have established the effect of favorable cassava-mycorrhizal interaction on the yield of the host plant (Howeler, Edwards and Asher, 1979; Howeler, 1979). Mycorrhizal infection of cassava roots, either from indigenous or introduced strains, was known to increase total plant uptake of P, Ca Mg and K as well as the dry matter (Howeler, Edwards and Asher, 1979).

In the Philippines, however, this favorable association still remains unexplored. In addition, there has been no study conducted yet with regard to the NPK uptake of cassava as influenced by soil type, fertilization and mycorrhizal inoculation.

Different soil types vary in their chemical and physical properties which affect the availability of nutrients as well as microbial activity in the soil and consequently exert marked influence on the nutrient uptake of plants. Therefore, different types of soil may differ in their effects on the uptake of nutrients and growth of cassava and may also considerably determine the kind and rate of fertilizer and inoculum to be applied for optimum growth. Hence, investigation on these factors influencing nutrient uptake is important.

MATERIALS AND METHODS

Collection and Characterization of Soil Types. — Surface soil samples (topsoil up to a depth of 30 cm) of Luisiana clay and Lipa clay loam were collected in Luisiana, Laguna and at the UPLB Central experiment Station, respectively. Prior to any treatment, representative samples were taken from each soil type for analysis of pH, % organic matter, % total nitrogen (N), available phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg) and CEC. The results of the analyses are shown in Table 1.

Preparation of Soil Media for Potting. — Seven and a half kg of air-dried, unsterilized soil were placed in a size 12 clay pot (28.8 cm in diameter, 8 kg capacity) the inner side of which was painted with coal tar.

Experimental Design. — The experiment was laid out in a split-split plot design arranged in 2 x 2 x 8 factorial with soil type (Lipa clay loam and Luisiana clay) as the main plots, mycorrhizal inoculation levels (with and without inoculation) as the subplots, and the 8 fertilizer treatments as the sub-subplots. Three replications were used per treatment combination. The fertilizer treatments ($N-P_2O_5-K_2O$ kg/ha) used were as follows:

1) 0-0-0	5) 90-0-60
2) 0-60-60	6) 90-30-60
3) 45-60-60	7) 90-60-0
4) 90-60-60	8) 90-60-30

Method of Inoculation. — Five ml of infected cassava root suspension was poured using a graduated cylinder into a previously made hole (10 cm deep, 6 cm in diameter) in the potted soil immediately before planting. Mycorrhizal roots were taken from cassava, cv. Java, growing wildly in an area near UPLB. A root suspension was prepared by mixing macerated mycorrhizal-infected cassava roots and sterile distilled water at 1:1 ratio.

Mycorrhizal Infection Determination. — Ten randomly selected lateral root tip segments of non-tuberous roots were washed with tap water, cleared and stained following the method described by Philipps and Hayman (1970). For clearing, the root segments were placed in a vial with a 10 ml of 10% potassium hydroxide at 90°C for 1 hr in an oven, washed with distilled water and soaked in 30% hydrogen peroxide until the dark pigments were removed. The root segments were then rinsed thoroughly with distilled water, acidified in 0.1 N hydrochloric acid and simmer-stained with 0.05% trypan blue in lactophenol. The stained root segments were examined under the microscope to determine the presence or absence of mycelia and/or vesicles. Infected cassava roots were those with mycelia or vesicles.

Planting. — One viable cassava (cv. Lakan) cutting, 25 cm long was planted vertically in each soil-filled pot with about 10 cm of the stake below the soil surface.

Application of Fertilizer. — Immediately after planting, P was applied by mixing solophos with the top 2.5 cm of soil. N and K were also applied immediately in solution form by dissolving urea and muriate of potash in distilled water and dispensing the needed quantity into the soil by means of a pipette.

Plant Tissue Analysis. — Three months after planting, the plants were harvested. The harvested shoots were oven-dried at 65% C for 3 days, weighed, ground through a Wiley mill and analyzed for N, P and K contents. N, P and K uptakes were obtained from the product of shoot dry weight and its respective N, P and K contents.

RESULTS AND DISCUSSION

Shoot Dry Weight.

Both soil type and inoculation failed to show any significant effect on the shoot dry weight of cassava. However, fertilization and its interaction with soil type significantly affected shoot dry matter production of cassava (Tables 1 and 2).

The plants grown in Lipa clay loam applied with 90-60-60 yielded the highest shoot dry weight which did not significantly vary with the yield obtained from the plants grown in Luisiana clay with the same fertilizer rate. With the application of 45-60-60, however, the plants grown in Luisiana clay produced an average shoot weight which was significantly lower than that obtained in Lipa clay loam. This could be due to chemical properties of Lipa clay loam which was comparatively better than that of Luisiana clay (Table 3).

Nitrogen Content and Uptake.

Regardless of soil type and inoculation, highest average shoot N content was obtained from plants applied with 0-60-60 and 90-0-60 (Table 1). These values were significantly higher when compared with plants treated with 45-60-60 and 90-60-30. This finding indicated that plants with lower shoot dry weight tend to accumulate N in their tissues. This observation could be explained by the fact that nutrient uptake and translocation represent only a part of the process of determining nutrient concentration in a tissue. The most important is growth (Tamm, 1964). With increase in growth, a "dilution effect" would occur (Paningbatan, 1974).

On the other hand, with the application of 60 kg P_2O_5 and 60 kg K_2O per hectare, increased rates of N application resulted in significantly higher N uptake than that of the control (0-0-0) and 0 kg N (0-60-60). With regards to P and K fertilization, significant increase in shoot N uptake was observed only at levels of 60 kg P_2O_5 and 60 kg K_2O/ha. This pattern agreed with the observed shoot yield response. Taking the product of shoot yield and N content as the N uptake value, the observed marked increase in N uptake could be attributed to high yield response to N, P and K fertilization. On the contrary, no significant differences were observed between the 2 soil types and between uninoculated and inoculated treatments on the mentioned

Table 1. Shoot dry weight and its NPK content and uptake of cassava at three months after planting as influenced by soil type, mycorrhizal inoculation and fertilizer treatment.[1]

VARIABLE	Dry Weight (g/pot)	NUTRIENT CONTENT N	P (%)	K	NUTRIENT UPTAKE N	P (mg/pot)	K
Soil Type							
Lipa clay loam	11.46	1.49	0.172a	0.91	166.19	18.96a	99.21a
Luisiana clay	10.59	1.61	0.124b	0.81	167.63	13.11b	83.63b
Inoculation							
Uninoculated (O)	10.67	1.58	0.136b	0.86	163.23	14.97b	89.71
Inoculated (5 ml)[2]	11.39	1.52	0.160a	0.86	169.59	17.97a	93.13
Fertilizer level (N-P2O5-K2O in kg/ha)							
0-0-0	7.63c	1.54ab	0.175a	0.93ab	115.72c	13.33cd	63.84b
0-60-60	6.55c	1.68a	0.189a	1.05a	106.27c	11.60d	66.54b
45-60-60	12.00ab	1.48b	0.145bc	0.87ab	182.82b	17.71b	102.54a
90-60-60	14.22a	1.52ab	0.148b	0.83ab	213.96a	21.50a	118.92a
90-0-60	11.25b	1.68a	0.139bc	0.83ab	182.40b	16.61bc	91.70ab
90-30-60	12.73ab	1.51ab	0.135bc	0.76ab	187.23ab	17.57b	97.05ab
90-60-0	11.54ab	1.54ab	0.125c	0.75b	176.87b	14.26bcd	86.82ab
90-60-30	12.30ab	1.48b	0.130bc	0.85ab	180.00b	15.71bc	103.95a

[1] All values having the same letters are not statistically significant at 5% level, DMRT.

[2] Macerated mycorrhizal infected cassava root suspension per 7.5 kg soil sample.

Table 2. Shoot dry weight (g/pot) of cassava at three months after planting as affected by soil types and fertilizer levels.[1]

FERTILIZER LEVEL (N-P_2O_5-K_2O in kg/ha)	SHOOT DRY WEIGHT (g/pot)	
	Lipa Clay Loam	Luisiana Clay
0-0-0	7.73d	7.52d
0-60-60	5.24e	7.87d
45-60-60	13.88a	10.12bcd
90-60-60	14.84a	13.60a
90-0-60	13.31ab	9.19cd
90-30-60	13.31ab	12.14abc
90-60-0	11.27abc	11.82abc
90-60-30	12.13abc	12.45abc

[1] All values having the same letters are not statistically significant at 5% level, DMRT.

parameters.

A significant interaction between the soil type and different fertilizer levels on the N content was also observed (Table 4). In Lipa clay loam, the N content in cassava shoots was significantly higher in plants treated with 0-60-60 (N-P_2O_5-K_2O kg/ha) than with the combined effect of the said soil type with other fertilizer levels. In Luisiana clay, however, highest nitrogen content was obtained from plants treated with 90-0-60 (N-P_2O_5-K_2O kg/ha). This indicates that with sufficient supply of phosphorus (60

Table 3. Chemical properties of Lipa clay loam and Luisiana clay.

Soil Property	Soil	
	Lipa Clay Loam	Luisiana Clay
pH	5.7	4.8
Organic matter (%)	2.11	3.28
Total N (%)	0.13	0.14
Available P (ppm)	1.75	0.93
Exchangeable bases (me/100 g)		
Calcium	12.51	1.55
Magnesium	11.09	2.26
Potassium	0.28	0.24
Cation Exchange Capacity (CEC) (me/100 g)	28.22	21.21

Table 4. Nitrogen content of cassava shoots at three months after planting as affected by soil types and fertilizer levels.[1]

FERTILIZER LEVEL ($N-P_2O_5-K_2O$ in kg/ha)	NITROGEN CONTENT (%) OF SHOOTS	
	Lipa Clay Loam	Luisiana Clay
0-0-0	1.53bc	1.54bc
0-60-60	1.83a	1.54bc
45-60-60	1.40c	1.56bc
90-60-60	1.44bc	1.59bc
90-0-60	1.46bc	1.90a
90-30-60	1.45bc	1.57bc
90-60-0	1.40c	1.68ab
90-60-30	1.44bc	1.53bc

[1] All values having the same letters are not statistically significant at 5% level, DMRT.

kg P_2O_5/ha) and potassium (60 kg K_2O/ha) but with inherently low nitrogen in Lipa clay loam, accumulation of nitrogen is greater in shoot tissues. However, in Luisiana clay, the accumulation of nitrogen was greater with sufficient supply of nitrogen (90 kg N/ha) and potassium (60 kg K O/ha) but with inherently low available phosphorus. This suggests that with limited nitrogen or phosphorus even with sufficient supply of the other fertilizer elements, the plants may not be able to utilize nitrogen for the formation of protein, nucleoprotein or other nitrogenous compounds as reflected by limited shoot growth.

Phosphorus Content and Uptake.

Regardless of inoculation and fertilizer treatment, the shoot P content and uptake of plants grown in Lipa clay loam were significantly higher than that in Luisiana clay (Table 1). This could be partially attributed to the higher pH, hence more available P in Lipa clay loam.

Significant variations on the same parameters were noted also between uninoculated and inoculated treatments irrespective of soil type and fertilizer treatment. Inoculation significantly increased the P uptake of cassava shoots. This result clearly indicated that in unsterile soils, the introduced mycorrhizal fungi, together with the native ones, effected a higher P uptake than the native endophytes alone. This underscores the beneficial effect of mycorrhizal inoculation on improved plant phosphorus nutrition to augment the activity of the indigenous ones.

As to the influence of fertilizer application, P content was significantly higher in the control and in the plants without N fertilization. Similar to N content, this marked decrease in P content in nitrogen-treated plants could be attributed to the dilution effect on P concentration brought about by the marked increase in shoot dry matter production.

With blanket application of 60 kg P_2O_5 and 60 kg K_2O per hectare, increasing the rate of N application generally resulted in significant increase in P uptake. On the other hand, high rates of P (60 kg P_2O_5/ha) and K (60 kg K_2O/ha) resulted in higher P uptake when maximum rates of other fertilizer elements were applied. This observation could be attributed to increase in shoot dry weight brought by N, P and K fertilization.

A significant combined effect of soil type and fertilizer treatment on P content (Table 5) and P uptake (Table 6) was also observed. Generally, interactions between soil types and fertilizer treatments used in this study effected a significantly higher P content of shoots of cassava grown in Lipa clay loam than in Luisiana clay except for 90-60-0 and 45-60-60. This could be attributed to higher level of available P in Lipa clay loam.

Application of either 45-60-60, 90-60-60, 90-0-60 or 90-30-60 in Lipa clay loam resulted in significantly higher P uptake than in Luisiana clay. This observation could be partially attributed to the significantly higher shoot dry weight effected by these treatment combinations.

Potassium Content and Uptake.

Table 1 shows that highly significant effects of soil type and fertilizer treatments were exhibited only on the K uptake but not on the K content of shoots regardless of inoculation treatments. Potassium uptake in Lipa clay loam was higher than in Luisiana clay. This may be due to considerably higher shoot dry weight and shoot K concentration of plants grown in Lipa clay loam.

Table 5. Phosphorus content of cassava shoots at three months after planting as affected by soil types and fertilizer levels.[1]

FERTILIZER LEVEL ($N-P_2O_5-K_2O$ in kg/ha)	PHOSPHORUS CONTENT (%) OF SHOOTS	
	Lipa Clay Loam	Luisiana Clay
0-0-0	0.203a	0.147bcd
0-60-60	0.232a	0.147bcd
45-60-60	0.157bc	0.135cde
90-60-60	0.168b	0.128def
90-0-60	0.173b	0.105ef
90-30-60	0.173b	0.097f
90-60-0	0.128cdef	0.123def
90-60-30	0.146bcd	0.173ef

[1] All values having the same letters are not statistically significant at 5% level, DMRT.

Table 6. Phosphorus uptake of cassava shoots at three months after planting as affected by soil types and fertilizer levels.[1]

FERTILIZER LEVEL (N-P_2O_5-K_2O in kg/ha)	PHOSPHORUS UPTAKE OF SHOOTS	
	Lipa Clay Loam	Luisiana Clay
	mg/pot	
0-0-0	15.50cd	11.15de
0-60-60	11.84de	11.35de
45-60-60	20.72ab	14.70cde
90-60-60	25.35a	17.66bc
90-0-60	23.25a	9.97e
90-30-60	23.21a	11.92de
90-60-0	14.59cde	13.97cde
90-60-30	17.26bc	14.17cde

[1] All values having the same letters are not statistically significant at 5% level, DMRT.

LITERATURE CITED

COTEJO, F.R. and TALATALA, R.L. 1978. The effect of rate and time of fertilizer application on the yield of cassava. *ViSCA Vista*. 101: 22-23.

HOWELER, R.H. 1977. Repuesta de la yuca a la applicacion del fosforo (The response of cassava to phosphorus). *Centro Internacional de Agricultura Tropical Seminarios Internos*, 1977. Cali, Colombia. Series SE-09-77. 29 p.

HOWELER, R.H., CADAVID, I.F. and CALVO, F.A. 1976. The interaction of lime with minor elements and phosphorus in cassava production. 4th Symp. of the Int. Soc.for Trop. Root Crops. Cali, Colombia, 1976. (*Abstracts of Cassava* 3: 31).

HOWELER, R.H., EDWARDS, D.G. and ASHER, C.J. 1979. The effect of soil sterilization and mycorrhizal inoculation on the growth, nutrient uptake and critical P concentration of cassava. *Proc. Int. Symp. Trop. Root Crops*. Manila, Phil. Sept. 17-21, 1979.

MOHAN KUMAR, B. 1978. Soil and fertilizer rates of cassava. In: Cassava production technology. (N. Hrishi and R. Copinathan Nair, eds.). Trivandrum, India, Cen. Tuber Crops Res. Inst., 1978, pp. 17-20. (*Abstracts on Cassava* 5: 29).

MOLINYAWE, C.D. 1968. *Cassava, a Guide to its Culture*. UPLB, College, Laguna.

OBIGBESAN, G.O. 1977. Nutritional problems in root crops production. In: Ene, L.S.O. et al., des. National Seminar on Root and Tuber Crops, 1st Umudlike, Nigeria. Umudlike, National Root Crops Research Institute, 1978. pp. 25-35. *(Abstracts on Cassava* 5: 25).

PANINGBATAN, E.P. 1974. Effect of nitrogen, phosphorus and potassium fertilization on yield and rhizome quality of ginger. M.S. Thesis. UPLB, College, Laguna.

PHILIPPS, J.M. and HAYMAN, D.S. 1970. Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. *Trans. Br. Mycol. Soc.* 55: 157-161.

PHILIPPINE COUNCIL FOR AGRICULTURE AND RESOURCES RESEARCH. 1977. *The Philippines Recommends for Cassava*. Los Baños, Laguna. pp. 12-14.

TAMM, C.O. 1964. Determination of nutrient requirement of forest stands. *Int. rev. For. Res.* Vol. I. J.A. Romberger and P. Mikula, eds. Acad. Press. New York. In: Crus, Dela, L. 1978. The effects of nitrogen fertilization and mulching on the growth and survival of outplanted Kaatoan bangkal *(Antocephalus chinensis* Rich. Ex. Walp) seedlings and on some soil properties of an open grassland. M.S. Thesis. UPLB, College, Laguna.