PERFORMANCE OF TARO UNDER LOWLAND CONDITION AS AFFECTED BY GENOTYPE, NUTRITIONAL STATUS AND POPULATION DENSITY

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Funded by Philippine Council for Agriculture and Resources Research and Development.

ABSTRACT

The local taro variety Kalpao performed better than the introduced variety Big Lehua. Kalpao had higher yield, shorter growing period and was relatively resistant to adverse growing conditions than Big Lehua. Nitrogen was a more important nutrient than P and K for growth and increased yield of lowland taro. Plants which received higher rates of N, regardless of the levels of P_2O_5 and K_2O, consistently grew taller and produced larger leaf area. Corm yield was significantly increased with increasing rate of N. Yield of plants applied with P_2O_5 and K_2O but without N was not significantly different from that obtained from the unfertilized plants. Corm yield increased proportionately with increase in plant population. Yield of taro appeared to be associated with the number rather than size of the corms at harvest.

Ann. Trop. Res. 4: 156-167.

KEY WORDS: Taro. *Colocasia esculenta.* Kalpao. Big Lehua. Fertilizer level. Population density.

INTRODUCTION

Taro *(Colocasia esculenta* (L) Schott) is an important root crop in the Philippines. Although it ranks only third to sweet potato and cassava in terms of production, it has an advantage over the 2 crops because it can be grown both under dry land and lowland conditions, although it is more adapted under the latter. The crop is traditionally grown as vegetable, and the corms and other parts of the plant like the leaves, petioles and rhizomes are utilized as food.

While other food crops had been given much research emphasis, little attention has been given to taro. Most of the available information about production practices for this crop comes from Hawaii and other leading producing countries. Earlier studies in the Philippines on taro were mainly adaptability trials (Cadiz, 1975).

Although taro is grown commercially in some areas in the Philippines, its production level is very low. In 1975, the national average yield was only 3.5 tons per ha (PCARR, 1977) which was very much lower than those reported in other countries (de la Peña, 1976). This may be explained partly by the absence of recommended varieties and cultural practices. Many farmers follow cultivation methods they themselves developed through experience. De la Peña (1967) reported that taro has a relatively high yield potential when well-managed and applied with fertilizers. To improve the yield of the crop, there is a need to identify, among others, better varieties and appropriate cultural management techniques for both garden and commercial production.

MATERIALS AND METHODS

Local and foreign taro germplasm materials were collected for selection of varieties and development of cultural management techniques for lowland and upland conditions. This experiment was laid out in a split-split plot design with fertilizer level, variety and plant population as main plot, subplot, and sub-subplot, respectively. There were 6 croppings established during the period from 1977 to 1980.

The fertilizer levels (kg/ha N, P_2O_5 and K_2O) were as follows:

1) 0-0-0
2) 30-0-0
3) 30-30-0
4) 30-30-30
5) 60-30-30
6) 90-60-60
7) 120-60-60

Fertilizer was applied in 2 equal installments, i.e., at planting and at 2 months after planting. The varieties used were Kalpao and Big Lehua. Kalpao is a rhizome-producing local variety that is widely grown in Leyte and in other areas in the Visayas. This was entered as PR-G 068 in the PRCRTC taro accessions. Big Lehua, on the other hand, is a sucker-producing variety introduced from Hawaii which was entered as PR-G 058 in the taro accessions of PRCRTC. The plant populations used were: 1) 17,778 plants/ha, 2) 26,667 plants/ha and 3) 40,000 plants/ha. These were established by using distances of 75 cm x 75 cm, 50 cm x 75 cm and 50 cm x 50 cm, respectively.

Based on the results of the first 4 croppings, the treatments were modified in the fifth crop. Varieties were assigned to main plots and fertilizer levels to subplots. The same fertilizer rates as in the previous 4 croppings were used. This was done in an attempt to reduce experimental error that might have been caused by the probable fertilizer losses due to the use of a large area in the main plot. Plant populations remained as sub-

subplots but different densities were adopted. The plant populations were: 1) 26,667 plants/ha, 2) 40,000 plants/ha, and 3) 53,333 plants/ha. Spacing of 50 cm x 75 cm, 50 cm x 50 cm and 37.5 cm x 60 cm, respectively, were used to attain the populations required.

In the sixth crop, fertilizer levels (subplots) were also modified. This was done for easier assessment of the direct effect of the individual fertilizer elements N, P_2O_5 and K_2O. The fertilizer levels were:

1) 0-0-0
2) 30-30-0
3) 30-0-60
4) 0-30-60
5) 30-30-60
6) 30-60-60
7) 60-30-60
8) 30-30-120

Before planting, the field was thoroughly puddled in the same manner a field for lowland rice is prepared. After laying out the plan, dikes were constructed around each plot containing fertilizer treatment. This was done to prevent the fertilizer from being washed out by irrigation water especially after its application. Planting materials used consisted of about 1 cm of the tip of the corm plus about 15 to 20 cm of the lower petioles of the plant. These were planted by inserting them into the puddled soil at a depth of 3 to 5 cm. The 2 varieties used were planted on the same date. Time of harvest of the 2 varieties varied between croppings depending on the readiness of the corms. This ranged from 7 to 10 months after planting. Irrigation was done whenever needed. Mechanical weeding, using rotary weeders similar to those used for rice, was done regularly during the early stage of plant development.

RESULTS AND DISCUSSION

Influence of Variety.

The local variety Kalpao was noted to be taller and had larger leaves than the introduced variety Big Lehua. Differences between the 2 varieties in the first, third and fourth croppings were significant at 1% level (Table 1). No significant difference in corm yield was observed in the fifth and sixth croppings. The higher yield obtained from Kalpao in the first and fourth croppings tends to suggest that Kalpao can withstand adverse growing conditions better than Big Lehua. The severe occurrence of leaf blight disease caused by *Phythopthora colocasiae* which was

Table 1. Yields of Kalpao and Big Lehua varieties for each cropping, averaged across population density and fertilizer level.

	Corm Yield (t/ha/yr)	
Cropping	**Kalpao**	**Big Lehua**
First	12.77	9.86
Second	27.26	30.77
Third	24.54	30.91
Fourth	14.13	7.94
Fifth	20.60	18.46
Sixth	27.80	25.28

on its fourth month of development during the first cropping might have reduced photosynthate accumulation resulting in low yield. When leaf blight occurs, corms are either poorly formed or not produced at all (PCARR, 1977). Also, the severe drought which occurred during the fourth cropping might have impaired the development of both varieties even when irrigation was provided. The root system of taro which is not as extensive as many other crops makes it less adaptable to drought.

Starting from the second cropping, the 2 varieties were harvested at different times depending upon the development of the main corms. Kalpao was harvested earlier since its corms were fully developed earlier than Big Lehua. The former could be harvested from 7 to 9 months after planting while the latter must be harvested 10 to 12 months from planting. When allowed to grow longer than their normal growing period, the corms of both varieties became susceptible to rot.

Influence of Fertilizer Level.

Fertilizer level seemed to influence the vegetative development of both varieties. In the first 5 plantings, the plants which received higher fertilizer rates, i.e., 60-30-30, 90-60-60 and 120-60-60, were taller compared to those applied with lower rates (30-0-0, 30-30-0 and 30-30-30). Similarly, leaf area was larger in plants given higher fertilizer rates. Regardless of variety, fertilizer level and plant population, parameters such as plant height and leaf area tended to increase during the early stage of plant development until they reached the maximum at about 4 to 5 months from planting. Both plant height and leaf area declined after this period. De la Peña and Plucknett (1972) reported that taro has a rapid growth rate during the first 6 months followed by a decline in top growth and a steady increase in corm weight from 3 months until maturity.

In the sixth crop, highest plant height during the maximum growth period was observed in plants applied with 60-30-60 kg/ha N, P_2O_5 and K_2O. During the same period, the shortest plant height was noted in plants from the unfertilized plots. The plants which received only P_2O_5 and K_20 (0-30-60) were almost of the same height as the plants in the unfertilized treatments. Plants applied with 30 kg/ha N, regardless of the levels of P_2O_5 and K_20 were taller than those not given N, but generally shorter than plants which received 60 kg/ha N. A similar trend was observed for leaf area. This suggests that among the 3 major fertilizer elements, N has more influence on the vegetative growth and development of taro under lowland condition. Villanueva and Abenoja (1981) made a similar observation on the growth of taro under upland conditions. They found that plants grew taller and developed larger leaf area when applied with higher rate of N regardless of the levels of P_2O_5 and K_20.

Table 2. Mean yields of Kalpao variety for each cropping as influenced by seven fertilizer levels, averaged across population density[1]

Fertilizer level (kg/ha)	Yield (t/ha/yr)				
	1st Cropping	2nd Cropping	3rd Cropping	4th Cropping	5th Cropping
0-0-0	12.45bcd	25.76b	17.27d	9.31de	14.28f
30-0-0	11.77cd	22.78b	22.27bcd	7.74e	18.16cdef
30-30-0	11.19de	26.50ab	22.58bcd	15.29ab	19.84bcdef
30-30-30	12.40bcd	25.75b	22.96bcd	16.47ab	20.69abcde
60-30-30	14.43abc	28.84ab	30.06abc	14.53bc	21.47abcd
90-60-60	14.41a	31.74ab	29.21abcd	17.59ab	25.84a
120-60-60	13.63ab	32.95ab	27.46abcd	17.99a	23.96ab

[1] Yields in the same column followed by a common letter are not significantly different from each other, DMRT.

Both Kalpao and Big Lehua varieties had relatively lower yields in the first and fourth croppings (Tables 2 and 3) which might also be attributed to the incidence of leaf blight disease and drought. Leaf blight was also observed during the fifth cropping but its damage was not considered serious as manifested by the slight reduction in yield of the 2 varieties. Regardless of fertilizer level, the higher yield of Kalpao and Big Lehua in the second and third croppings must have been

Table 3. Mean yields of Big Lehua variety for each cropping as influenced by seven fertilizer levels, averaged across population density[1]

Fertilizer Level (kg/ha)	Yield (t/ha/yr)				
	1st Cropping	2nd Cropping	3rd Cropping	4th Cropping	5th Cropping
0-0-0	9.70ef	28.88ab	19.28cd	4.43f	15.30ef
30-0-0	9.10e	30.45ab	24.45bcd	3.71f	15.96def
30-30-0	9.19e	28.03ab	33.17ab	8.40e	18.20cdef
30-30-30	9.96ef	31.02ab	38.64a	10.39de	18.92bcdef
60-30-30	10.92de	33.66ab	30.46abc	7.79e	17.81cdef
90-60-60	9.11e	31.08ab	31.14abc	12.12ed	22.31abc
120-60-60	11.06de	37.31a	39.24a	8.77e	20.73abcde

[1] Yields in the same column followed by a common letter are not significantly different from each other, DMRT.

brought about by the favorable growing conditions that took place during these periods.

In the first 4 croppings, the general trend in the effects of fertilizer treatments was highly significant. Increase in yield obtained by applying 60-30-30 kg/ha N, P_2O_5 and K_2O was statistically the same as applying 90-60-60 and 120-60-60 kg/ha N, P_2O_5 and K_2O. In the fifth cropping where the assignment of main plots and subplots was changed, fertilizer effect on corm yield was highly significant. As in the third and fourth croppings, highly significant differences in corm yield were obtained between the unfertilized plot and the means of all fertilized plots. Likewise, difference between the mean yield of lower fertilizer levels (30 kg/ha N, 0-30-30 kg/ha N and P_2O_5 and 30-30-30 kg/ha N, P_2O_5, K_2O) was also significant at 1% level.

The trend in the effect of fertilizer treatments in the fifth cropping was similar to that in the previous 4 croppings. Corm yield obtained by applying 60-30-30 kg/ha N, P_2O_5 and K_2O did not differ significantly from the yield obtained with the application of 90-60-60 and 120-60-60 kg/ha N, P_2O_5 and K_2O. This indicated that fertilizer application in lowland taro needs to be regulated. Excessive fertilizer application generally produces dark green, succulent vegetative growth at the expense of corm development.

In the sixth crop, where modification of fertilizer treatments (subplots) was made, results showed that N had more influence on the final corm yield of lowland taro than P_2O_5 and K_2O (Table 4). Regardless of variety and population density, the mean corm yield was subsequently increased when the level of

Table 4. Mean yields of Kalpao and Big Lehua varieties for the sixth cropping as influenced by eight fertilizer levels, averaged across population density.[1]

Fertilizer	Yield (t/ha/yr)		
Level (kg/ha)	Kalpao	Big Lehua	Mean
0-0-0	19.73d	11.99e	15.86
30-30-0	29.72abc	29.45abc	29.59
30-0-60	29.84abc	28.24bc	29.04
0-30-60	19.80d	17.87de	18.84
30-30-60	29.55abc	27.43bc	28.49
30-60-60	28.74bc	28.65bc	28.70
60-30-60	33.98ab	36.78a	35.38
30-30-120	31.06abc	24.23cd	27.65

[1] Yields in the same column followed by a common letter are not significantly different from each other, DMRT.

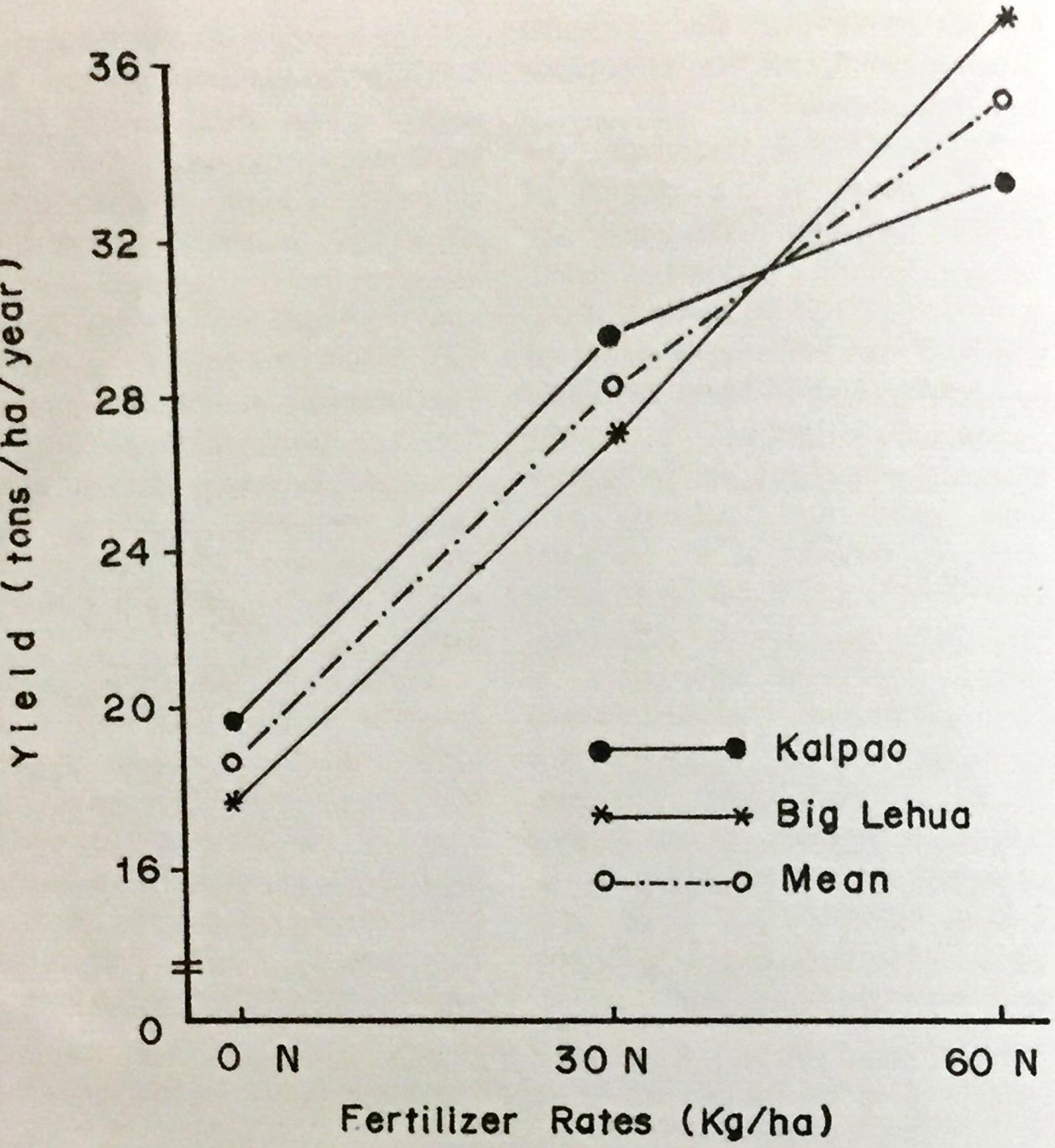

Fig. 1. Yield of taro under lowland conditions as influenced by different levels of N with P and K held constant in each treatment (30 P_2O_5 and 60 K_2O).

N was increased while the levels of P_2O_5 and K_2O were held constant (Fig. 1). On the other hand, the increase in rate of P_2O_5 while maintaining the amount of N and K_2O applied did not bring about any significant change in corm yield (Fig. 2). When the level of K_2O was increased while both N and P_2O_5 were maintained, a slight decrease in mean yield was observed (Fig. 3).

The general result of the sixth planting tends to suggest that without any increase in the rate of N, the increase in the levels of P_2O_5 and K_2O does not give any significant change in corm yields under lowland conditions. The mean yield obtained by applying P_2O_5 and K_2O without N (0-30-60 kg/ha N, P_2O_5, K_2O) was statistically the same as the yield obtained from the unfertilized plot (given 0 kg/ha N, P_2O_5, K_2O). This indicates that nitrogen is

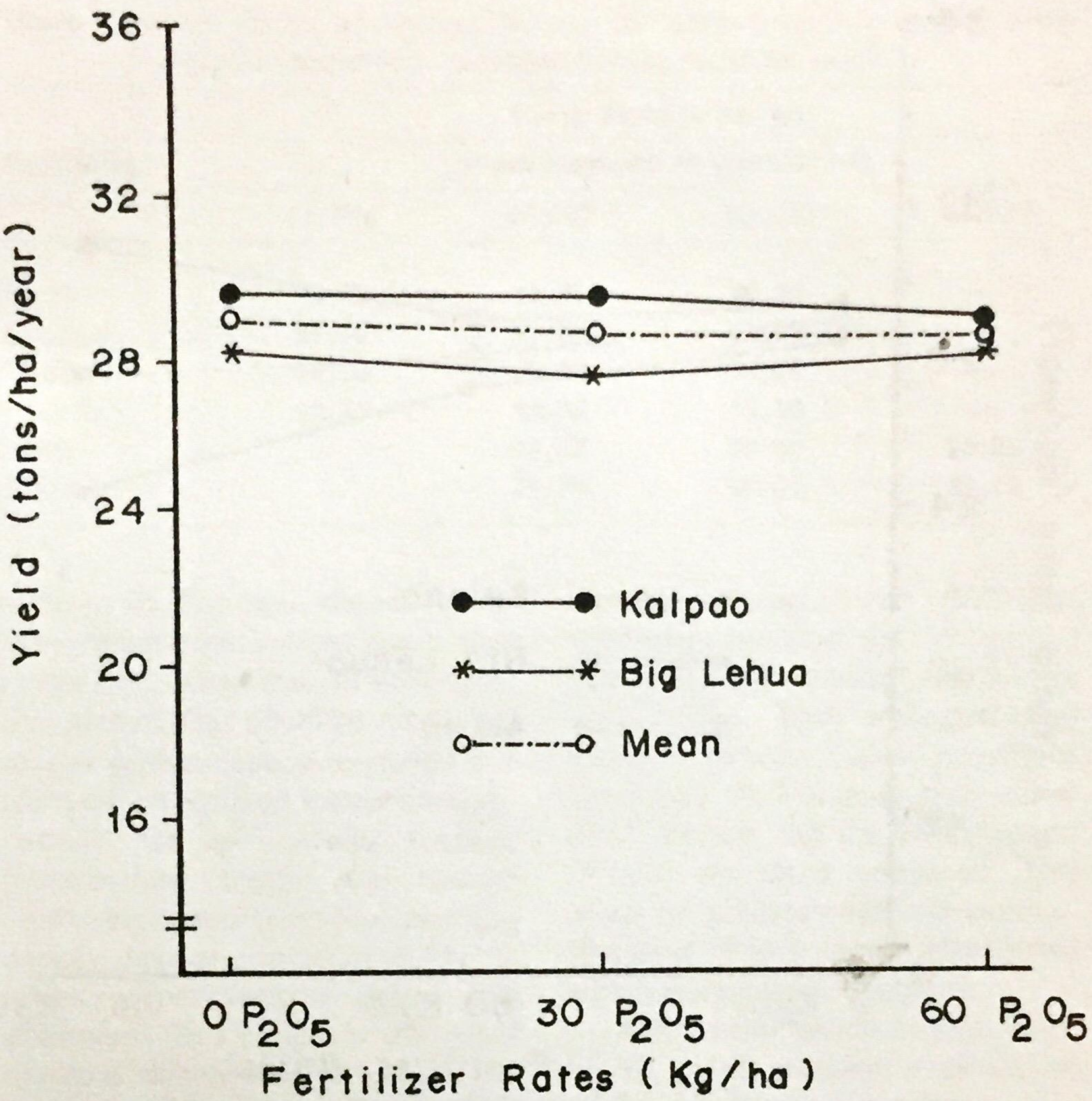

Fig. 2. Yield of taro under lowland conditions as influenced by different levels of P with N and K held constant in each treatment (30 N and 60K).

the primary nutrient needed in the production of lowland taro. A similar view was presented by Kagbo et al. (1973). They indicated that lowland taro responds mostly to nitrogen.

Influence of Plant Population.

Yields of both Kalpao and Big Lehua generally increased with increasing plant population (Tables 5 and 6). When yields were averaged across variety and fertilizer level, analysis of results showed highly significant effect of planting density in all croppings except in the second crop. In the first 4 croppings, lowest yield continuously increased from the lowest population density (17,778 plants/ha) to the highest density (40,000 plants/ha). In the

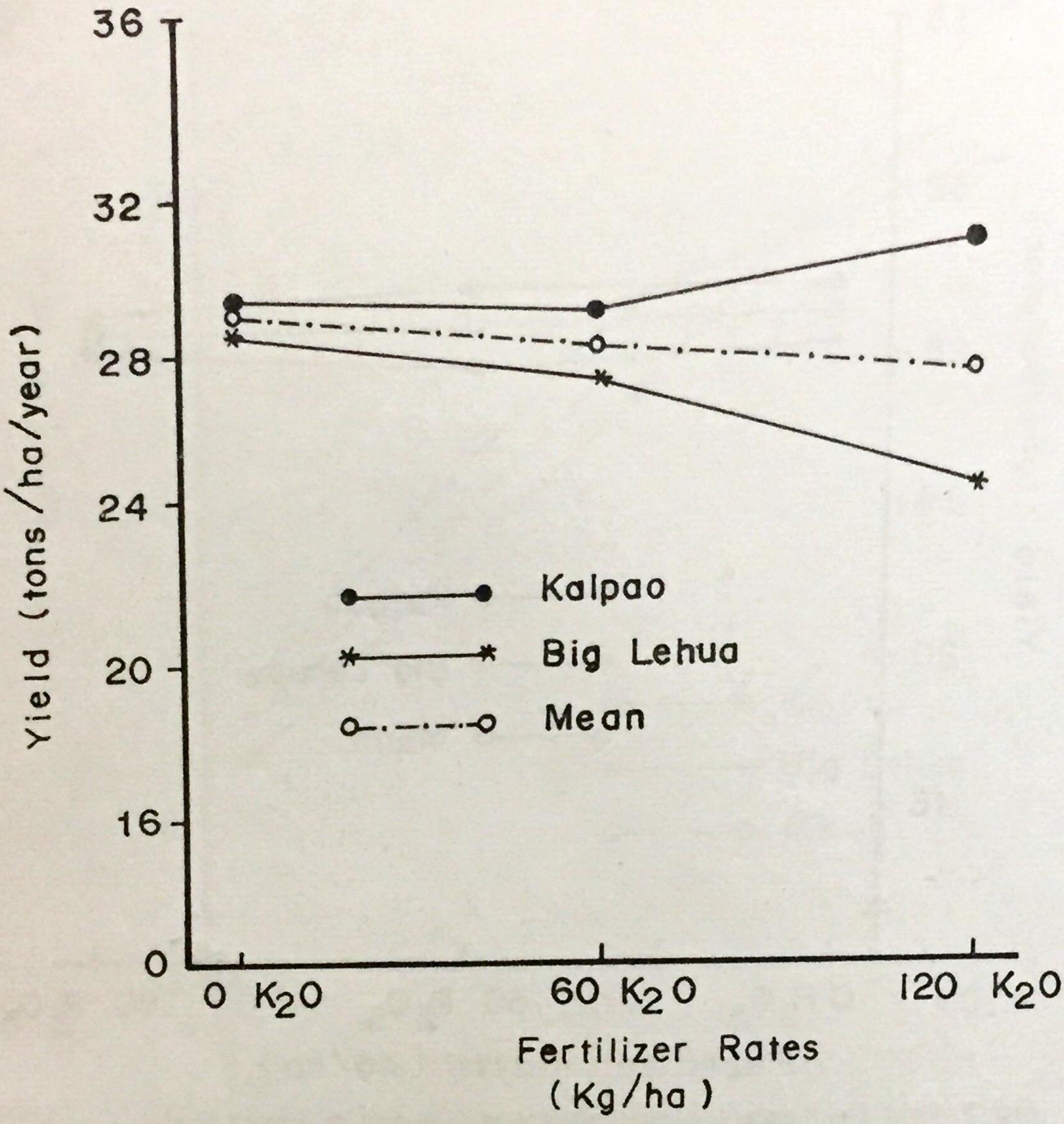

Fig. 3. Yield of taro under lowland conditions as influenced by different levels of K with N and P held constant in each treatment (30 N and 30 P_2O_5).

fifth and sixth croppings where lowest density level was dropped and a new higher density was added, increase in yield was again obtained when plant population was increased further to 53,333 plants per ha. The increase in yield from higher plant population in the last 2 croppings was more pronounced in Kalpao than in Big Lehua (Fig. 4). The proportional increase in yield with increase in plant population may be due to the higher number of plants per unit area of land which intercepts solar radiation and thereby enhances higher photosynthesis on a unit area basis (Kagbo et al., 1973).

Observation made at harvest for all croppings showed that the main corms produced in the lowest population density were consistently

Table 5. Mean yields of Kalpao variety for each cropping under three population densities, averaged across fertilizer level.

Cropping	Corm Yield (t/ha/yr) Plant Population (plants/ha)			
	17,778	26,667	40,000	53,333
First	9.72	12.35	16.24	—
Second	27.65	27.75	27.87	—
Third	18.50	23.90	31.23	—
Fourth	12.35	14.05	15.99	—
Fifth	—	17.09	20.90	23.82
Sixth	—	21.74	29.95	31.72

uniform in size and shape. Moreover, mean corm weight was higher at low population than in the higher population. This could be attributed to the greater space available per plant which reduced interplant competition for all growth factors. Nevertheless, bigger and heavier corms produced from low planting density did not compensate for the fewer corms formed under this treatment. This suggests that yield of taro is closely associated with the number rather than the size of corms at harvest. Sivan (1973) and Villanueva and Abenoja (1981a) had also reported similar results for upland taro. They indicated that yield of taro under upland conditions continued to increase with closer plant spacing, but the mean weight of corm per plant decreased. This tends to indicate that the production level of taro can be maintained by adjusting plant population.

Apart from giving higher yield, higher plant population offers an added advantage since it provides

Table 6. Mean yields of Big Lehua variety for each cropping under three population densities, averaged across fertilizer level.

Cropping	Corm Yield (t/ha/yr) Plant Population (plants/ha)			
	17,778	26,667	40,000	53,333
First	7.89	9.84	11.87	—
Second	30.86	31.21	30.25	—
Third	28.98	30.94	32.81	—
Fourth	7.40	7.89	8.55	—
Fifth	—	17.80	17.51	20.07
Sixth	—	21.59	26.59	28.56

much earlier full ground cover which suppresses weeds effectively. Weed competition during the early stage of plant development had been reported to be critical for taro (Plucknett et al., 1973).

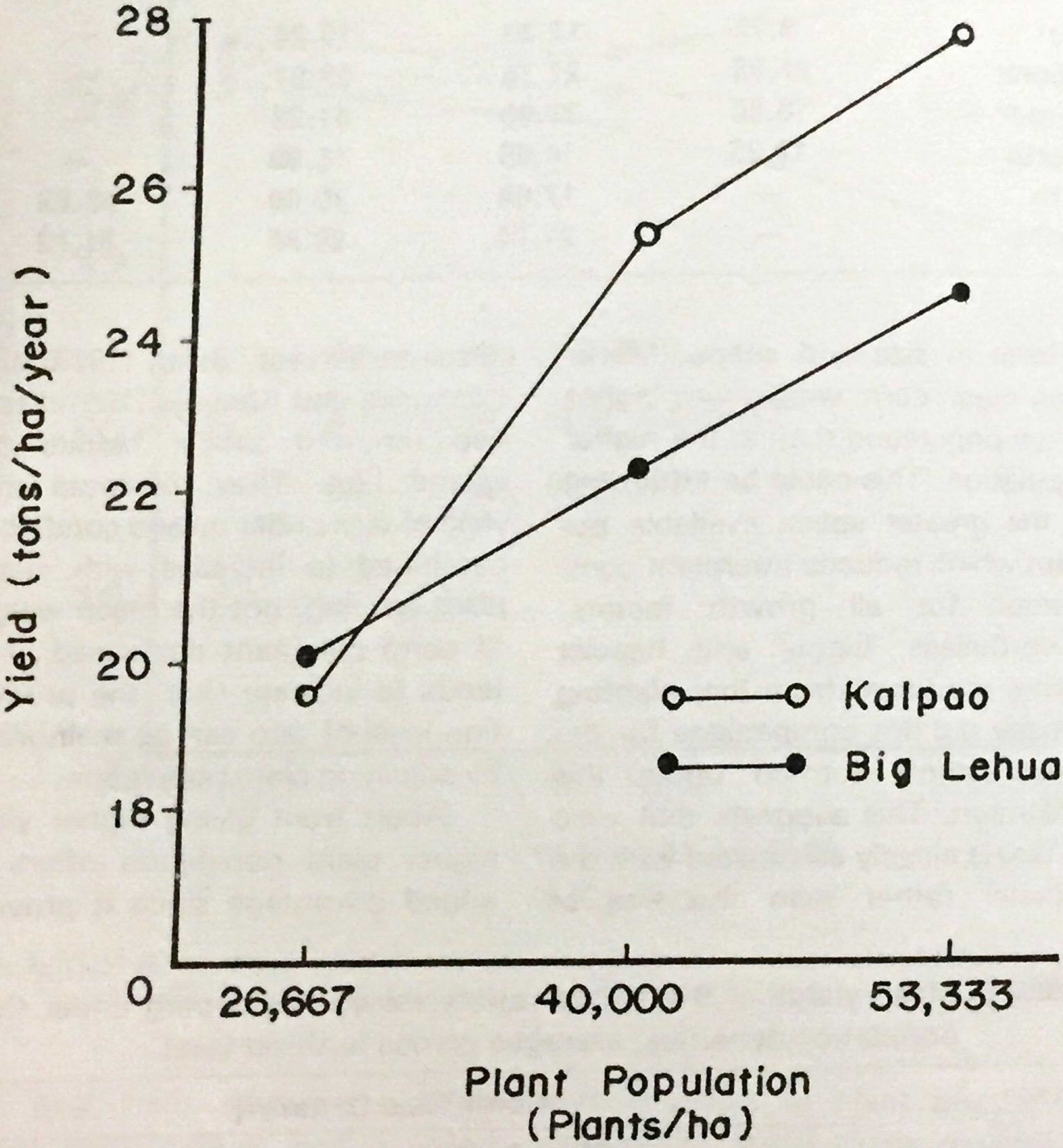

Fig. 4. The influence of plant population on the yield of two lowland taro varieties. (average of the fifth and sixth croppings.)

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