THE RESPONSE OF TARO (COLOCASIA ESCULENTA [L.] SCHOTT) TO N, P, AND K FERTILIZATION UNDER UPLAND AND LOWLAND CONDITIONS IN HAWAII

— *by* —

Ramon S. de la Pena and Donald L. Plucknett

Taro is one of man's oldest food crops. Records of taro cultivation date back to 400 B.C. It is widely used throughout the tropic, sub-tropic and subtemperate zones as a vegetable or a starch source. It is used for food either as boiled, diced cubes or as "poi", a paste made from boiled, mashed corms allowed to ferment a day or more. It is also sliced and baked or made into taro chips. Dieticians have long recognized the unique properties of poi as a baby food (Derstine and Rada, 1952; Miller, 1927, 1929; Miller, Bauer and Denning, 1952). Clinical studies conducted to determine the food properties of poi confirmed it values as food for normal, allergic, and potentially allergic babies (Glaser, Lawrence, Harrison and Ball, 1965).

Taro is of primary importance in the Pacific Basin because it is the staple food of most of the inhabitants. In most of Asia and Africa, it is used as a vegetable similar to potato or sweet potato. In the Hawaiian Islands it is still an economically important crop despite the rapidly declining acreage devoted to its production.

Despite its importance, little is known of the fertility and nutrient requirements of the taro plant. This research was designed to study the response of taro to relatively high rates of fertilization and to investigate the N,P, and K requirements of taro under upland and lowland conditions in Hawaii.

MATERIAL AND METHODS

Two field experiments were established in the island of Kauai. A pot experiment was conducted in the Manoa campus of the University of Hawaii. The lowland paddies were located in Hanalei Valley, the major taro producing area of the state. The site is about 3m above sea level with an average annual rainfall of 230 cm. The soil is classified as a Hauula Paddy.

The upland plots were located at the Kauai Branch Experiment Station of the University of Hawaii. The site is about 150 m above sea level with an average annual rainfall of 240 cm.The soil is classified in the Halii series of the Aluminous Ferruginous Latosol Great Soil Group.

The field experiments were laid out in an incomplete factorial design with 12 treatments and three replications. One-third of the N and K and all of the P fertilizers were applied before planting. The remaining N and K were applied in equal amounts two and four months after planting. The plots were 4.5 x 6 m and the plants were spaced 45 x 60 cm.

Twenty-four 5-gallon cans were filled with about 15 Kg of air-dried Waimanalo soil (Low Humic Latosol) and a completely randomized 2 x 2 x 2 N-P-K interaction experiment was set-up with three replications. Rates of fertilizers used were uniform for N, P, and K being 0 and 15 g per pot. Just before planting, one-third of the N and K and all of the P fertilizers were thoroughly mixed with the soil and the remaining N and K were applied in equal amounts at two and four months after planting. In all experiments, urea, treble super phosphate and potassium sulfate were used as sources of the elements.

Periodic plant samples were collected consisting of the petioles and blades of the physiologically most active leaves of three plants per plot. Petioles and blades were analyzed separately for N, P, K, Ca and Mg. Nitrogen was analyzed by the Kjeldahl method modified to include nitrates (A.O.A.C. 1960), P. colorimetrically as the ammonium-vanadate yellow complex. Potassium was analyzed using a Beckman Model Du flamephotometer. Calcium and Mg were complexometrically analyzed by titration with EDTA using Calcon and Eriochrome Black T indicators (Black, 1965).

Harvesting consisted of pulling 15 plants per plot at 12, 14 and 15 months from the fields. The main and sucker corms were weighed separately. In the pot experiment, the plants were pulled out at the age of six months. The roots, corms and leaves were thoroughly washed and prepared separately for chemical analysis.

RESULTS AND DISCUSSION

Nitrogen fertilization

The total yields in tons per hectare of upland lowland taro as affected by increasing rates of N applications are shown in tables 2 and 3. Statistical analysis of the yield data shows significant differences among means of different treatments both in the upland and lowland fields. In the upland crop, however, only increasing N fertilization increased the yields significantly whereas in the lowland, both fertilization and date of harvesting gave significant increases in the yields which seems to indicate that upland taro matures earlier than lowland taro.

The highest yield in upland taro fertilized with N were obtained from plots which received 560 Kg/Ha N. The yields at 280 and 1120 Kg/Ha N were also higher than those of the control; the decrease in yields at the highest level of N was probably due to inadequate supply of other nutrients or the imbalance brought about by the excessive supply of N.

In the lowland taro, the highest yields were obtained from the plots given 1120 Kg/Ha N. Although the trend in yield increase for both crops was curvilinear, the highest rate of N application did not seem to upset the balance of nutrients in the lowland field since analysis of both soils showed that the lowland fields had higher fertility level than the upland field (Table 1).

The composition of leaves of both upland and lowland taro was affected significantly by fertilization and age (Tables 4 and 5). In upland taro, only per cent N in the petioles was increased significantly by N fertilization. Per cent P, K and Ca decreased with application of N, while Mg tended to increase but the increase was not significant. In the blades, per cent N and Mg increased significantly when N fertilization increased. Per cent P, K and Ca in the blades decreased significantly with N fertilization and age.

Per cent N and Mg in the leaves of lowland taro showed significant increases due to N fertilization and decreases due to maturation. The effect of N applications and age on per cent P and K of lowland taro leaves is similar to those obtained from the upland crop.

Table 1.—Analysis of soils used in the field experiments.[1]

	Lowland	Upland
pH	5.67	4.58
C. E. C. me./100 g. O.D.	17.45	24.49
Exch. Ca me./100 g. O.D.	9.77	1.54
Exch. Mg me./100 g. O.D.	3.92	0.45
Exch. K me./100 g. O.D.	0.323	0.260
Total N %	0.22	0.23
Ext. P ppm	319.4	9.4
Sand fraction %	54	5

1 Average of determinations from 36 plots.

Table 2.—Effects of nitrogen on total yields (tons/hectare) of upland taro.[1]

Treatment Kg. N/Ha.	Age at harvest 12 months	14 months	15 months
0 (Control)	6.69	6.18	7.32
0	9.67^{c}	12.63^{bc}	9.77^{c}
280	18.58^{ab}	21.27^{ab}	20.63^{ab}
560	22.56^{a}	22.40^{a}	25.54^{a}
1120	19.56^{ab}	17.23^{abc}	16.67^{abc}

1 Differences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 3.—Effects of nitrogen on the yields (tons/hectare) of upland taro.[1]

Treatment Kg. N/Ha.	Age at harvest 12 months	14 months	15 months
0 (Control)	24.06	28.97	32.49
0	24.73^{f}	36.85^{de}	33.14^{e}
280	32.81^{e}	41.29^{cd}	44.02^{c}
560	33.45^{e}	51.54^{ab}	50.41^{b}
1120	37.95^{cde}	55.01^{ab}	57.62^{a}

1 Differences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 4.—Effects of nitrogen fertilization composition of upland taro leaves.[1]

Treatments Kg./Ha. N	Petioles Age in months 3	6	9	12	Blades Age in months 3	6	9	12
				Per cent N				
0 (Control)[2]	1.25	1.12	0.80	1.29	3.75	3.27	3.09	3.43
0	1.00	1.04	0.77	1.11	3.64	3.30	3.02	3.32
280	1.63	1.20	0.73	1.11	4.09	3.80	3.33	3.20
560	2.28	1.72	0.82	1.18	4.45	4.14	3.69	3.46
1120	2.70	1.82	0.87	1.32	4.88	4.33	3.64	3.51
				Per cent P				
0 (Control)	0.112	0.164	0.164	0.203	0.231	0.265	0.251	0.270
0	0.312	0.411	0.431	0.385	0.356	0.338	0.313	0.337
280	0.165	0.158	0.275	0.281	0.340	0.281	0.288	0.298
560	0.164	0.144	0.178	0.285	0.317	0.281	0.288	0.314
1120	0.162	0.144	0.185	0.232	0.316	0.288	0.298	0.293
				Per cent K				
0 (Control)	8.40	7.30	3.32	4.76	4.73	5.27	3.91	4.03
0	10.70	7.99	6.53	6.85	5.52	5.30	4.90	4.40
280	10.13	7.85	5.77	5.33	5.70	5.79	4.77	4.05
560	9.15	7.10	4.19	4.50	5.07	5.46	3.92	3.72
1120	7.90	6.27	3.65	4.80	4.63	5.00	4.12	3.98
				Per cent Ca				
0 (Control)	1.19	0.87	0.72	1.08	1.39	1.24	1.16	1.63
0	1.06	0.71	0.57	0.88	1.29	1.03	1.21	1.44
280	0.87	0.66	0.57	0.76	1.17	0.92	0.92	1.25
560	0.95	0.83	0.57	0.81	1.20	0.95	0.89	1.32
1120	0.97	0.75	0.54	0.74	1.19	0.75	0.75	1.10
				Per cent Mg				
0 (Control)	0.10	0.15	0.13	0.14	0.18	0.13	0.22	0.24
0	0.10	0.12	0.10	0.12	0.15	0.11	0.19	0.21
280	0.11	0.13	0.12	0.14	0.18	0.15	0.19	0.23
560	0.12	0.18	0.12	0.15	0.19	0.17	0.20	0.23
1120	0.13	0.14	0.11	0.12	0.20	0.15	0.17	0.22

[1] Average of three replications. Results of analysis expressed in per cent oven dry basis.

[2] Control plots were not fertilized, all other treatments received basic applications of 280 Kg./Ha. each of P and K.

Table 5.—Effects of nitrogen fertilization on composition of lowland taro leaves.[1]

Treatments Kg./Ha. N	Petioles 3	6	9	12	Blades 3	6	9	12
				Per cent N				
0 (Control)[2]	1.00	0.97	0.81	0.65	4.02	4.09	3.13	2.78
0	0.99	0.98	0.73	0.63	4.11	4.10	3.18	2.77
280	1.06	1.05	0.71	0.64	4.32	4.23	3.23	2.99
560	1.22	1.39	0.76	0.68	4.37	4.61	3.47	3.09
1120	1.38	1.81	0.87	0.61	4.77	4.96	3.69	2.98
				Per cent P				
0 (Control	0.268	0.570	0.516	0.312	0.400	0.477	0.377	0.319
0	0.353	0.654	0.517	0.355	0.437	0.499	0.359	0.320
280	0.381	0.645	0.476	0.337	0.461	0.522	0.380	0.321
560	0.364	0.629	0.438	0.251	0.457	0.568	0.376	0.322
1120	0.247	0.581	0.339	0.237	0.435	0.565	0.343	0.307
				Per cent K				
0 (Control)	2.05	3.60	1.93	1.02	2.83	4.30	2.85	2.60
0	4.61	6.40	3.94	1.76	4.44	5.23	4.27	3.45
280	4.03	5.69	3.49	1.64	4.06	4.97	4.14	3.37
560	3.05	4.77	2.33	0.97	3.37	4.80	3.34	2.71
1120	2.30	3.90	1.44	0.85	2.99	4.53	2.70	2.46
				Per cent Ca				
0 (Control)	0.77	0.74	0.88	0.69	1.59	1.55	1.55	1.76
0	0.64	0.62	0.72	0.70	1.22	1.22	1.25	1.66
280	0.67	0.71	0.71	0.51	1.11	1.29	1.28	1.43
560	0.74	0.80	0.77	0.45	1.31	1.29	1.32	1.01
1120	0.85	0.74	0.64	0.42	1.43	1.22	1.27	1.02
				Per cent Mg				
0 (Control)	0.58	0.44	0.48	0.33	0.71	0.35	0.35	0.33
0	0.46	0.33	0.31	0.32	0.62	0.32	0.24	0.27
280	0.52	0.41	0.34	0.32	0.51	0.35	0.24	0.27
560	0.61	0.49	0.45	0.29	0.64	0.35	0.33	0.27
1120	0.56	0.49	0.45	0.32	0.62	0.33	0.38	0.29

Age in months.

1 Average of three replications. Results of analysis expressed in per cent oven dry basis.

2 Control plots were not fertilized, all other treatments received basic applications of 280 Kg/Ha. each of P and K.

Phosphorus Fertilization

Corm yields of both upland and lowland taro in tons per hectare are shown in Tables 6 and 7. Yields of both crops increased significantly as P fertilizer increased. In the upland, the effect of P is curvilinear and the highest yields were obtained from plots fertilized with 560 Kg/Ha P. Delayed harvesting did not give significant effect on yields of upland taro, again showing that upland taro matures earlier than lowland taro.

Yields of lowland taro were significantly influenced by increasing rates of P fertilization and delayed harvesting. The highest yields were obtained from plots which received 1120 Kg/Ha P and which were harvested at the age of 15 months.

Leaf composition of upland and lowland taro fertilized with increasing rates of P are shown in Tables 8 and 9. The per cent P in petioles of upland taro was directly related to P fertilization while other elements studied were negatively affected by P applications. In the blades, only P content was significantly affected by P fertilization. With the exception of Mg, tissue content of other elements decreased with the age of the plants.

Similarly, the composition of the lowland taro leaves was influenced by P fertilizer and age. The decrease in per cent K was the only significant change, although P, Ca and Mg tended to decrease. All elements studied decreased significantly as plants reached maturity. In the blades, N, P, K, Ca and Mg were significantly affected by age of the plants when the samples were collected.

Potassium fertilization

Significant increase in yields of upland taro due to increased fertilization with K were obtained (table 10). Delayed harvesting gave a slight decrease in yields, but the effect was not statistically significant. In the lowland, there were no significant increases in corm yield due to fertilization with K. Yield increase due to delayed harvesting, however, were highly significant (table 11). Highest mean yield obtained from upland fields were from plots fertilized with 1120 Kg/Ha K and harvested at the age of 12 months. In the lowland, highest yields were obtained from plots which received 1120 Kg/Ha K, but harvested at the age of 15 months. Yields obtained at 15 months from lowland paddies which received 1120 Kg/Ha K were not significantly higher than yields from 0, 280 and 560 Kg/Ha K plots, but were significantly higher than yields obtained at 12 months.

Per cent N, P and K in petioles of upland taro increased with K fertilization (table 12). The increases in per cent N and K were highly significant while the increase in per cent P was not significant. Potassium application significantly decreased Ca and Mg content of the petioles. Age also affected the composition of the petioles; per cent N, K and Ca decreased significantly as the plants matured. Per cent P increased significantly, while increase in per cent Mg was not significant. The composition of leaf blades of upland taro showed the same trends as those found in the petioles, however, increase in per cent N and P were not significant while increase in per cent K and decreases in per cent Ca and Mg were highly significant. The only element analyzed in the blade which increased as the plants matured was Mg, all other constituents decreased significantly (1 % level of significance).

Table 6.—Effects of phosphorus on the yields (tons/hectare) of upland taro.[1]

Treatment Kg. P/Ha.	Age at harvest 12 months	14 months	15 months
0 (Control)	6.69	6.18	7.32
0	14.01[g]	16.80[fg]	14.91[fg]
280	18.58[efg]	21.27[cdefg]	20.63[defg]
560	29.66[bcb]	26.94[bcde]	40.18[a]
1120	32.10[a]	23.84[bcdef]	30.09[bc]

1 Defferences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 7.—Effects of phosphorus on the yields (tons/hectare) of lowland taro.[1]

Treatment Kg. P/Ha.	Age at harvest 12 months	14 months	15 months
0 (Control)	24.06	28.97	32.49
0	29.26[ef]	38.67[bcd]	39.27[bcd]
280	32.81[cdef]	41.29[abc]	44.02[ab]
560	24.47[f]	37.69[bcde]	38.18[bcde]
1120	31.42[def]	46.80[ab]	48.66[a]

1 Differences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 8.—Effects of phosphorus fertilization on composition of upland taro leaves.[1]

Treatments Kg./Ha. P	Petioles				Blades			
	Age in months							
	3	6	9	12	3	6	9	12
	Per cent N							
0 (Control)[2]	1.25	1.12	0.80	1.29	3.75	3.27	3.09	3.43
0	2.48	1.70	0.84	1.25	4.38	3.99	3.53	3.53
280	1.63	1.20	0.73	1.11	4.09	3.80	3.33	3.20
560	2.12	1.48	0.83	1.32	4.23	3.99	3.68	3.74
1120	2.00	1.21	0.77	1.22	4.28	3.72	3.16	3.66
	Per cent P							
0 (Control)	0.112	0.164	0.164	0.203	0.231	0.265	0.251	0.270
0	0.118	0.128	0.120	0.159	0.232	0.254	0.245	0.266
280	0.165	0.158	0.275	0.281	0.340	0.281	0.288	0.298
560	0.239	0.143	0.228	0.313	0.340	0.287	0.310	0.320
1120	0.311	0.154	0.244	0.461	0.407	0.283	0.319	0.379
	Per cent K							
0 (Control)	8.40	7.30	3.32	4.76	4.73	5.27	3.91	4.03
0	10.90	8.68	5.67	6.20	5.39	5.38	4.65	4.15
280	10.13	7.85	5.77	5.33	5.70	5.79	4.77	4.05
560	9.67	7.26	5.12	5.51	5.70	5.23	4.59	3.93
1120	8.77	7.08	4.60	5.27	5.50	5.13	4.50	4.11
	Per cent Ca							
0 (Control)	1.19	0.87	0.72	1.08	1.39	1.24	1.16	1.63
0	0.99	0.77	0.68	0.81	1.13	0.89	1.04	1.27
280	0.87	0.66	0.57	0.76	1.17	0.92	0.92	1.25
560	0.87	0.71	0.56	0.78	1.16	0.95	0.95	1.23
1120	0.94	0.82	0.53	0.90	1.27	0.96	1.11	1.35
	Per cent Mg							
0 (Control)	0.10	0.15	0.13	0.14	0.18	0.13	0.22	0.24
0	0.09	0.13	0.10	0.16	0.16	0.14	0.20	0.26
280	0.11	0.13	0.12	0.14	0.18	0.15	0.19	0.23
560	0.13	0.12	0.13	0.15	0.18	0.14	0.20	0.25
1120	0.13	0.12	0.10	0.12	0.19	0.14	0.17	0.20

1 Average of three replications. Results of analysis expressed in per cent oven dry weight.

2 Control plots were not fertilized, all other treatments received basic applications of 280 Kg./Ha. each of N and K.

Table 9.—Effects of phosphorus fertilization on composition of lowland taro leaves.[1]

Treatments Kg./Ha. P	Petioles				Blades			
	Age in months							
	3	6	9	12	3	6	9	12
				Per cent N				
0 (Control)[2]	1.00	0.97	0.81	0.65	4.02	4.09	3.13	2.78
0	1.31	1.17	0.74	0.62	4.74	4.44	3.30	3.07
280	1.06	1.05	0.71	0.64	4.32	4.23	3.23	2.90
560	1.16	1.19	0.73	0.66	4.61	4.46	3.50	2.99
1120	1.10	1.27	0.74	0.70	4.28	4.42	3.43	3.06
				Per cent P				
0 (Control)	0.268	0.570	0.516	0 322	0.400	0.477	0.377	0.319
0	0.326	0.670	0.419	0.291	0.492	0.532	0.359	0.344
280	0.381	0.645	0.476	0.337	0.461	0.522	0.380	0.321
560	0.374	0.670	0.468	0.299	0.483	0.560	0.394	0.334
1120	0.372	0.639	0.431	0.288	0.465	0.568	0.374	0.335
				Per cent K				
0 (Control)	2.05	3.60	1.93	1.02	2.83	4.30	2.85	2.60
0	5.02	6.00	2.33	1.33	4.45	4.70	3.32	3.08
280	4.03	5.69	3.49	1.64	4.06	4.97	4.14	3.37
560	3.85	5.63	2.52	1.26	4.10	4.83	3.45	2.76
1120	3.75	5.00	1.93	1.00	3.94	4.83	3.12	2.56
				Per cent Ca				
0 (Control)	0.77	0.74	0.88	0.69	1.59	1.55	1.55	1.76
0	0.61	0.69	0.74	0.56	1.09	1.24	1.21	1.42
280	0.67	0.71	0.71	0.51	1.11	1.29	1.28	1.43
560	0.66	0.79	0.71	0.49	1.10	1.37	1.23	1.37
1120	0.66	0.67	0.71	0.53	1.13	1.27	1.32	1.28
				Per cent Mg				
0 (Control)	0.58	0.44	0.48	0.33	0.71	0.35	0.35	0.33
0	0.60	0.44	0.37	0.31	0.64	0.37	0.30	0.29
280	0.52	0.41	0.34	0.32	0.51	0.35	0.24	0.32
560	0.45	0.45	0.39	0.31	0.52	0.35	0.28	0.35
1120	0.53	0.46	0.39	0.31	0.55	0.35	0.31	0.30

1 Average of three replications. Results of analysis expressed in per cent oven dry weight.

2 Control plots were not fertilized, all other treatments received basic applications of 280 Kg./Ha. each of N and K.

Table 10.—Effects of potassium on the yields (tons/hectare) of upland taro.[1]

Treatment	Age at harvest		
Kg. K/Ha.	12 months	14 months	15 months
0 (Control)	6.69	6.18	7.32
0	16.90[bc]	18.08[abc]	14.85[c]
280	18.58[abc]	21.27[abc]	20.63[abc]
560	26.77[ab]	25.52[ab]	20.95[abc]
1120	27.77[a]	20.75[abc]	23.09[abc]

1 Differences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 11.—Effects of potassium on the yields (tons/Ha.) of lowland taro.[1]

Treatment	Age at harvest		
Kg. K/Ha.	12 months	14 months	15 months
0 (Control)	24.06	28.97	32.49
0	31.97[b]	41.81[a]	45.32[a]
280	32.81[b]	41.29[a]	44.02[a]
560	29.94[b]	42.47[a]	43.75[a]
1120	32.27[b]	41.32[a]	45.99[a]

1 Differences among values with the same letter in the superscript are not significant. Control data not included in statistical analysis.

Table 12—Effects of potassium fertilization on composition of upland taro leaves.[1]

Treatments Kg./Ha. K	Petioles				Blades			
	Age in months							
	3	6	9	12	3	6	9	12
				Per cent N				
0 (Control)[2]	1.25	1.12	0.80	1.29	3.75	3.27	3.09	3.43
0	1.62	1.19	0.73	1.33	4.20	3.86	3.16	3.47
280	1.63	1.20	0.73	1.11	4.09	3.80	3.33	3.20
560	1.69	1.83	0.92	1.21	4.18	3.87	3.50	3.23
1120	1.92	2.27	0.88	1.30	4.12	3.95	3.59	3.68
				Per cent P				
0 (Control)	0.112	0.164	0.164	0.203	0.231	0.265	0.251	0.270
0	0.147	0.143	0.253	0.311	0.293	0.296	0.306	0.321
280	0.165	0.158	0.275	0.281	0.340	0.281	0.288	0.298
560	0.201	0.145	0.270	0.350	0.339	0.362	0.299	0.305
1120	0.168	0.153	0.234	0.364	0.331	0.266	0.297	0.325
				Per cent K				
0 (Control)	8.40	7.30	3.32	4.76	4.73	5.27	3.91	4.03
0	3.10	2.71	3.13	3.53	3.20	3.30	3.31	3.24
280	10.13	7.85	5.77	5.33	5.70	5.79	4.77	4.05
560	10.27	9.61	5.70	5.86	6.10	6.28	4.67	4.20
1120	11.15	11.27	5.90	7.11	6.17	6.35	4.69	4.53
				Per cent Ca				
0 (Control)	1.19	0.87	0.72	1.08	1.39	1.24	1.16	1.63
0	1.17	1.04	0.63	0.95	1.87	1.78	1.30	1.44
280	0.87	0.66	0.57	0.76	1.17	1.92	0.92	1.25
560	0.84	0.68	0.60	0.84	1.16	0.88	0.77	1.27
1120	0.87	0.63	0.55	0.67	1.22	0.92	0.65	0.97
				Per cent Mg				
0 (Control)	0.10	0.15	0.13	0.14	0.18	0.13	0.22	0.24
0	0.19	0.26	0.18	0.22	0.31	0.27	0.24	0.33
280	0.11	0.13	0.12	0.14	0.18	0.15	0.19	0.23
560	0.11	0.13	0.13	0.12	0.16	0.14	0.22	0.21
1120	0.10	0.12	0.10	0.09	0.15	0.11	0.19	0.20

1 Average of three replications. Results of analysis expressed in per cent oven dry weight.

2 Control plots were not fertilized, all other treatments received basic applications of 280 Kg./Ha. each of N and P.

Increasing rates of K fertilization increased K in petioles of lowland taro significantly (table 13). Calcium and Mg in the petioles decreased significantly while P and N were not affected significantly. Phosphorus, K and Ca increased significantly as the plants matured whereas N and Mg decreased with age. In the blades, only the K content increased significantly with increasing K fertilizers. Potassium fertilization had negative effects on N, P, Ca, and Mg contents of the blades. Decreases in per cent Ca and Mg were highly significant while decreases in per cent N and P were not. Phosphorus, K and Ca also increased significantly as the plants grew old while N and Mg decreased.

N-P-K interactions

Results of the pot experiment showed that only N gave significant increases in the weights of corms, roots and leaves of the plants. Nitrogen deficiency characterized by general yellowing of the plants was observed in all plants which did not receive N fertilization. No P and K deficiencies were observed even though plant analysis gave P and K contents of as low as 0.15% and 1.5%, respectively in the petioles of N-treated plants and about 0.2% P and 2.0% K in the blades.

Table 14 shows the weights of corms, roots and tops of the plants at six months. Phosphorus and K fertilization tended to increase the growth of the plants but the effects were not significant.

The concentrations of N, P and K in the individual leaves decreased from the youngest to the oldest, except P which increased from the youngest to the oldest when P supply in the soil was not limiting (table 15). Composition of the roots and crops is also influenced by fertilization (table 16).

The results of the tissue analysis are very encouraging since they are suggestive of the feasibility of using leaf analysis as a possible guide to the fertilizer needs of the taro crop.

Table 13.—Effects of potassium fertilization on composition of lowland taro leaves.[1]

Treatments Kg./Ha P.	Petioles				Blades			
	Age in months							
	3	6	9	12	3	6	9	12
	Per cent N							
0 (Control)[2]	1.00	0.97	0.81	0.65	4.02	4.09	3.13	2.78
0	1.21	1.18	0.78	0.74	4.62	4.42	3.31	3.11
280	1.06	1.05	0.71	0.64	4.32	4.23	3.23	2.90
560	1.11	1.17	0.69	0.66	4.51	4.29	3.24	2.81
1120	1.12	1.22	0.71	0.71	4.30	4.22	3.25	2.85
	Per cent P							
0 (Control)	0.268	0.570	0.516	0.312	0.400	0.477	0.377	0.319
0	0.327	0.628	0.463	0.307	0.437	0.542	0.377	0.333
280	0.381	0.645	0.476	0.337	0.461	0.522	0.380	0.321
560	0.363	0.684	0.472	0.316	0.455	0.547	0.362	0.316
1120	0.361	0.678	0.405	0.316	0.439	0.530	0.342	0.306
	Per cent K							
0 (Control)	2.05	3.60	1.93	1.02	2.83	4.30	2.85	2.60
0	1.85	2.87	1.36	0.92	2.51	3.56	2.30	2.28
280	4.03	5.69	3.49	1.64	4.06	4.97	4.14	3.37
560	5.50	6.93	3.24	1.49	4.83	5.27	3.90	3.32
1120	7.23	8.51	4.15	2.24	5.42	5.87	4.30	3.62
	Per cent Ca							
0 (Control)	0.77	0.74	0.88	0.69	1.59	1.55	1.55	1.76
0	0.81	0.84	0.77	0.58	1.47	1.65	1.44	1.33
280	0.67	0.71	0.71	0.51	1.11	1.29	1.28	1.43
560	0.56	0.71	0.60	0.58	0.91	1.19	1.14	1.39
1120	0.50	0.62	0.45	0.52	0.86	1.13	1.02	1.09
	Per cent Mg							
0 (Control)	0.58	0.44	0.48	0.33	0.71	0.35	0.35	0.33
0	0.57	0.58	0.46	0.33	0.68	0.43	0.45	0.37
280	0.52	0.41	0.34	0.32	0.51	9.35	0.24	0.32
560	0.42	0.40	0.33	0.33	0.52	0.36	0.25	0.27
1120	0.40	0.38	0.25	0.27	0.56	0.40	0.26	0.28

1 Average of three replications. Results of analysis expressed in per cent oven dry weight.

2 Control plots were not fertilized, all other treatments received basic application of 280 Kg./Ha. each of N and P.

Table 14.—Weight of corms, roots and tops of taro plants grown in pots.[1]

Treatments	Corms Fresh wt.	Roots Dry wt.	Tops[2] Dry wt.
		grams per plant	
Control	49.60	1.04	8.76
N	478.36	22.27	86.67
P	73.12	1.93	10.86
K	76.90	1.72	8.50
NP	654.49	22.49	67.44
NK	661.88	41.85	69.93
PK	70.72	2.38	11.54
NPK	771.67	26.39	64.32

1 Average of three replications.

2 Tops include petioles and blades.

Table 15.—Composition of the petioles and blades of individual leaves of six-month old taro grown in pots.[a]

Treatments	Petioles Leaf number 1	2	3	4	Blades Leaf number 1	2	3	4
	Per cent nitrogen							
Control	0.88	0.84	0.84	0.79	3.16	3.29	3.00	2.53
N	1.02	0.86	0.81	0.77	3.67	3.60	3.27	2.83
P	0.95	0.93	0.89	0.85	3'51	3.63	3.19	2.85
K	1.16	0.93	0.89	0.82	3.84	3.52	3.49	3.01
NP	1.41	1.06	0.83	0.79	4.06	3.49	3.33	2.86
NK	1.10	0.95	0.87	0.85	3.77	3.65	3.36	2.69
PK	0.94	0.82	0.77	0.75	3.68	3.47	3.03	2.53
NPK	1.41	1.12	1.06	0.97	4.79	4.16	3.41	2.60
	Per cent phosphorus							
Control	0.562	0.714	0.822	1.126	0.424	0.372	0.344	0.382
N	0.232	0.168	0.154	0.140	0.326	0.260	0.214	0.204
P	0.628	0.828	0.932	1.210	0.478	0.526	0.498	0.508
K	0.646	0.624	0.702	0.836	0.512	0.386	0.376	0.366
NP	0.618	0.484	0.436	0.452	0.484	0.326	0.302	0.274
NK	0.274	0.200	0.163	0.154	0.352	0.260	0.228	0.200
PK	0.728	0.736	0.874	1.214	0.522	0.520	0.494	0.550
NPK	0.642	0.586	0.558	0.544	0.558	0.386	0.330	0.246
	Per cent potassium							
Control	4.20	4.55	4.40	4.95	4.05	3.64	3.00	3.00
N	2.52	1.84	1.46	1.16	3.24	2.60	2.15	1.68
P	4.20	4.05	3.80	3.90	3.80	3.64	3.08	2.75
K	5.68	4.90	4.90	4.74	4.80	4.45	3.56	3.56
NP	3.34	1.90	1.60	1.16	3.34	2.06	1.90	1.45
NK	5.96	5.10	4.55	4.55	4.00	4.20	3.65	3.90
PK	5.60	4.45	4.45	4.95	4.54	4.20	3.65	3.20
NPK	6.50	5.48	5.86	5.30	4.45	3.84	3.40	3.26

a Composite samples from three plants per treatment.

Table 16.—Nitrogen, phosphorus and potassium contents of the roots and corms of six-month old taro grown in pots.

	Roots			Corms		
Treatments	% N	% P	% K	% N	% P	% K
Control	0.79	0.248	5.05	0.23	0.198	1.00
N	0.93	0.095	0.75	0.81	0.152	0.56
P	0.89	0.394	4.90	0.33	0.239	0.94
K	0.78	0.214	5.52	0.25	0.197	1.04
NP	1.07	0.290	0.48	0.71	0.232	0.52
NK	1.20	0.116	4.00	0.60	0.121	1.20
PK	0.89	0.396	5.88	0.38	0.239	1.02
NPK	1.20	0.276	3.40	0.60	0.212	1.17

REFERENCES

1 Akana, D. A. 1932. The production of wetland taro. **Univ. Hawaii Agr. Ext. Serv. Agricultural Notes** No. 16.

2 A.O.A.C. 1960. Official methods of analysis. 9th Edition. A.O.A.C., Washington, D. C. xx + 832 p.

3 Black, C. A. (Ed). 1965 Methods of soil analysis, Part 2. **Amer. Soc. of Agronomy**, Series 9.

4 Bowers, F. A. I. 1965. Some facts about taro. (Mimeographed) **Taro Conference, Honolulu, Hawaii.**

5 ———— D. L. Plucknett, and O. R. Younge, 1964. Specific gravity evaluation of corm quality in taro. **Hawaii Agr. Exp. Sta. Circular** No. 16.

6 Derstine, V. and E. L. Rada, 1952. Some dietetic factors influencing the market for poi in Hawaii. **Univ. Hawaii Agr. Econ. Bul.** 3.

7. Glaser, J., R. A. Lawrence, A. Harrison, and R. Ball, 1965. Poi — Its use as a food for normal, allergic and potentially allergic infants. (Mimeograph). **Taro Conference, Honolulu, Hawaii.**

8. King N. 1936. Dryland taro and its culture. **Univ. Hawaii Agr. Ext. Serv. Agricultural Notes** No. 129.

9 Miller, D. C. 1927. Food values of poi, taro and limu. P. Bernice, **Bishop Museum Bul.** 37.

10. ———— 1929. Food values of breadfruit, taro leaves, coconut and sugar cane. **P. Bernice, Bishop Museum Bul.** 64.