Yield and Related Components of Flooded Taro (*Colocasia Esculenta*) as Affected by Land Preparation, Planting Density, and Planting Depth

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Abstract

Management studies relating to mechanization were undertaken to evaluate their effects on yield and related components. Methods of land preparation, plant spacing, and planting depth had no significant effect on either corm and cormel specific gravity or vertical growth. However, lateral growth of corms and cormels was significantly greater under deep than shallow planting, and cormels under deep planting tended to bend away more from the corm. Also, nutrient concentrations in corms and cormels were generally higher under flat than ridge culture.

Plant population alone had a significant effect on yields of corms and cormels. The highest yield, 69.4 metric tons per ha, was obtained from a plant population of 50,000 plants/ha. None of the interactions was significant except spacing x planting depth. These results indicate that changes in land preparation, plant population, and planting depth (minor adjustments) can be made without significantly affecting yields.

Introduction

Taro (*Colocasia esculenta*) belongs to the family Araceae. In some cultures it is called "old cocoyam," dasheen, or eddoe. It is often confused with *Xanthosoma sagittifolium* ("new cocoyam" or tanier) because of their morphological similarity. However, in *Xanthosoma* the point of petiole attachment to the blade is at the very edge of the leaf at the junction of the two basal lobes (Plucknett, 1974), whereas in *Colocasia* the point of attachment is peltate and well within the leaf outline. Also, in taro both corms and cormels are eaten, whereas in *Xanthosoma* only the cormels are eaten. The main corms of *Xanthosoma* are used as planting materials, although cormels can also be planted.

Taro can be grown both on dry land and under completely flooded conditions like rice. Isotopic work in rice (Cherian, *et al.* 1968) has demonstrated a translocation of oxygen from the leaves to the roots. A similar mechanism might operate in flooded taro.

About ninety percent of the taro crop grown in Hawaii is under flooded conditions on puddled soils. Puddling and leveling require a lot of labor and specialized tillage machinery. Most youths are not attracted to growing taro by hand because of the long hours of stooping and wading in the mud, especially during planting and harvesting. Thus, there has been continued interest among farmers in mechanizing the production of taro, and that interest has led to initiation of related management studies (Ezumah, 1972; Plucknett *et al.* 1973).

Mechanization will require some changes in cultivation techniques. Some of these may have a significant negative or positive effect on yield and growth. This study is a continuation of studies of management factors that could affect taro mechanization. Studies on management factors that make mechanization easier and do not reduce yield or quality significantly can be considered potentially important.

Materials and Methods

The experiment was conducted in Wailua Valley, island of Kauai, from June 1974 to June 1975. The soil belongs to the Hanalei series, a Typica fluvaquents, isohypothermic, very fine, oxidic non-acid soil family. The experimental design was a 3 x 3 x 2 split-split plot replicated 3 times. Methods of land preparation (flat; ridge, 13 and 26 cm high--main plots), plant spacing (100 x 20, 100 x 40 cm--subplots) were variables. These spacings corresponded to 50,000, 33,333 and 25,000 plants/ha, respectively.

Fertilizer rates were 500 kg N/ha as urea, 500 kg P/ha as treble superphosphate, and 400 kg K/ha as potassium sulphate. All P was applied before planting while N and K were applied in three equal applications, at planting, and at 2 and 4 months after planting.

Ridge heights of 13 and 26 cm were measured from the bottom of the furrow. Ridges were initially constructed with a lister plow and water was introduced into the plots to settle the soil and to detect uneven spots. Measuring devices corresponding to the ridge heights were placed in furrows and soil was removed or added as necessary until the desired heights were obtained. Soil in flat culture plots was not puddled.

"Huli," the planting material consisting of 0.2-0.4 cm of the tip of the corm or cormel plus about 24 cm of the lower petioles of taro (variety Lehua), were planted at 8 and 14 cm depths. Plots were flooded throughout the experimental period. Hand weeding and paraquat were used to control weeds.

Lateral and vertical growth of corms and cormels was determined by making a cut through the center of a hill (all plants arising from one propagule) perpendicular to the ridge for each of two plants in each sub-subplot. Maximum vertical growth of corms was then measured from the soil surface to the tip of the corm. For lateral growth or spread, corms and cormels were measured at their point of maximum width. Plots were drained two days prior to taking these measurements.

Estimation of vertical force required to pull a taro hill out of the ground was made by the use of a device constructed in the Agricultural Engineering Department of the University of Hawaii. The device consisted of a pulley, a chair-shape metal frame, and two L-shape metal pieces that were inserted at the base of the corms and cormels. When the pulley was operated, a scale was read as soon as the clump of plants in the hill was raised out of the soil.

Specific gravity was determined by the displacement method. Corms and cormels were thoroughly washed, allowed to drain, and suspended individually in air and in distilled water from a balance by means of a thin, flexible wire. Specific gravity was then calculated from these readings.

Total N was determined by the Kjeldahl method while the other elements were analyzed by x-ray fluorescence (quanto-meter). Yield was determined on 10 hills/sub-subplot at 10 and 12 months after planting. Marketable cormels were those that potentially could be sold fresh in the market. These weighed over 32 grams each.

Results

Specific Gravity, Lateral and Vertical Growth, Vertical Force and Nutrient Composition. Results in Table 1 show an insignificant treatment effect on the taro traits listed except on planting depth of corm and cormel lateral growth. This confirms the finding that cormels under deep planting tend to bend away from the corm more than those from shallow planting. Thus, in terms of mechanical harvesting, a border auger would probably be required if taro is planted deep. Specific gravity of cormels was generally higher than for corms in all treatments. This suggests that cormels may have a better internal quality than corm . Since specific gravity is closely related to starch content, total solids, and mealiness.

The great amount of force required to pull out one taro hill (Table 1) clearly justifies the increased interest among taro farmers in mechanizing, at least in part, the harvesting of taro, and indicates the amount of effort expended in hand harvesting.

Nutrient composition in corms and cormels tended to be slightly higher under flat than ridged culture (Table 2). Perhaps this was a result of the more extensive root system observed at harvest under flat culture.

Yield. Land preparation method had no significant effect on yield (Table 3). This is in agreement with results of an earlier work (Ezumah, 1972) in flooded taro. Enyi (1967) cited Okigbo as finding no significant response of cassava on ridge or flat culture. However, ridging would be advantageous if water is to be drained from plots prior to harvesting to facilitate the operation of mechanical equipment for harvesting. For some soils ridging might make mechanical harvesting easier. Also, ridges should help to control soil erosion.

Plant spacing. The aim of any planting program is to obtain a plant population that will effectively utilize as much solar radiation as possible. The increased yield with higher planting populations shown in Table 4 was highly significant at the 12-month harvest. In terms of marketable and total cormels however, only the yield at 50,000 plants/ha was significantly higher than the two lower planting densities. Marketable cormels at 12 months for 25,000, 33,333 and 50,000 plants/ha were 34.5, 38.3 and 43.1 tons/ha, respectively, whereas total cormels plus corm yields were 51.4, 58.6 and 69.4 tons/ha.

The increased yield with age and planting density obtained in this study is similar to reported information for yams (Cruzado *et al.* 1964; Gooding and Hoad, 1967; Enyi, 1970), Irish potatoes (Chapman, 1965) and taro (Ezumah, 1972). This increase is due to the higher number of plants per unit area of land which intercept solar radiation and thereby enhance photosynthesis on a unit area basis.

Planting Depth. The effect of planting depth on yield was not significant (Table 3). Since only a part of the planting material in taro is covered with soil, the only influence of planting depth would be in relation to water, aeration and nutrient status, rather than light. The effect of planting depth is an important consideration in the use of mechanical planters especially where planting depth is difficult to control. Too deep planting may lead to lower yields or undesirable corm shapes. Too shallow planting may cause shallow root development or increased susceptibility to attack by insects or diseases.

Corms from shallow planted plots were more compact, oval and were more elongated with an undesirable slender base from that of deep planted plots. Furthermore, cormels under deep planting had a more convex hook-shaped base than those under shallow planting.

Spacing x Planting Depth. At 30 cm plant spacing, deep planting was consistently superior. This might be due to greater production of suckers and leaves; the greater number of leaves could result in the manufacture of more photosynthates, and possibly a higher yield, assuming that translocation into the underground storage organs was not limiting.

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Table 1. Influence of cultural methods on selected taro traits at 10 months

Trait	Land Preparation			Plant Spacing			Planting Depth	
	Flat Culture	Ridge 13cm	Ridge height 26cm	20cm	30cm	40cm	8cm	14cm
Corm specific gravity	1.05	1.06	1.07	1.06	1.06	1.06	1.06	1.06
Cormel specific gravity	1.12	1.13	1.14	1.12	1.14	1.13	1.14	1.12
Corm and cormel lateral growth, cm	23.4	24.1	23.8	22.9	23.6	24.8	23.0	24.4
Cormel vertical growth cm	13.6	14.6	14.3	14.2	14.1	15.2	13.9	24.4a
Vertical force to pull a taro hill, kg	45.2	–	48.2	44.8	–	48.5	45.7	47.6

Means in the same row and without or followed by the same letter are not significantly different (DLSD P=0.05).

Table 2. Effect of cultural methods on nutrient and protein content of flooded taro corms and cormels at 10 months

Nutrients (%)	Land Preparation			Plant Spacing			Planting Depth	
	Flat Culture		Ridge; height					
		13cm	26cm	20cm	30cm	40cm	8cm	14cm
N	0.65	0.54	0.50	0.56	0.57	0.57	0.55	0.57
P	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.11
K	0.27	0.28	0.25	0.25	0.27	0.27	0.26	0.28
Mg	0.07	0.06	0.06	0.07	0.06	0.07	0.06	0.07
Ca	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06
Na	0.11	0.10	0.09	0.10	0.10	0.09	0.10	0.10
Cl	0.15	0.12	0.11	0.13	0.12	0.13	0.13	0.13
Protein	4.08	3.35	3.11	3.48	3.54	3.54	3.44	3.59

Nutrients = Air dry weight basis; Protein = N x 6.25

Table 3. Influence of cultural methods on yield of flooded taro at 10 and 12 months

Yield Component	Land Preparation Method			Planting Depth	
	Flat Culture	Ridge	Ridge height		
		13cm	26cm	8cm	14cm
		TONS PER HECTARE			
			10 Months		
Corms	13.8	17.3	17.9	16.4	15.5
Cormels	27.7	30.7	26.2	28.5	27.9
Total Yield	41.5	48.0	44.1	44.9	43.4
			12 Months*		
Corms	16.9	19.3	17.9	18.2	17.9
Marketable cormels	35.7	40.2	40.1	37.3	40.0
Total cormels	38.5	43.0	42.6	40.4	42.4
Total Yield	55.4	62.3	60.5	58.6	60.3

*Analyzed statistically but not significant

Table 4. Effect of plant spacing on yeild of taro at 10 and 12 months

Yield Component	PLANT SPACING		
	100 x 20 cm	100 x 30	100 x 40
		ton/ha	
		10 Months*	
Corms	19.3	13.4	14.4
Cormels	28.9	28.9	26.2
		12 Months	
Corms	23.0a	17.5b	13.7c
Marketable cormels**	43.1a	38.3b	34.5b
Total cormels	46.4aa	41.3b	37.6b
Corms + Marketable cormels	66.0a a	55.6b	49.4c
Corms + Total cormels	69.4a	58.6b	51.4c

Means in the same row followed by the same letter are not significantly different (DLSD 5%)

*Not analyzed statistically

**Cormels that weigh over 32 grams each and that potentially can be sold fresh in the market.