MECHANIZATION OF TARO (*COLOCASIA ESCULENTA*) CULTURE IN HAWAII[1]

D.L. Plucknett, H.C. Ezumah and R.S. de la Pena*

SUMMARY

A modified management system to allow mechanization of taro in Hawaii has been studied. A seedling transplanter has been used successfully to plant taro setts in dry soil. To achieve this the soils were prepared by using a rotovator without puddling. After planting, the fields were flooded and managed in the traditional way. Two mechanical means of herbicide application show promise. A sweet protato/solanum potato digger can be used to harvest the crop. To allow mechanization, the entire management system must be reviewed and modified.

RESUME

Un système de mise en valeur modifié en vue de la mécanisation du tarot en Hawaï e été exposé. Une repiqueuse a été utilisée avec succés pour repiquer des boutures de tarot en sol sec. Pour entreprendre l'opération, le sol a été préparé à l'aide d'un rotovator sans mise en boue. Après le semis, les champs ont été submergés et entretenus selon le système traditionnel de culture. Les moyens mécanisés d'application d'herbicide sont encourageants. On peut utiliser une récolteuse de patate douce pour faire la récolte du tarot. Pour que la mécanisation soit possible, tout le système de mise en valeur doit être revue et modifié.

RESUMEN

Se ha estudiado un sistema modificado de manejo para hacer posible la mecanización de la malanga en Hawaii. Se ha usado exitósamente un transplantador de plantas para sembrar malanga en suelos secos; para lograrlo, se prepararon los suelos con "rotovator" sin humedecer. Después de la siembra se inundó el campo y se trabajó en la forma tradicional. Dos formas mecánicas de aplicar herbicidas se muestran prometedoras. Puede usarse una cosechadora de camote/papa para cosechar este cultivo. Se debería de revizar y modificar todo el sistema de manejo para permitir la mecanización.

INTRODUCTION

Taro (*Colocasia esculenta*) is an important crop in Hawaii[5,6]. Most of the corms are processed into poi, the paste-like staple food of the ancient Hawaiians. The crop is produced in flooded fields which are managed much like flooded rice (Fig. 1). Traditional taro production requires long hours of standing and working in mud and water. Therefore, in spite of the good income obtainable from growing taro, few young farmers are entering the industry. If taro production is to survive, the management system must, at least in part, be modified to mechanization. This work presented results from a grant by the State Legislature to the Hawaii Agricultural Experiment Station.

MECHANIZATION PROBLEMS IN FLOODED SOILS

Most mechanization problems are related to the practice of growing taro in small flooded fields[7]. Throughout most of the crop period the soil surface is covered with 2 to 10 cm of slowly moving water. Traditional land preparation consists of ploughing or harrowing and then puddling of the soil. The cuttings or setts (consisting of about 6 to 12 mm of the tip of the corm plus the lower 2o to 30 cm of the petioles) are then planted by hand in the soft mud. Plant populations range from about 12,000/ha (90 x 90 cm spacing) under high solar radiation. Weeds are controlled mainly by flooding and by hand pulling. Crop duration varies from 12 to 16 months or so. Harvesting is done by hand, using a pipe with a sharpened tip to loosen and pry the corms from the soil and to sever roots. Mud is washed from the corms which are separated from petioles and leaves, and the corms are then bagged for shipment to the processing plant.

The main hand labour requirements for taro culture occur during planting, weed control and harvesting. Of these tasks perhaps harvesting is most onerous and difficult. In our programme it was decided to examine mechanization possibilities in planting, weed control and harvesting.

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* D.L. Plucknett, H.C. Ezumah, R.S. de la Pena) University of Hawaii, Department of Agronomy and Soil Science, Honolulu, Hawaii 96822.

The major problem in mechanizing a flooded crop is obtaining 'trafficability' for the machines. Management studies to determine the effects of modifications in methods of irrigation, spacing and land preparation to allow machinery traffic have been conducted.[2] From these studies a modified management system for the crop was designed in order to obtain high yields while at the same time allowing mechanization. The studies showed that flood irrigation produced best taro growth and yields and that 90 cm row spacings could be used without loss in yield.

Trafficability depends upon how muddy the soil surface is. Under very muddy conditions most machines cannot obtain traction and may sink in the soft mud. Also, very close row spacings will not allow enough room for tractor wheels or tracks. An early question then arose: could we eliminate puddling of the soil? If so, could we then prepare the soil under relatively dry conditions, thereby allowing conventional tillage practices? One problem remained in this system: if we ploughed or disked the soil surface we could develop an uneven soil surface which would then need to be re-levelled. The solution, we believe, is to use a rotovator to prepare the soil; this machine can till fairly dry soil without leaving an uneven surface. After rotovating it would then be easy to use machines for planting and then to flood and manage the rest of the crop in the usual way.

MECHANICAL PLANTING OF TARO

We have purchased and tested one planting machine, a machine designed to transplant seedlings of tobacco or tomatoes.* This machine works well in fairly dry soil and required little modification to plant taro[3]. The major modification was to widen the furrow opener a little in order to handle large setts. The 3-point hitch transplanter has the following features: a furrow opener, two plant boxes in which the setts are carried, two seats for the men feeding the setts into the machine, pick-up trays upon which the plants are placed and a planting wheel which picks up the plants and releases them just behind the furrow opener and adjustable packing wheels.

The transplanter was tested for use in taro (Fig. 2). It was necessary to increase row width to 122 cm to allow use of the tractor without driving over previously planted rows. Plants were spaced 30 cm apart. The soil had been rotovated. Comparisons with hand planting showed that mechanical planting using two men to feed setts into the machine plus one tractor operator saved 59% of the time required to plant by hand in non-ridged plots (Table 1). When planted on ridges 62-68% of the hand planting labour requirement was saved by mechanical planting. The machine planted with few skips and achieved reasonably good spacing. The desired within-row spacing was 30 cm; the machine planted within a range of 27.5 to 37.5 cm, with a mean of 32.5 cm. It was concluded that the soil must be well prepared and well pulverized for best use of the transplanter. Under dry soil conditions the transplanter appears to be satisfactory for planting taro. Planting on ridges was not very successful since the ridges tend to be flattened during planting. If planting on ridges is desired, then we feel that it would be better to plant on a flat surface and then 'hill up' afterwards. Flooding after mechanical planting produced good crop growth (Fig. 3).

MECHANICAL AIDS FOR WEED CONTROL IN TARO

Until the present time nitrofen is the only herbicide which has been cleared by the U.S. Environmental Protection Agency for use in taro. However, several other herbicides have appeared to be promising and would work well if clearances can be obtained[5].

Nitrofen works well for weed control in flooded taro when it is injected into the irrigation water which flows into the paddy[1]. To ensure thorough and uniform coverage by the herbicide, an injection pump was constructed and calibrated to inject a known amount of herbicide into irrigation water. The water was pumped into a previously-drained paddy which had all outlets blocked to prevent drainage of the herbicide solution. This system provided excellent pre-emergence application of herbicides without spray injury to the vigorous, leafy, growing crop.

Another aid to weed control is still under study. A single row shielded sprayer* for application of post-emergence herbicides was purchased. This should be especially useful for upland or rainfed taro.

MECHANICAL HARVESTING

Taro yields under flooded culture can be very high[6]. The Hawaii state average in 1969 was 22.4 metric tons per ha. Some farmers obtain yields of 35 to 45 metric tons per ha. Harvesting and handling such yields in soft, deep mud can be difficult and tiring, and it is in this activity that real gains for the industry could be made if a successful mechanization system can be obtained.

*This machine was built by the Powell Manufacturing Co., Inc. Company or model names are used for the purpose of identification, and no endorsement to the exclusion of other similar equipment is intended.

Mechanical harvesting in the mud is most difficult, and it calls for light and specialized equipment. A commercial firm in Honolulu** has devised a twin horizontal auger attachment for a small Japanese rice paddy tractor as a harvesting aid in taro. This machine digs and windrows two rows of closely planted taro in standing water or mud. While this has been a major step in overcoming the labour requirement for loosening and digging the crop by hand, it also causes difficulty in gathering the loosened corms. In loosening and windrowing, this machine also mixed much mud with the corms, making pickup and cleaning of the corms very difficult. In order to assist in this problem our Department of Agricultural Engineering has designed a machine which can pick up the loosened corms from the windrow[8]. This system will require further study.

Our research group undertook the task of studying existing root crop machinery which might be used to harvest taro under fairly dry soil conditions. We purchased a commercial singlerow sweet potato/solanum potato harvester*** (Fig. 4). This 3-point hitch machine can be mounted on a conventional pneumatic-tyred or tracked farm tractor. It is equipped with a digging blade behind which is mounted an agitator chain to clean the roots before dropping them on the soil surface. The machine digs taro without difficulty in dry soils. In wet soils, however, problems arise which are related to movement of the tractor.

Ikehara and Hiroshige[4] compiled data on the labour requirements in taro production. They found that harvesting one hectare of taro under puddled flooded culture required about 850 man-hours.

A study was conducted using the commercial single-row sweet potato harvester in taro. Three large taro fields were subdivided into 26m x 16m plots. The three plots were treated as follows:

Plot A : ridges and land intermittently flooded. Flooding interval was under a week.

Plot B : ridged and flooded throughout growing season. The field was then drained six weeks before harvesting of corms.

Plot C : nonridged (flat); field flooded throughout experimental period. The field was also drained for six weeks before harvesting. The spacing used was 1.3m x 0.3m.

Time taken to harvest taro corms (digging and collection of corms) was recorded for each of the three sub-plots per field (A, B and C). Corm yields were generally low. Large portions of the field were attacked by *Phythophtora colocasiae* and incidence of *Pythium* corm rot was high. The poorest yield was obtained from the intermittently flooded plot, while continuously flooded plots, whether ridged or not, gave almost identical yields.

An average of 186 hours per hectare was required to harvest the flat, continuously flooded plot, while 139 and 122 hours per hectare were required for the intermittently flooded ridged and continuously flooded ridged plots, respectively. By using the harvester, only 14 to 22 percent of the time needed to harvest one hectare by hand was required (Table 2). The results indicated that ridging provided some advantages in mechanized harvesting.

We believe that this digging machine can be used satisfactorily if the soil is allowed to dry enough to allow tractor movement in the field. In one test in a flooded field using a small tractor equipped with tracks as the prime mover for this digging machine, we concluded that the machine worked well enough to justify mounting of the digger at the side of the tractor to permit harvesting of single rows without running over the rows. However, this modification has not been made.

FUTURE RESEARCH

Current plans call for study and refinement of the complete mechanization system. Fields must be prepared by rotovation, followed by mechanical planting. Row spacings will be wide (probably 120 cm or so) in order to accommodate the tractor. Some plots will be ridged in order to evaluate the effect of planting on ridges to facilitate harvesting. To obtain good yields, flooding or deep furrow irrigation will be used. Weed control will be effected through injection of herbicides in shielded, single-row sprayers. As harvest time approaches, irrigation will be terminated in order to dry the soil enough for tractor use. We believe that this system will be useful for those farmers whose soils will dry sufficiently to allow machinery movement.

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*, 'Uniro' Chemical Weeder, Allman Patents Ltd., Sussex, U.K.
** Rainbow Distributors, representing Iskeki Equipment Co., Japan.
***Darf one row potato digger, Darf Corp., Edison, N.C., U.S.A.

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TABLE 1

Man hours of labour required to plant one hectare of taro

Treatment	Planting by hand	Mechanically planted: Ridged	Over hand planting	Flat (non-ridged)	Time saved over hand planting
	hours	hours	%	hours	%
Ridged, flooded weekly	65.1	22.3	65.8	20.4	68.6
Ridged continually flooded	52.7	23.2	55.9	20.1	61.8
Flat (non-ridged) continually flooded	46.3	24.0	48.3	19.0	59.0
Average	54.7	23.1	56.6	63.1	63.1

TABLE 2

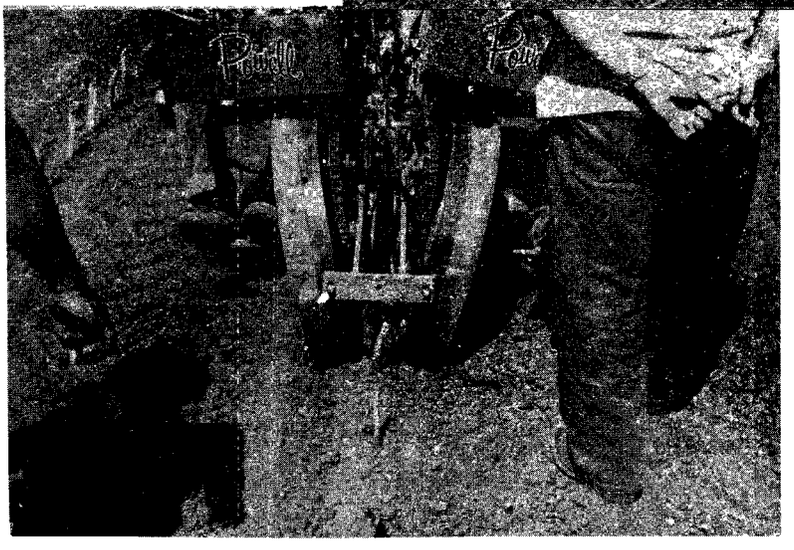
Yield and time required to harvest 1 hectare of taro using mechanical harvesting equipment

Field	Plot	Yield tons/ha	% of hand harvest*	Time (hrs/ha)
A	1	16.03		86
(Ridged flooded	2	17.03		159
weekly)	3	22.40		172
Average		18.49	16.3	139
B	1	36.02		77
(Ridged contin-	2	23.87		156
uously flooded)	3	31.81		133
Average		30.57	14.3	122
C				
(Flat	1	22.60		176
continuously	2	27.68		189
flooded)	3	37.05		193
Average		29.10	21.9	186

*Based on 851 man-hours per ha. requirement reported by Ikehara and Hiroshige[4].

Figure 1. *A taro farm on the island of Kauai. Most fields are irregular in shape and are bordered by earthen-dikes about 50-70 cm in height. Two flooded but unplanted fields can be seen on the right side.*

a.



b.

Figure 2. *Planting taro setts (huli) mechanically*
(a) Machine requires 3 men; 1 tractor operator and 2 men to place the setts on the pickup tray.
(b) Close up view of the planter from the rear. Planting wheel is just in front of the twin soil-packing wheels shown at the rear.

Figure 3. *This field was planted mechanically using the seedling transplanter. Row spacing was 122 cm. Spacing between plants was 30 cm. The setts were planted on ridges. After planting the field was kept flooded until harvest. At that time the soil was allowed to dry out and the crop was harvested mechanically using the potato digging machine.*

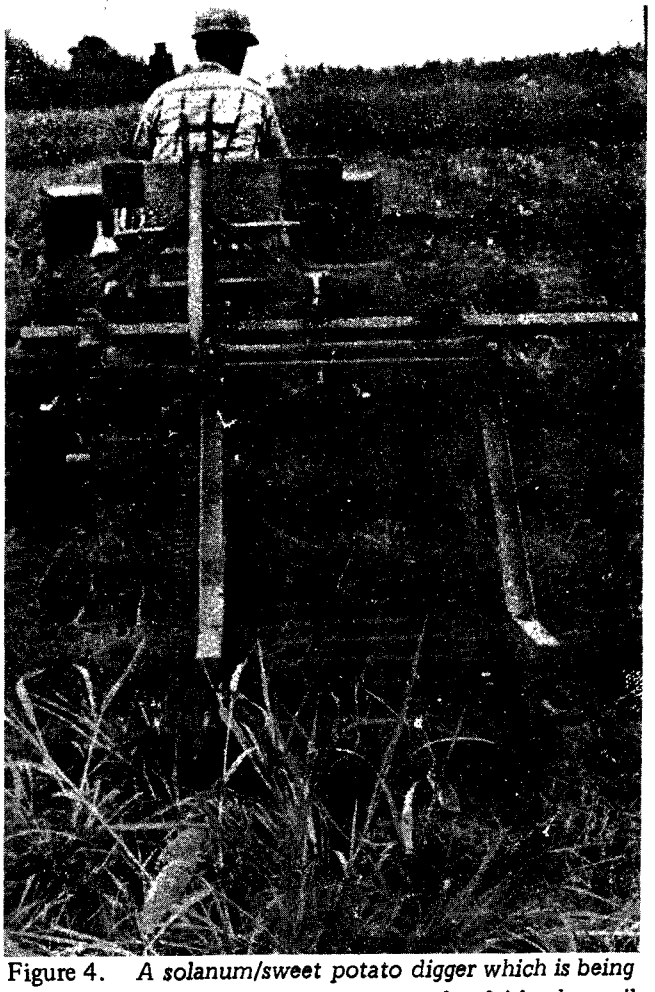


Figure 4. *A solanum/sweet potato digger which is being studied to harvest taro under fairly dry soil conditions. The corms are left on the soil surface, and must be picked up by hand or by mechanical means.*