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CASILLA, GERARD E. APRIL 2007. Shoot and Root Growth as Affected by the Number of Eyebuds on Yacon (*Smallanthus sonchifolius*) Offset and Growing Media. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted at Tuding Minac, Itogon, Benguet from August 2006 to October 2006 to determine the effect of the number of eyebuds in the root and shoot formation of yacon offsets grown in different growing media.

Based on the results of the study, yacon offsets with 5 eyebuds is the best planting material to use for yacon production; while the use of 1:1 sandyloam soil and alnus leaves compost is also recommended as growing media for faster growth of yacon plants since it promoted the production of the earliest roots and shoots from planting, promoted the production of the longest roots and the tallest shoots two months from planting.

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INTRODUCTION

The Andean region has been the cradle of a surprisingly wide range of edible tubers and roots. Most of them have been used by the Andean inhabitants as food energy, while two - ahipa *(Pachyrhizus ahipa)* and yacon *(Smallanthus sonchifolius)* have been considered 'fruits'. That perception is particularly strong in the case of yacon, which despite its juiciness and sweet taste, has been recognized as a food of relatively low energy value since the early times. In modern times however, the human view of yacon could be radically different from the past. Certainly, calories are still limited and critical in many regions of the earth. In contrast, on a global scale, sources of starch, glucose and fructose are comparatively common commodities, with relatively low prices, and are available to certain sectors of the human population in quantities well above their dietary requirements and even beyond their physiological tolerance. Under these conditions, yacon may provide the low calories and fiber necessary to survive the stress of sedentary lifestyles combined with over consumption of carbohydrates and fats (Robinson, 1978).

Gonzales (2001) cited that yacon is herbaceous plant that belongs to the Compositae family (sunflower family). Unlike its better-known cousin, the sunflower, it is grown mainly for its tubers and not for its seeds. The yacon plant is native to the Andes Mountains of South America, the longest mountain range in the world. It grows wild at medium altitudes (2,000-7,000 ft. above sea level) from Columbia to Argentina, but can be cultivated even at sea level.

Appell (2003), stated that the tubers are sweet, crunchy, and juicy, and they can be eaten fresh out of hand or stewed. They are wonderful when combined with a salad of raw carrots, raw sweet potatoes, or when sliced with bananas and oranges. The tubers taste sweeter when they are allowed to cure in the sun after harvesting a process called *ckochascca* in the Andes.

Several carbohydrates are stored in the roots of yacon: fructose, glucose, sucrose, low polymerization degree (DP) oligosaccharides (DP 3 to 10 fructans), and traces of starch and inulin. However, yacon inulin appears to be only a minor component (Asami *et al.*, 1989).

In Ecuador, yacon roots are especially consumed during the 'Todos los Santos' or 'Day of the Dead' festivals (National Research Council, 1989). These current practices may indicate old religious values, modified after the advent of the Catholic religion. In Bolivia diabetics and persons suffering from digestive problems commonly consume yacon. Properties to treat kidney problems and skin-rejuvenating activity also have been mentioned. Medicinal (antidiabetic) properties have been attributed to yacon leaves (Kakihara *et al.* 1996) in Brazil, where the dried leaves are used to prepare a medicinal tea. Dried yacon leaves are used in Japan mixed with common tealeaves. Hypoglycemic activity has been demonstrated in the water extract of dried yacon leaves, feed on rats with induced diabetes (Volpato *et al.*, 1997). All yacon carbohydrates including oligofructans can be rapidly metabolized by ruminants, so tuberous roots can be used to feed cattle or sheep. The foliage, with a protein content of 11-17% (dry weight basis) has been suggested as forage (National Research Council, 1989).

The study was conducted to determine the effect of the number of eyebuds present in yacon offsets before planting and growing media in the growth of shoots and roots.

The study was conducted at Minac, Itogon Benguet from August 2006 to October 2006.

REVIEW OF LITERATURE

Morphological Description of Yacon

The yacon is a perennial herb, 1.5-3 m tall. The root system is composed of 4-20 fleshy tuberous storage roots that can reach a length of 25 cm by 10 cm in diameter, and an extensive system of thin fibrous roots. Storage roots are mainly-fusiform, but often acquire irregular shapes due to the contact with soil stones or the pressure of neighboring roots. Roots have an adventitious nature, growing from a developed and ramified stem system formed by short, thick sympodial rhizomes or rootstock (‘corona’, crown), (Robinson, 1978). Endemic to the Andes, yacon is cultivated on the mountain slopes at approximately 2000 meters over the sea level. It is an herbaceous plant that grows to up to 2m in height; spongy stem with purple projections; small, terminal, yellow to orange-colored flowers; large, long tuberous roots with sweet flesh. Peru has the greatest number of varieties, and is the world’s biggest producer with an estimated 1,480 acres under cultivation (Silva *et al*., 2002).

Yacon is native to Colombia and Ecuador and is a hardy, attractive herbaceous perennial that yields a large harvest of tubers. It is always a bit tricky describing the taste of a new food as we are forced to compare it to familiar foods but generally it gets a very positive response, especially from children. As a member of the sunflower family, yacon can grow to 2 meters in height with small, daisy-like yellow flowers. When growing it is similar in appearance to Jerusalem artichokes but is not invasive in the same way (Frances and Jeff Michaels, 2001).

Reproductive Biology

Rather than starting from seed, which is evidently quite difficult, propagate yacon plants from dividing the "crown", a ginger-like root structure from which the edible tubers emanate. This is done much in the same way that potatoes can be divided, with each new sprout emerging from an "eye" or by rooting cut stems. The crown divisions are generally planted in a rich soil (Vlaun, 2004).

According to Christman (2006), after flowering, the yacon plant dies back to the ground for a rest period during the dry season and the tubers are usually harvested then. Harvest the tubers after the plant dies to the ground by groping around with your hands under the plant; don't disturb the main roots because the plant will come back and produce more tubers.

Uses of Yacon

Yacon has attracted interest of medical researchers, particularly in Japan. Dieters and diabetics can accept yacon as a sweet and starchy without affecting the blood sugar level. Japanese scientists and food industries are studying yacon as a source for purified fructose and a variety of processed products such as pickled slices and dried slices. The leaves and stems are dried and used as a medicinal tea for diabetics. The effects Yacon tea to reduce the blood sugar level has been confirmed by Japanese researchers. Eating oligofructose improves health of intestine because of the bifidus bacteria (beneficial) in the colon are stimulated. Yacon is commonly consumed by diabetics and persons suffering from digestive problems. It has properties that treat kidney problems and skin-rejuvenating activities also have been mentioned. Medicinal (antidiabetic) properties have been attributed to yacon leaves (Kakihara *et al*., 1996). The dried leaves are used to prepare a medicinal tea. Dried yacon leaves are used in Japan mixed with common tealeaves. Hypoglycemic activity has been demonstrated in the water extract of dried yacon leaves, feeding rats with induced diabetes (Volpato *et al*., 1997).

When the roots are exposed to the sun for 15 days, the concentration of sugar greatly increases. In 100g of fresh roots, fructose increased from 2 to 22g; alpha glucose from 2 to 7g; beta glucose from 2 to 6g and sucrose from 2 to 4g. These sugars are similar to insulin. As can be done with sugar cane, the sugars of Yacon can be made into blocks. In addition, these sugars can be changed into alcohol and used in the agro-industrial sector.

Furthermore, Yacon has extensive agricultural potential because it is a perennial species; consequently, it can be used to protect the soil from erosion, especially in dry agro-ecological area. In spite of its sweetness Yacon will not contribute to gaining weight as the human organism cannot metabolize the sugar contained in the root. This is a very important argument for people suffering diabetes and gives an outlook on the tremendous market chances for yacon as a substitute for regular sugar, made for instance from cane or other sources.

They are eaten raw, usually after being dried in the sun, which increases their sweetness, by partly hydrolyzing oligofructans, producing fructose, glucose and sucrose. Drying wrinkles the skin, which is peeled before eating. The roots can also be stewed or can be grated and squeezed through a cloth to produce a drink. Consumption of yacon in some areas is linked to particular cultural or religious festivals.

The impact of Yacon on a healthy intestine environment is of vital importance to health depends to a large extent on a sound digestive system. Yacon strengthens and activates the good bacilli like *L. acidophilus* and *B.bifidum,* as both uses Yacon as a carbon source for their growth. These two bacilli provide vitamin B, enzymes and vital acids. The healthy intestine environment with its fragile flora is the condition for your overall health, your personal appearance and your immune system. Yacon also contributes to your body's capacity to regulate lipidic levels and that the risk of cancer can be reduced.

According to Dr. H Brams, as cited by Robinson (1978), said that yacon roots themselves had not been proven to have the same palliative effect as the leaves. Even so, yacon is now popularly associated in Peru with diabetes, though other benefits such as its laxative quality and ability to help prevent colon cancer and osteoporosis are less well known.

Cultivation Details

For best results, this plant requires a warm position in deep rich soil though it survives even when growing in poor soils. Plants are unaffected by day length and so can produce good yields of roots in temperate zones. The roots are brittle and it must be harvested with care to avoid damage, yields of 38 tons per hectare have been recorded in South America, while yield of over 2 kilos per plant have been achieved outdoors in corn wall. The harvested roots can be stored for several months. Plants might be use full in Agroforestry because they succeed under trees, though in the relatively sunless climates of Britain the plants are not likely to do well in shaded trees (Nederpelt, 2003).

MATERIALS AND METHODS

Materials

The materials used were yacon offsets, knife, plastic pots, sandy loam soil, mountain soil, 1:1 sandy loam soil and composted alnus leaves labeling materials and farm tools.

Methods

Yacon offset were propagated by dividing the "crown", a ginger-like root structure from which the edible tubers emanate. This was done in the same manner in which potato tubers are divided, with each new sprout emerging from an "eye." The crown divisions were planted in different growing media in a 6 inch black plastic bags. There were five samples per treatment combination with three replications. The experiment was laid out following the simple CRD experimental design.

The yacon offsets were sliced according to the following treatments:

Factor A. Growing Media

M_0 = Sandy loam soil

M_1 = Mountain soil

M_2 = 1: 1 Sandy loam + alnus leaves compost

Factor B. Number of Eyebuds in Yacon Offset

T_1 = Offset with one bud

T_2 = Offset with two buds

T_3 = Offset with three buds

T_4 = Offset with four buds

T_5 = Offset with five buds

All the recommended cultural practices in yacon production were done in all of the treatments.

The data gathered were as follows:

1. Days from planting to initial root formation. This was obtained by counting the number of days from planting to root formation (1cm root size).

2. Days from planting to shoot emergence. This was obtained by counting the number of days from planting to shoot formation.

3. Number of roots per offset. The number of roots formed was counted and recorded two months after planting the offset.

4. Length of roots (cm). This was measured from the basal portion of the tuber to the tip of the longest root two months from planting.

5. Length of shoots (cm). This was measured from the base of the plant to the tip of the longest shoot, two months after planting.

6. Number of shoots formed per plant. The number of shoots formed was counted and recorded two months after planting.

7. Documentation. This was taken through pictures of the study.

RESULTS AND DISCUSSION

Number of Days from Planting
to Initial Root Formation

Effect of growing media. Results show that yacon offset planted in 1:1 sandy loam + alnus leaves compost had the earliest root initials observed from planting date with a mean of 12.86 days which was significantly different from the offsets planted in sandy loam soil and mountain soil. Yacon offsets planted in both sandy loam soil and mountain soil had significantly delayed root formation with means 15.00 and 14.53 days respectively; from planting as shown in Table 1.

Effect of number of eyebuds in offset. Table 1 shows that offsets with 5 eyebuds had the shortest days from planting to initial root formation with a mean of 12.33 days which was significantly different from offsets with 4 and 2 eye buds which had a means of 13.22 and 13.77 days respectively from planting to root initiation However, they were both statistically comparable with offsets which had only 2 eye buds which had root initials after 13.77 days from planting the offsets. Offsets with 3 eye buds had the longest duration to form root initials with 15.88 days but were statistically similar to offsets with only 1 eyebud which had root initials after a mean of 15.44 days.

Interaction effect. There were no significant interaction effects between the different growing media used and the number of eye buds in the offset before planting with regards to the number of days from planting to initial root formation.

Table 1. Days from planting to initial root formation

TREATMENT	MEAN (Days)
Growing Media	
Sandy loam soil	14.53[a]
Mountain soil	15.00[a]
1:1 Sandy loam soil and alnus leaves compost	12.86[b]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	15.14[ab]
Offset with 2 eyebuds	13.77[bc]
Offset with 3 eyebuds	15.88[a]
Offset with 4 eyebuds	13.22[c]
Offset with 5 eyebuds	12.33[c]

Means with the same letter are not significantly different at 5% level by DMRT

Days From Planting to Shoot Emergence

Effect of growing media. The effect of the different kinds of growing media on the number of days from planting to shoot emergence is shown in Table 2. Results show that yacon offsets planted in 1:1 sandy loam + alnus leaves compost were the earliest to have shoots emerged from the soil with a mean of 9.80 days from planting which was significantly different from offsets planted in a sandy loam soil only with a mean of 10.46 days. Offsets grown in mountain soil only had the longest duration to form shoots with a mean of 11.80 days from planting date.

Effect of number of eyebuds in offset. Offsets with 5 eyebuds were the earliest to have shoot emergence with a mean of 9.11 days but was comparable from offsets with 4 eyebuds and 2 eyebuds with means of 9.66 and 10.33 days; respectively. However, they were statistically comparable with offsets with only 1 eyebud which had shoot emergence

Table 2. Days from planting to shoot formation

TREATMENT	MEAN (Days)
Growing Media	
Sandy loam soil	10.47[ab]
Mountain soil	11.80[a]
1:1 Sandy loam soil and alnus leaves compost	9.00[b]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	12.11[a]
Offset with 2 eyebuds	10.33[b]
Offset with 3 eyebuds	12.22[a]
Offset with 4 eyebuds	9.67[b]
Offset with 5 eyebuds	9.11[b]

Means with the same letter are not significantly different at 5% level by DMRT

after 12.11 days and was statistically comparable with those with 1 eyebud and the offset with a mean of 12.22 days (Table 2).

Interaction effect. There were no significant interaction effect between the different growing media used and the number of eyebuds in the offset before planting with regards to the number of days from planting to initial shoot formation.

Number of Roots Per Offset

Effect of growing media. Yacon offsets planted in 1:1 sandy loam + alnus leaves compost had more number of roots formed with a mean of 10.80 days however, it was not significantly different from offsets planted in a sandy loam soil and mountain soil only. Yacon offsets planted in both sandy loam soil and mountain soil had almost similar number of short roots with means of 10.00 and 10.80 days; respectively.

Table 3. Number of roots per offset

TREATMENT	MEAN
Growing Media	
Sandy loam soil	10.00[a]
Mountain soil	9.00[a]
1:1 Sandy loam soil and alnus leaves compost	10.80[a]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	7.77[c]
Offset with 2 eyebuds	10.00[b]
Offset with 3 eyebuds	9.66[bc]
Offset with 4 eyebuds	12.11[a]
Offset with 5 eyebuds	11.44[ab]

Means with the same letter are not significantly different at 5% level by DMRT

Effect of number of eyebuds in offset. Offsets with 4 eyebuds had more roots with a mean of 12.11 which was significantly different from offsets with 5 eyebuds which had a mean of 11.44 roots but was significantly different from offsets with 1, 2 and 3 eyebuds which had means ranging from 9.66 to 10.00 roots per offset (Table 3).

Interaction effect. There were no significant interaction effects between the different growing media used and the numbers of eye buds in the offset before planting with regards to the number of roots formed per plant.

Length of Roots

Effect of growing media. Yacon offset planted in 1:1 sandy loam + alnus leaves compost had the longest roots formed from planting date with a mean of 20.06 days from planting which was significantly different from offsets planted in sandy loam and in mountain soil only which had significantly shorter roots with means of 10.20 and 9.33 cm; respectively in (Table 4).

Table 4. Length of roots

TREATMENT	MEAN (cm)
Growing media	
Sandy loam soil	10.20[b]
Mountain soil	9.33[b]
1:1 Sandy loam soil and alnus leaves compost	20.06[a]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	11.77[a]
Offset with 2 eyebuds	12.77[a]
Offset with 3 eyebuds	12.88[a]
Offset with 4 eyebuds	12.66[a]
Offset with 5 eyebuds	15.88[a]

Means with the same letter are not significantly different at 5% level by DMRT

Effect of number of eyebuds in offset. Table 4 shows that there were no significant differences noted on the number of eyebuds in the offset before planting in the root length in yacon 60 days after planting. Root length varies from 11.77 to 15.88 cm days from planting.

Interaction effect. There were no significant interaction effects noted between the different growing media used and the number of eyebuds in the offsets before planting on the length of roots two months from planting.

Length of Shoots

Effect of growing media. Table 5 shows that there were no significant differences on the length of shoots measured 60 days from planting the yacon offsets. Means ranged from 1.26 to 1.80 cm.

Table 5. Length of shoots

TREAMENT	MEAN (cm)
Growing media	
Sandy loam soil	1.60[a]
Mountain soil	1.26[a]
1:1 Sandy loam soil and alnus leaves compost	1.80[a]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	1.00[c]
Offset with 2 eyebuds	1.33[bc]
Offset with 3 eyebuds	1.66[ab]
Offset with 4 eyebuds	1.77[ab]
Offset with 5 eyebuds	2.00[a]

Means with the same letter are not significantly different at 5% level by DMRT

Effect of number of eyebuds in offset. Significant differences on the length shoots of yacon offsets after 2 months of observations was noted as affected by the number of eyebuds. It was observed that offsets with 5 eyebuds had the longest shoots with a mean of 2.00 cm followed by offsets with 4 and 3 eyebuds with means of 1.77 and 1.66 cm respectively; which were not significantly different from offsets with 2 and 1 eyebuds. Means were 1.33 and 1.00 cm; respectively.

Interaction effect. Again, there were no significant interaction effects noted between the different growing media used and the numbers of eyebuds in the offset before planting on the length of shoots 60 days from planting.

Number of Shoots Formed Per Plant

Effect of growing media. Results show that yacon offsets planted in 1:1 sandy loam soil + alnus leaves compost had significantly more shoots formed 60 days from planting date with a mean of 46.69 shoots per plant. Those grown in sandy loam had more shoots than those grown in mountain soil; means were 15.71 and 6.43 shoots per plant; respectively

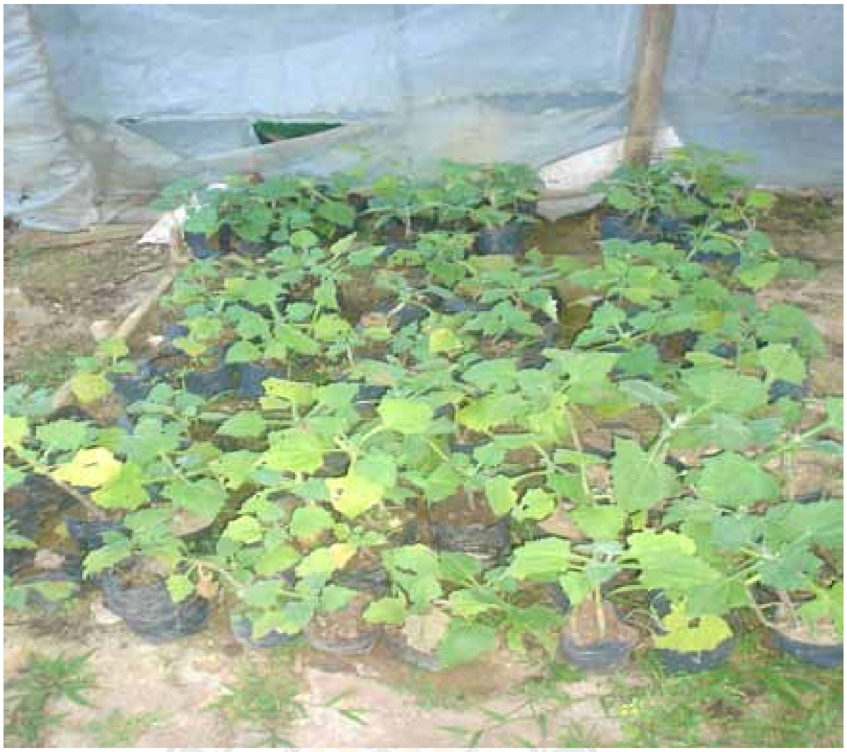
Effect of number of eyebuds in offset. Table 6 shows that offsets with 3, 4 and 5 eyebuds produced the highest number of shoots with means of 30.43, 25.82 and 23.28 shoots per plant respectively. Offsets with 2 eyebuds were comparable in the number of shoots formed 60 days from planting with those with only 1 eyebud per offset; means were 21.86 and 13.31 shoots; respectively.

Interaction effect. There were no significant interaction effects between the different growing media used and the number of eyebuds in the offset before planting on the number of shoots 60 days from planting of the offsets.

Table 6. Number of shoots formed

TREATMENT	MEAN (Number)
Growing media	
Sandy loam soil	15.71[b]
Mountain soil	6.43[c]
1:1 Sandy loam soil and alnus leaves compost	46.69[a]
Number of Eyebuds in the Offset	
Offset with 1 eyebud	13.31[b]
Offset with 2 eyebuds	21.86[ab]
Offset with 3 eyebuds	23.28[a]
Offset with 4 eyebuds	25.82[a]
Offset with 5 eyebuds	30.43[a]

Means with the same letter are not significantly different at 5% level by DMRT a)



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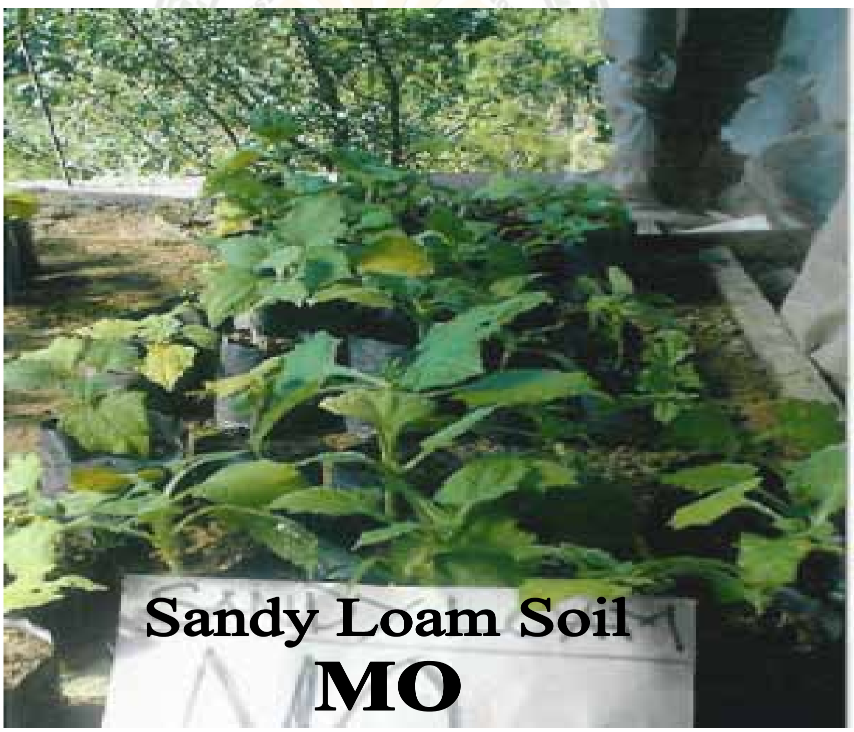

Figure 1. a.) Overview of the study two months from planting
b.) Two months old yacon seedlings grown in sandy loam soil only (control)

a)

b)

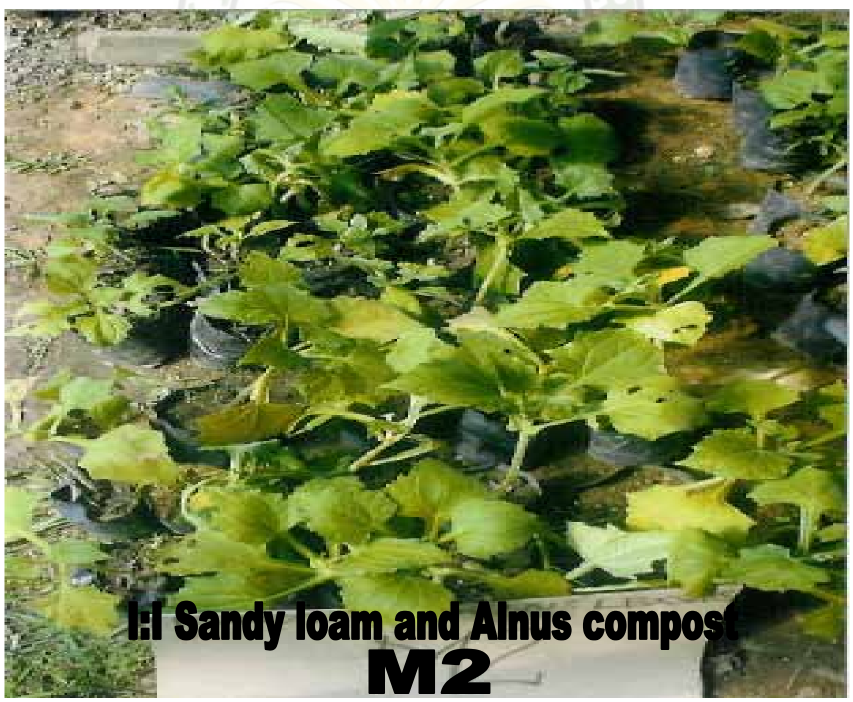

Figure 2 a.) Two months old yacon seedlings grown in mountain soil
b) 1:1 Two months old yacon seedlings grown in sandy loam and alnus leaves compost

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

This study was conducted at Tuding, Minac, Itogon Benguet from August to October, 2006 to evaluate the effects of the number of eyebuds in the offset before planting; and determine the growing media that will promote vigorous root and shoot growth on yacon offsets.

Yacon offsets were cut according to their respective number of eyebuds. All the different eyebuds were rooted directly in sandyloam, mountain soil and 1:1 sandyloam soil and composted alnus leaves medium.

Results show that yacon offsets with 5 eyebuds that were directly planted in a 1:1 sandyloam soil and composted alnus leaves media were the earliest to form initial roots after of 12.86 days, were the earliest to have shoot emergence after 9.11 days, had more roots formed per offset with a mean of 11.44, had the longest roots formed from planting with a mean of 20.06 cm and had more shoots formed with a mean of 46.69 days after planting.

Conclusion

Based on the results of the study, yacon offsets with 5 eyebuds is the best planting materials to use with 1:1 sandyloam soil and alnus leaves compost as growing media for faster growth in yacon plants since it promoted the production of the earliest roots and shoots from planting, promoted the production of the longest roots, and tallest shoots two months from planting.

Recommendation

In using yacon offset for commercial yacon production, offsets with 5 or more eyebuds is recommended to be planted in a 1:1 sandy loam soil and alnus leaves compost for earlier root and shoot formation, longer roots and taller plants with more shoots.

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APPENDICES

APPENDIX TABLE 1. Days from planting to shoot emergence

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
S_0P_1	9	14	12	35	11
S_0P_2	9	13	14	36	12
S_0P_3	8	13	10	31	10
S_0P_4	10	18	9	24	9
S_0P_5	8	7	10	25	8
S_1P_6	13	14	11	35	12
S_1P_7	12	8	10	30	10
S_1P_8	16	12	11	39	13
S_1P_9	8	12	14	34	11
S_1P_{10}	10	9	8	27	9
S_2P_{11}	10	12	14	36	12
S_2P_{12}	10	11	9	30	10
S_2P_{12}	8	13	11	32	10
S_2P_{14}	9	10	8	27	9
S_2P_{15}	9	8	6	23	7

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	11	12	10	9	8	50	10
S_1	12	10	13	11	9	55	11
S_2	12	10	10	9	7	48	9.6
TOTAL	35	32	33	29	24	153	
MEAN	11.66	10.66	11	9.66	8		10.2

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F	
					0.05	0.01
Treatment						
A	2	37.733	18.867	5.4774**	3.32	5.39
B	4	80.978	20.244	5.8774**	2.69	4.02
A x B	8	25.156	3.144	0.9129ns	2.27	3.17
Error	30	103.333	3.444			
TOTAL	44	247.200				

** = highly significant
ns = not significant

CV = 13.13%

APPENDIX TABLE 2. Days from planting to initial root formation

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
S_0P_1	12	17	13	42	14
S_0P_2	16	15	17	48	16
S_0P_3	15	13	12	40	13
S_0P_4	14	11	12	37	12
S_0P_5	13	14	17	44	14
S_1P_6	16	14	14	44	15
S_1P_7	15	11	17	43	14
S_1P_8	19	15	14	48	16
S_1P_9	14	15	11	40	13
S_1P_{10}	13	12	11	36	12
S_2P_{11}	13	17	13	45	15
S_2P_{12}	12	14	13	39	13
S_2P_{12}	12	14	13	40	13
S_2P_{14}	13	13	11	38	12
S_2P_{15}	11	11	12	34	11

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	14	16	13	12	14	69	13.8
S_1	15	14	16	13	12	70	14
S_2	15	13	13	12	11	64	12.8
TOTAL	44	43	42	37	37	203	
MEAN	14.66	14.33	14	12.33	12.33		13.53

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F	
					0.05	0.01
Treatment						
A	2	31.111	15.556	4.6667*	3.32	5.39
B	4	72.311	18.078	5.4233**	2.69	4.02
A x B	8	16.222	2.028	0.6083ns	2.27	3.17
Error	30	100.000	3.333			
TOTAL	44	219.644				

* = significant

** = highly significant

ns = not significant

CV = 17.08%

APPENDIX TABLE 3. Number of roots per offset

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
S_0P_1	7	10	7	24	8
S_0P_2	12	11	7	30	10
S_0P_3	7	6	12	26	9
S_0P_4	12	8	13	33	11
S_0P_5	12	14	12	37	12
S_1P_6	6	8	8	22	7
S_1P_7	8	10	13	31	10
S_1P_8	14	10	8	32	11
S_1P_9	12	11	14	37	12
S_1P_{10}	10	8	7	25	8
S_2P_{11}	7	9	8	24	8
S_2P_{12}	12	8	9	29	9
S_2P_{12}	8	10	12	30	10
S_2P_{14}	13	12	14	39	13
S_2P_{15}	14	13	13	40	13

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	8	10	9	11	12	50	10
S_1	7	10	11	12	8	48	9.6
S_2	8	9	10	13	13	53	10.6
TOTAL	23	29	30	36	33	151	
MEAN	7.66	9.66	10	12	11		16.66

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F 0.05	Tabular F 0.01
Treatment						
A	2	8.400	4.200	1.0328^{ns}	3.32	5.39
B	4	102.533	25.633	6.3033**	2.69	4.02
A x B	8	52.267	6.533	1.6066^{ns}	2.27	3.17
Error	30	122.000	4.067			
TOTAL	44	285.200				

** = highly significant

^{ns} = not significant

CV = 19.77%

APPENDIX TABLE 4. Length of roots per offset

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
S_0P_1	7	8	7	20	7
S_0P_2	12	11	7	30	10
S_0P_3	7	6	12	26	9
S_0P_4	13	8	14	33	11
S_0P_5	11	14	11	36	12
S_1P_6	6	8	8	22	7
S_1P_7	8	14	10	32	11
S_1P_8	8	12	8	28	9
S_1P_9	7	11	9	26	8
S_1P_{10}	12	9	10	31	10
S_2P_{11}	16	14	32	53	18
S_2P_{12}	16	20	56	92	19
S_2P_{12}	22	24	17	63	21
S_2P_{14}	13	19	20	52	17
S_2P_{15}	21	26	24	71	23

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	7	10	9	11	12	49	9.8
S_1	7	11	9	8	10	45	9
S_2	18	19	21	17	23	98	19.6
TOTAL	32	40	39	36	45	128	
MEAN	10.66	13.33	13	12	15		12.8

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F 0.05	Tabular F 0.01
Treatment		1066.533	533.267			
A	2	88.311	22.078	41.6615**	3.32	5.39
B	4	92.356	11.544	1.7248ns	2.69	4.02
A x B	8	384.000	12.800	0.9129ns	2.27	3.17
Error	30					
TOTAL	44	1631.200				

** = highly significant
ns = not significant

CV = 27.10%

APPENDIX TABLE 5. Length of shoot per offset

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
S_0P_1	9.13	10.57	9.87	29.07	9.85
S_0P_2	11.9	30.50	12.32	54.72	18.24
S_0P_3	14.7	12.58	14.63	41.91	13.97
S_0P_4	16.9	18.43	19.42	54.75	18.25
S_0P_5	18.83	18.85	15.13	52.81	17.60
S_1P_6	14.30	2.68	3.74	20.72	6.90
S_1P_7	5.50	3.46	7.18	26.14	8.71
S_1P_8	5.48	6.00	6.42	17.90	5.96
S_1P_9	6.10	5.60	5.32	17.02	5.67
S_1P_{10}	8.32	8.42	7.94	24.68	8.22
S_2P_{11}	20.40	28.18	21.00	69.58	23.19
S_2P_{12}	42.10	46.46	46.42	134.98	44.99
S_2P_{12}	66.48	10.94	58.44	137.86	49.95
S_2P_{14}	48.14	50.44	56.38	198.52	66.17
S_2P_{15}	70.24	58.44	74.38	203.06	67.68

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	9.85	18.24	13.97	18.25	17.60	77.91	15.58
S_1	6.90	8.71	5.96	5.67	8.22	35.46	7.09
S_2	23.19	44.99	49.95	66.17	67.68	251.98	50.39
TOTAL	39.94	31.94	69.88	90.09	160.80	410.89	
MEAN	13.31	10.64	23.29	30.03	53.60		24.35

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F 0.05	Tabular F 0.01
Treatment						
A	2	2.178	1.089	2.7222[ns]	3.32	5.39
B	4	5.556	1.389	3.4722*	2.69	4.02
A x B	8	3.378	0.422	1.0556[ns]	2.27	3.17
Error	30	12.000	0.400			
TOTAL	44	23.111				

* = significant
[ns] = not significant

CV = 40.66%

APPENDIX TABLE 6. Number of shoots per offset

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
S_0P_1	1	1	1	3	1
S_0P_2	1	1	2	4	1
S_0P_3	1	2	2	5	2
S_0P_4	1	3	2	6	2
S_0P_5	1	3	3	7	7
S_1P_6	1	1	1	3	1
S_1P_7	1	2	1	4	1
S_1P_8	1	1	1	5	1
S_1P_9	3	1	1	3	1
S_1P_{10}	1	1	1	3	1
S_2P_{11}	1	1	1	3	1
S_2P_{12}	1	1	2	4	1
S_2P_{13}	1	3	2	5	1
S_2P_{14}	3	2	2	7	2
S_2P_{15}	3	2	1	6	2

TWO-WAY TABLE

TREATMENT	P_1	P_2	P_3	P_4	P_5	TOTAL	MEAN
S_0	1	1	2	2	7	13	2.6
S_1	1	1	1	1	1	5	1.6
S_2	1	1	1	2	2	7	1.4
TOTAL	3	3	4	5	10	25	
MEAN	1	1	1.3	1.6	3.3		1.64

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Tabular F	
					0.05	0.01
Treatment						
A	2	13336.085	6668.042	81.6532**	3.32	5.39
B	4	1425.728	356.432	4.3647**	2.69	4.02
A x B	8	1808.886	226.111	2.7688*	2.27	3.17
Error	30	2449.890	81.663			
TOTAL	44	19020.589				

** = highly significant
* = significant

CV = 39.38%