

Response of Different Seedlings to Growth and Yield in Yacon

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ABSTRACT : The seedlings of yacon (*Polymnia sonchifolia* Poeppig & Endlicher), which were cuttings, plug seedling (PS), crown bud before sprouting (CBBS), crown bud after sprouting (CBAS), and divided seedling after budding (DSAB) were planted at 70×50 cm planting distance on ridge; that was interrow spacing narrower spacing, and about 28,500±71 plants/ha. CBBS didn't need work and equipment to raise seedlings. PS and DSAB grew taller to 140.5 and 143.3 cm, respectively, than others at 150 days after planting. In the changes of plant height, PS and DSAB showed taller than others during growth period, cuttings, CBBS, and CBAS grew rapidly in middle growth stage. Excepting main stem and petiole length, other characters were significant for seedling. Fresh weights were different among seedlings. Even though the yield of plants grown from CBAS and CBBS were lower with 34.7 and 36.4 ton/ha, respectively, than 3.6 ton/ha of DSAB; its yield index were over 95%, hence, those of plants grown from cutting and PS were lower with 73 and 87%, respectively. The ratio of tuberous roots over 200 g to total tuberous roots per plant was the highest from DSAB. Most of tuberous roots were under 200 g per tuberous root from cuttings. CBBS, CBAS, and DSAB are suitable to use seedlings for high yield of yacon. Yacon plant by DSAB much produced tuberous root of over 200 g.

Keywords : yacon, cutting, budding, sprouting, plug seedling, tuberous root, growth, yield

Yacon (*Polymnia sonchifolia* Poeppig & Endlicher) is often cultivated for its edible root in South America. Recently, some researchers studied its cultivation, using and various fields after import from New Zealand to Japan 15 years ago (Asami *et al.*, 1991, 1992; Ohyama *et al.*, 1990; Tsukihashi *et al.*, 1996). It is concerned about cultivation and use of yacon, cultivation area is expanding by some farmers in Korea.

Yacon, a root vegetable, when eaten uncooked, is very crunchy, watery to translucent, and sweet. Any attempt to

improve or develop these plants further is being undertaken by private individuals in New Zealand (Hewett, 1992). Yacon is a vigorous herbaceous perennial related to the sunflower, it grows to 2 meters tall, extremely hardy and will grow in hot or cold conditions. Yacon plant produces large tuberous roots, which look similar to sweet potatoes but have a crunchier juicier flesh; hence their nickname is apple of the earth.

Yacon plant has dark yellow flower, but it hardly bears fruits and differs from sunflower and Jerusalem artichoke. So, it has been propagated by vegetative organ named crown bud in general. Doo *et al.* (1998a, b) reported some propagation methods such as cutting, sprouting, and plug seedling. Hence, Sgeno (1989) suggested that propagation methods of yacon were cutting and division, and its yields were 0.67 and 2.4 kg/plant.

A vegetative plant is propagated by tuber commonly, it multiplies as high efficiency and a part of crops is overwintering (David *et al.*, 1986; Vanstone & Chubey, 1978; Lim & Lee, 1983; Mondoza, 1984; Wyse & Wilfahet, 1982). Seedlings are various besides cutting and division. This study was carried out to investigate the growth and yield according to raising methods for seedlings.

MATERIALS AND METHODS

Plant materials and experimental field

Crown buds of yacon (*Polymnia sonchifolia* Poeppig & Endlicher) were obtained from the National Crop Experiment Station, Rural Development Administration in 1994, and were propagated by planting crown buds on the nursery field at the Chonbuk National University on April. In early November, the harvested crown buds from the nursery fields were stored in the chamber which was maintained at 10±1 °C and with dark condition. These were used for this study on March.

The experiment was conducted at Samcheon-dong in Jeonju, Korea. The physico-chemical properties of the topsoil (0 to 15 cm) were measured before experiments. pH

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Table 1. Physico-chemical properties of the soil in present experimental field.

pH	OM	P ₂ O ₅	Exchangeable cations			CEC	EC	Particle size distribution			Soil class
			Ca	Mg	K			Sand	Silt	Clay	
	(%)	(ppm)	------(me/100 g)-----				(dS/m)	------(%)-----			
6.1	7.3	190	5.6	2.0	1.72	19.20	0.45	45.5	32.5	22.0	Loam

was slightly acid. Contents of organic material was 7.3%, which was more about 3.6 times than mean of upland in Korea (Cho *et al.*, 1992). Phosphate was 190 ppm, which was more about 1.7 times than common upland. Exchangeable Ca, Mg, and K contents were 5.6, 2.0, and 19.2 me/100 g, respectively. Soil was classified into loam (Table 1). Physico-chemical properties were suitable to cultivate yacon. Experiment was conducted a randomized block design with three replications.

Raising of seedlings

Cutting, plug seedling (PS), crown bud before sprouting (CBBS), crown bud after sprouting (CBAS) and divided seedling after budding (DSAB) were planted. Cuttings were obtained from about 15 cm tall seedlings in green house covered with polyethylene film, and then were rooted after 100 ppm NAA treatment (Doo *et al.*, 1998a). PS is obtained by Doo *et al.* (1998b)'s method. CBBS and CBAS were planted directly in experimental field; only difference between both is sprouting in heating chamber. DSAB was divided about 10 cm tall from crown buds after budding in green house covered with polyethylene film, when this time. those were planted during 7~10 days in temporary seedling bed before planting in experimental field.

Four raising methods for seedling except on crown bud before sprouting (CBBS) needed sprouting, budding or temporary planting, heating chamber, green house or temporary seedling bed were needed in additional. The period of raising seedlings was 1~3 months. CBBS, however, didn't need those works and equipment (Table 2). If crown bud is

enough to obtain the seedlings, it will not be necessary for cutting. Seedlings were suitable to transplanting by plug seedling and divided seedling after budding.

Cultivation and investigation items

N-P₂O₅-K₂O with 70-60-200 kg/ha and organic materials of 10 t/ha were applied in this experiment. The experimental field was tilled twice by depth of 173 cm at 3 and 30 days before planting and ridged at every 70 cm intervals. Individual plot consisted of 10 ridges with 10 m length. The surface of ridges was mulched by polyethylene film, which was combined with transparency on center and black on both outside. Every seedlings were planted at 70×50 cm (28,500±71 plants/ha) on April 25. At 30 days after planting, plants were earthen up above film around roots. Two hundred times of herbicide (18% glufosinate ammonium) solution was sprayed on weeds to control weeds at 30, 45, and 60 days after planting. Tuberous roots were harvested at 150 days after planting on October 23.

Plant height, branch number, leaf number on the main-stem, petiole length, and stem diameter were measured 15 plants per plot at 150 days after planting, plant height was measured at an interval of 15 days. Fresh weight of root contains the root and crown bud. Tuberous root number per plant and yield per hectares were measured after harvesting. Investigated plants were sampled in the center rows from 4 to 7 m. Tuberous roots were classified into 3 groups after harvesting; the first group is less than 200 g, the second is 200-400 g, and the third is heavier than 400 g.

Table 2. Raising methods for seedlings of yacon in present experiment.

Seedling [†]	Raising period (days)				Required equipment			Plant height at planting (cm)
	Sprouting in chamber	Budding in field	Temporary planting	Total	Heating chamber	Green house	Temporary seedling bed	
Cutting	-	35-45	35-45	70-80	×	○	○	3.5 ± 1.2
PS	30	-	15-30	45-60	○	○	○	8.5 ± 2.0
CBBS	-	-	-	-	×	×	×	0.0 ± 0.0
CBAS	30	7-10	-	37-40	○	○	×	2.0 ± 0.5
DSAB	-	30	7-10	37-40	×	○	○	10.3 ± 2.5

[†]PS: plug seedling, CBBS: crown bud before sprouting, CBAS: crown bud after sprouting, DSAB: divided seedling after budding.

RESULTS AND DISCUSSION

Growth from different seedlings

In general, yacon is propagated as planting crown bud directly, dividing from crown bud or cutting from seedling after budding. In the change of plant height, PS and DSAB were taller height during total growth period than others. Even though CBAS and CBBS grew aboveground from 15 and 30 days after planting, respectively, these were taller than those of cuttings since 75 days after planting, and similar with PS and DSAB (Fig. 1). Plants from cuttings, CBBS and CBAS grew rapidly in middle growth stage.

The effects of five methods for raising seedlings on growth were shown in Table 3. PS and DSAB had taller height to 140.5 and 143.3 cm at 150 days after planting than others, respectively. Seedling by cutting was the shortest as 125.3 cm, which was 87.4% of seedlings by DSAB. Even though it was taller about 3.7 cm than seedlings by CBBS at

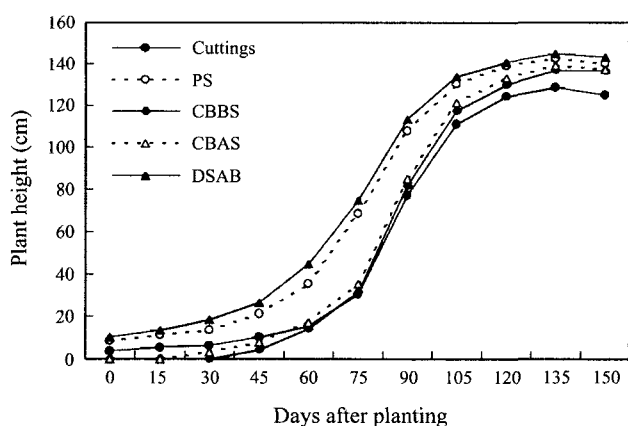


Fig. 1. Changes of plant height according to raising methods for seedlings during growth period in yacon. PS: plug seedling, CBBS: crown bud before sprouting, CBAS: crown bud after sprouting, DSAB: divided shoot after budding.

planting time but was shorter about 11 cm at harvesting time. In total growth duration, seedlings by DSAB was longest among raising methods, and the next was plug seedling. Kim & Joung (1986) reported that plant height by cutting was 155.2 cm in case of overwintering but it were short tall in case of delayed cutting.

Branch number was not significant except cuttings. Leaf number on main stem and petiole length didn't differ among seedlings. Branch and leaf numbers of overwintered seedlings were better than those of cuttings (Kim & Joung, 1986). Node number on main stem and stem diameter was different among raising methods for seedlings, the former should to be related with plant height.

Yield from different seedlings

Fresh weight was different among seedlings. The fresh weight of aboveground is related with plant height, branch number etc, that of underground should to be related with aboveground growth. The yields of plants grow from DSAB, CBAS, and CBBS were high with from 34.7 to 36.5 ton/ha. The yield indexes were high than 95.2%, cutting and PS, hence, were low with 73.3 and 86.8% compare with that of DSAB (Table 4).

Sgeno (1989) reported that division had higher yield with 2.4 kg than cutting with 670 g per plant. In our result, tuberous root was harvested 36.5 ton/ha; it was 0.5 times lower than his result in case of division, but it was 1.4 times higher in case of cutting. Even though yields were 26.8 and 31.7 ton/ha in cutting and PS, respectively, using for seedling was not suitable because of lower yields than CBBS, CBAS, and DSAB. DSAB was most effective to get high yield as 36.5 ton/ha.

Considering the above-mentioned results, CBBS, CBAS, and DSAB seems to be suitable to use seedlings for high yield of yacon. Because a plant usually produces from 60 to 120 crown buds (sometimes 150 or more), there is no problem to obtain crown buds. However, low temperature in

Table 3. Effects of raising methods for seedlings on growth of yacon at 150 days after planting.

Seedling [†]	Plant height (cm)	No. of branch per plant	No. of leaf on main stem	Petiole length (cm)	No. of node. on main stem	Stem diameter (cm)
Cutting	125.3	8.7	12.8	7.6	12.2	2.3
PS	140.5	12.3	13.2	8.8	17.5	2.5
CBBS	136.7	11.3	13.0	8.2	16.7	2.4
CBAS	137.5	11.7	13.5	8.8	17.3	2.5
DSAB	143.3	12.7	13.6	8.7	18.0	2.5
LSD(0.05)	2.1	1.4	ns	ns	1.7	0.1
CV(%)	0.8	6.5	5.4	7.4	5.6	2.7

[†]PS: plug seedling, CBBS: crown bud before sprouting, CBAS: crown bud after sprouting, DSAB: divided seedling after budding.

Table 4. Effects of raising methods for seedlings on yield of yacon at harvesting.

Seedling [†]	Fresh weight (kg/plant)		Tuberous root		
	Aboveground	Underground	No./plant	Yield (ton/ha)	Yield index
Cutting	1.43	1.73	7.0	26.8	73.3
PS	1.82	2.20	13.7	31.7	86.8
CBBS	1.70	2.67	16.3	34.7	95.2
CBAS	1.75	2.99	17.0	35.4	97.0
DSAB	1.86	2.90	19.5	36.5	100.0
LSD(0.05)	0.25	0.23	2.26	3.22	
CV(%)	7.75	4.81	8.16	5.17	

[†]PS: plug seedling, CBBS: crown bud before sprouting, CBAS: crown bud after sprouting, DSAB: divided seedling after budding.

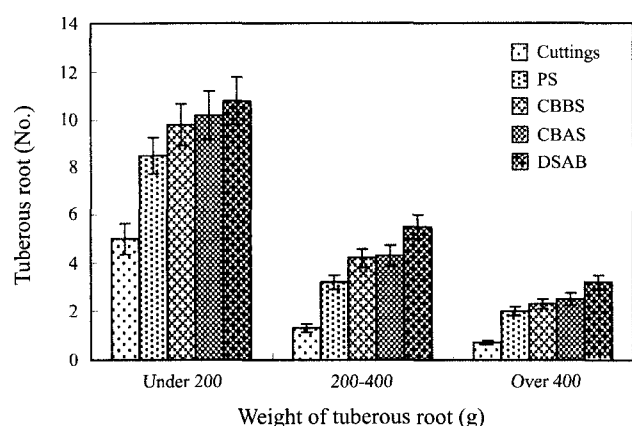


Fig. 2. Distribution by weight according to raising methods for seedlings in yacon. PS: plug seedling, CBBS: crown bud before sprouting, CBAS: crown bud after sprouting, DSAB: divided shoot after budding.

early growth stage may retard the development of plant. So, if planting will be late, aboveground part may wither before enough enlargement of tuberous roots. We think that optimum planting date was determined to prevent a cold injury on early growth stage in case of early planting.

Harvested tuberous root

The ratio of tuberous roots over 200 g to total tuberous roots was high from DSAB. Most of tuberous roots from cuttings were under 200 g (Fig. 2). Cuttings were not suitable to use the raising seedling because tuberous roots were the fewest among the kind of seedlings. Sprouting was not significant different between CBBS and DBAS, so sprouting before planting was not effective to produce the tuberous roots. Planting spacing was effective on the rate of over 200 g, number of tuberous roots was fewer but their weight was heavier in wide planting than in dense planting (Doo *et al.*, 2001). It is necessary to increase the rate of tuberous root

over 200 g, so it was required more researches in the future.

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