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Effect of Plant Density on Growth Responses and Yield in Yacon

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ABSTRACT : This study was conducted to determine the optimal planting distance in cultivation of yacon (*Polymnia sonchifolia* Poeppig & Endlicher). Plug seedlings were planted with 6 different plant densities of 80 × 60, 80 × 50, 70 × 50, 70 × 45, 70 × 40 and 60 × 45 cm. The plant height and the petiole length were increased with increasing the planting distance. The tallest plant height of yacon was 165.4 cm with the plant density of 80 × 60 cm. However, branch number per plant, leaf number on main stem and stem diameter were not significantly difference among planting densities. Tuberous root was harvested 31.42 tons/ha in 70 × 50 cm spacing. The ratio of heavier tuberous roots than 200 g to total tuberous roots decreased significantly according to increase of planting density. Fresh weights of shoot and root, contain the crown bud, were decreased, as planting distance was shorter. Tuberous root number was fewer but its weight was heavier in wide planting than in dense planting. We think that optimal planting density is about 30,000 plants/ha, if it were to be 70 cm row spacing, intrarow spacing should calculate about 47 cm.

Keywords **:** yacon, plant density, growth, yield, tuberous root

Yacon (*Polymnia sonchifolia* Poeppig & Endlicher) plant is *Compositae*; it is originated from the Andean highlands and has large subterranean tuberous root. Its fresh, boiled or fried tuberous roots are edible. Tuberous root of yacon is similar to that of the dahlia or sweet potato tubers, but the fresh tuberous roots of yacon are juicy and sweet like fruits such as pears (Ohyama *et al.*, 1990).

Yacon was imported as a new root crop from Japan to Korea since 15 years ago. Although a few advanced farmers have cultivated yacon, its characteristics and cultivation system were not known concretely in Korea.

Planting density is greatly effective in tuber or tuberous root crops not only growth but also yield. Tsukihashi *et al.* (1989) studied the effects of planting density on yield of yacon in Japan. They reported that yields of under ground were 4,170 kg/10a on dense planting density (70 × 30 cm), 5,403 kg/10a on wide planting density (70 × 70 cm) and 5,195 kg/10a on control (70 × 50 cm). In Korea, Shin *et al.* (1993) reported that the effects of polyethylene film mulching and planting density were approved on growth and yield in yacon. They reported that the height of main stem in yacon was increased lineally from July to October showing the highest at 70 × 55 cm spacing, which increased as planting distance was wide. Yield of tuberous root was 35,617 kg/10 ha at 70 × 40 cm spacing with mulching. Optimal planting density could be varied according to soil fertility, fertilizer application level, weather environment, and cultivars etc. This experiment carried out to high yield in cultivation of yacon in Korea.

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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 fields at Chonbuk National University on April 20 1996. 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. There were used for this study on March 1997.

This experiment was conducted at Chonbuk National University in Chonju, Korea. The physico-chemical properties of the topsoil (0 to 15 cm) were measured before experiments. Experiment was conducted a randomized block design with three replications.

Cultivation and management

N-P_2O_5-K_2O with 70-60-200 kg/ha and organic materials of 10 t/ha were applied in this experiment. Experimental field was tilled twice by depth of 17 ± 3 cm at 3 and 30 days before planting and ridged at every 80, 70 and 60 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. At 30 days after planting, plants were

earthen up above film around roots. 200 times solution of herbicide (18% glufosinate ammonium), 600 L/ha, 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, 1997.

Planting densities and investigation items

Plug seedlings were transplanted on the experimental field with six different plant densities of 80 × 60, 80 × 50, 70 × 50, 70 × 45, 70 × 40 and 60 × 40 cm (interrow spacingintrarow spacing) on March 23, 1997.

Plant height, branch number, leaf number on main stem, petiole length, stem diameter were investigated 15 plants per plot at 150 days after planting, plant height was measured 15 days interval. Fresh weights of shoot and root, contain the root and crown bud, tuberous root number per plant and yield per hectares were measured after harvesting. Investigated plants were sampled in 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.

RESULTS AND DISCUSSION

Physico-chemical properties of fields

Physico-chemical properties of experimental fields were shown in Table 1. pH was mildly alkaline. Organic material content was 1.6% which was a little lower than mean of upland in Korea (Cho *et al.*, 1992). Phosphate was 614 ppm that was higher about 5.4 times than common upland. Exchangeable Ca, Mg and K content were 14.2, 1.5 and 0.96 mg/100g, respectively. Soil was classified into clay loam.Growth As planting density was increased from 8060 to 6045 cm spacing, plant height and petiole length were decreased. However, branch number per plant, leaf number on main stem and stem diameter were not significantly different (Table 2). Plant height was similar tendency to Tsukihashi *et al.* (1989)'s report; that plant height was taller with wide planting (70 × 70 cm) than did dense planting (70 × 30 cm) and control (70 × 50 cm). Shin *et al.* (1993) reported that the height of the main stem of yacon was increased with raising the plant density and it was the tallest at 70 × 55 cm

Table 2. Effects of planting density on growth at 150 days after planting in yacon.

Plant density (cm)	Plant height (cm)	Branch no. per plant	Leaf no. on main stem	Petiole length (cm)	Stem diameter (cm)
80 × 60	165.4	11.5	13.5	9.9	1.7
80 × 50	159.7	10.6	13.3	9.3	1.8
70 × 50	160.3	10.8	13.2	8.7	1.8
70 × 45	147.3	10.5	13.0	8.2	1.7
70 × 40	145.5	10.7	13.1	7.6	1.8
60 × 45	131.4	10.6	12.7	7.3	1.9
LSD†	7.5	ns	ns	1.1	ns
C.V.(%)	2.7	6.5	4.7	4.5	4.3

†LSD is significant at 0.05 level, ns is non-significant

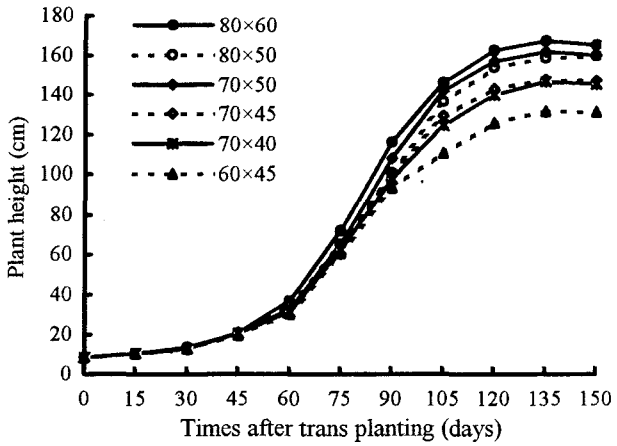

Fig. 1. Changes of plant height upon planting distance during growth in yacon.

spacing. Plants grown from 8.5 cm at plug seedlings to 131.4~165.4 cm tall at harvesting, and planting distance was effective on plant height (Fig. 1). Plant was taller as planting distance was wide. This result was similar to other crops (Lee & Ahn, 1988; Kwon *et al.*, 1989; Seong *et al.*, 1994; Kim *et al.*, 1994). Fresh weight and yield at harvesting, fresh weight of yacon plant and tuberous root were shown in Table 3. Fresh weights of shoot and root were decreased as planting density was increased from 80 × 60 to 60 × 40 cm spacing. Fresh weight of shoot was related with plant height and petiole length but the others were not significant. In

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

pH	OM	P_2O_5	Exchangeable cautions			CEC	EC	Particle size distribution			Soil class
			Ca	Mg	K			sand	silt	clay	
	(%)	(ppm)	-------(mg/100 g)-------				(dS/m)	-------(%)------			
7.6	1.6	614	14.2	1.5	0.96	14.59	0.27	33.7	28.4	37.9	Clay loam

Table 3. Frash weight of shoot and root, number of tuberous root and yield of yacon with six different plant densities.

Plant density (cm)	Fresh weight (kg/plant)		Tuberous root		Yield index
	Shoot	Root and crown bud	No. (/plant)	Yield (ton/ha)	
80 × 60	1.95	2.54	8.5	25.45	81
80 × 50	1.89	2.37	10.4	26.30	84
70 × 50	1.82	2.28	11.2	31.42	100
70 × 45	1.75	2.25	11.7	30.16	96
70 × 40	1.64	2.18	11.5	28.75	92
60 × 45	1.57	2.03	12.5	27.33	87
LSD†	0.11	0.35	1.6	2.97	-
C.V.(%)	3.42	8.34	7.9	5.78	-

†LSD is significant at 0.05 level.

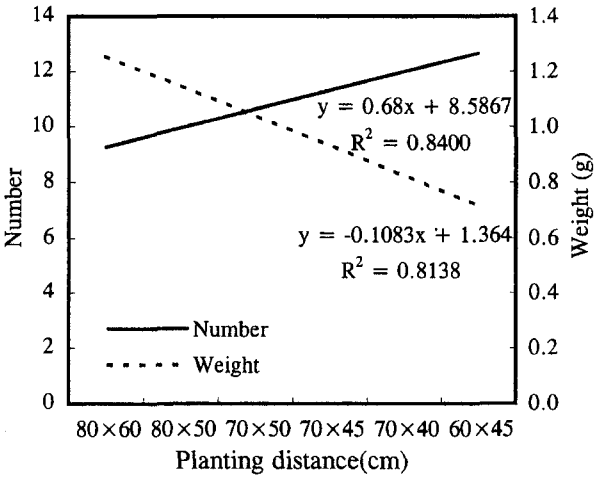

Fig. 2. Effects of planting distance on tuberous root number and weight per plant in yacon.

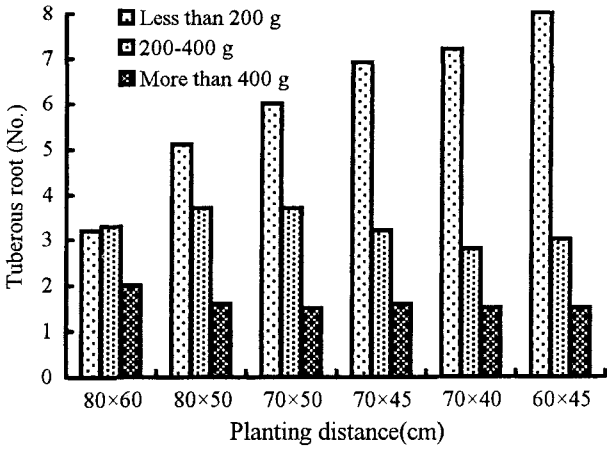

Fig. 3. Harvested tuberous roots upon planting distance in yacon.

yield, the tuberous root number per plant was many but the size was small and the weight was light according to increase the planting density (Fig. 2). Tuberous root was harvested 31.42 tons/ha on 70 × 50 cm spacing (28,50071 plants/ha) cm. Tsukihashi *et al.* (1989) reported that yields of under ground were 4,170 kg/10a at dense planting (70 × 30 cm), 5,403 kg/10a at wide planting (70 × 70 cm) and 5,195 kg/10a at control (70 × 50 cm). Shin *et al.* (1993) also obtained the greatest yield of yacon (3,561.6 kg/10a) at 70 × 40 cm spacing with mulching (35,714 plants/ha). The ratio of heavier tuberous roots than 200 g to total tuberous roots decreased significantly according to increase of planting density. Most of tuberous roots were less than 200 g per tuberous root at dense planting density (Fig. 3). This result was similar to Kim *et al.* (1997) and Choi & Cho (1977)'s results but different from Eastwood (1956) and Human (1961)'s results in potato. In present experiment, the tuberous root number was fewer but its weight was heavier in wide planting than in dense planting. This result is similar to the tuber or tuberous root crops; examples are *Scutellaria baicalensis* (Lee & Ahn, 1988), *Linnum usitatissimum* (Kwon *et al.*, 1989), *Liriope platyphylla* (Seong *et al.*, 1994) and *Ligusticum chuanxiong* (Kim *et al.*, 1994). However, in case of harvested crops the above ground parts, such as *Carthamus tinctorius* (Park, 1981) or *Nicotiana tabacum* (Bae *et al.*, 1981), were higher harvested flower or leaf in total yield. Considering the above results, planting densities is various according to harvesting materials. Tsukihashi *et al.* (1989) reported that, in case of planting crown bud, the weight and the number of tubers per a stump were more at the wide planting (5,403 kg/10a) than other planting densities. Therefore we think that optimal planting density is about 30,000 plants/ha, if it were to be 70 cm row spacing, intrarow spacing should calculate about 47 cm.

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