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Effect of In-row Plant Spacing on Growth and Yield of Korean Native *Allium wakegi* Araki

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ABSTRACT

Allium wakegi **Araki was grown at plant spacings of 5, 10, 15, and 20 cm to determine the effect of planting density on the growth and yield.** ***Allium wakegi*** **Araki plants grown at the 5 cm plant spacing had the lowest bulb diameter and bulb weight, while plants at the lowest density (20 cm spacing) had the highest bulb diameter, bulb number, bulb weight and fresh weight. In general, plants grown at narrower spacings produced significantly smaller bulb diameter and bulb weight, but resulted in the highest yields and plants per hectare and lower fresh weights per plant.**

Additional key words **:** *Allium wakegi* Araki, hydroponics, plant parameters, plant spacing

INTRODUCTION

Allium wakegi Araki (Araki, 1950) is a popular vegetable grown in China, Japan, and the southeast Asia for its mildly pungent bulbs and flavorful leaves. *Allium wakegi* has originated as a hybrid between *A. ascalonicum* and *A. fistuosum* (Tashiro, 1984). *Allium wakegi* is only propagated asexually, by planting bulbs, and is supposed to be developed into a vegetable population consisting of various clones over a long history of cultivation. Recently, fresh plant production of *A. wakegi* in the Chungcheongnam-do, Jeollanam-do, and Gyeonggi-do area is expanding (NAQS, 2002). Demand is increasing due to the popularity of the Kimchi, spice, and medicine industry. Bulb formation of *A. wakegi* has been studied well on the effects of daylength, temperature, temperature experienced, and soil moisture (Ohkubo *et al.*, 1981; Yamazaki *et al.*, 2003). Managing production inputs and minimizing production costs are increasingly important. Optimum in-row plant spacing studies have not been conducted on *A. wakegi in vitro* in hydroponic culture. Our objective was to investigate the influence of in-row plant spacing on *A. wakegi* growth and yield.

MATERIALS AND METHODS

A. wakegi A. plants derived from the shoot tip culture were propagated in MS solid medium (Murashige and Skoog, 1962) including 1 mg/L 2iP. The pH of the medium was adjusted to 5.8 before autoclaving at 121°C for 15 minutes. The shoot tip in culture tubes(ø 25 mm × h 150 mm) were incubated at 25 ± 1°C, 60 μmol · m^{-2} · s^{-1} photosynthetic photon flux

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Table 1. Chemical properties of standard nutrient solution of National Horticultural Research Institute, RDA, Korea[z]

Chemicals	Volume(me/L)	Chemicals	
		Property	Volume (me/L)
KNO_3	5	NO_3-N	14
$Ca(NO_3)_2 \cdot 4H_2O$	8	NH_4-N	1
KH_2PO_4	1	Ca	8
NH_4NO_3	1	PO_4-P	3
$MgSO_4 \cdot 7H_2O$	4	Mg	4
		SO_4-S	4
		K	6

[z] EC: 2.3 mS/cm, pH: 6.5

(PPF) for 2 weeks and then transferred to 500 ml culture bottle(ø 66 mm × h 132 mm) with a 16-h light provided by white fluorescence lamps for 7 weeks.

A field study was conducted in 24th December 2002 to 26th May 2003 at the Research Farm of Bioenvironmental Division, Chungcheongnam-do Agriculture Research and Extension Services. Seedlings with 2 to 3 leaves cultured *in vitro* were planted on 24th December 2002 on four in-row plant spacing were evaluated: 5, 10, 15, and 20 cm on Styrofoam beds (42.5 cm wide, 24.5 cm high, and 116 cm long) including a mixture of peatmoss: perlite: vermiculite (1:1:1=v/v/v) and placed in a plastic greenhouse. Plots were 10 m long with 91.5 cm between beds, on a raised beds (42.5 cm wide × 15 cm high). Twenty seedlings were planted in double rows (17.5 cm apart) per plot for each treatment. The artificial soil in the beds had been fertilized with 'standard nutrient solution of National Horticultural Research Institute, Rural Development Administration (RDA), Korea' (Park and Kim, 1998) (Table 1). Plots of *A. wakegi* were arranged in a completely randomized design with four replications. *A. wakegi* plants grown at 18~32℃ were harvested on 26th May 2003 for measurements. Plant height, bulb diameter, bulb number, bulb weight, and fresh weights were determined from four plants in each plot. Differences among mean values were tested by Duncan's multiple range test.

RESULTS AND DISCUSSION

Agronomic characteristics

Plant spacing influenced *A. wakegi* plant growth and development (Table 2 and Fig. 1). As plant spacing increased from 5 to 20 cm, bulb diameter and bulb weight increased significantly. Plant height, however, was unaffected by plant spacing. The highest plant, bulb diameter, bulb number, bulb weight, and fresh weights were from plants produced at the widest spacing (20 cm). The lowest bulb diameter and bulb weight were from at the narrowest spacing (5 cm). All plant characteristics, other than plant height were influenced by plant spacing. Fresh weights for plants spaced at 20 cm were about 1.6 times that of plants at the 10 cm spacing.

A low temperature period preceding the long daylength and high temperature phase served to fasten bulb formation (Ohkubo *et al.*, 1981). When bulbs were stored between 1 and 25℃ for 50 days and grown at 20 ℃ under a 13-hr photoperiod, storage at below 15℃ promoted the formation of new bulbs (Yamazaki *et al.*, 2003). Also, the results of the present study suggest that in-row plant spacing affects bulbing formation and that this factor may be important in determining optimum

Table 2. Comparison of growth in different plant spacing of Korean native *Allium wakegi* Araki after culture for 5 months

Plant spacing (cm)	Plant height (cm)	Bulb diameter (cm)	No. of bulbs	Bulb weight (g)	Fresh weight(g/plant)	
					Top	Root
5	45.8a	1.9b	24.0ab	3.4b	81.5b	82.6b
10	43.8a	2.0b	18.7b	3.8ab	70.2b	77.6b
15	46.8a	2.7a	23.2ab	5.1a	93.0ab	124.8a
20	48.2a	2.7a	28.0a	5.2a	112.6a	153.9a
Significance	ns	**	*	*	*	***

Mean separation within columns by Duncan's multiple range test at 5% level

NS,*,**,*** Nonsignificant or significant at $P = 0.05$, 0.01, and 0.001, respectively

Fig. 1. Effect of various in-row plant spacing (from left to right: 5 cm, 10 cm, 15 cm, and 20 cm) on the growth of Korean native *Allium wakegi* Araki plants after cultured for 5 months. Bar represent 5 cm in length.

seed bulb production.

Plant yield characteristics

Korean native *Allium wakegi* Araki yields were affected by in-row plant spacing (Table 3).

Fresh biomass production per plant were lower but the yield per hectare was highest at the narrow plant spacing. Fresh biomass production in our study were highest for the narrowest in-row plant spacing. These results suggest that the biomass production per hectare increase with a narrower spacing is attributed by to a higher planting density. Batal and Smittle(1981) concluded that total plant population was a more important factor affecting bell pepper yield than plant arrangement; yield from 27,000 plants/ha was lower than with populations of 40,000 to 60,000 plants/ha.

Table 3. Effect of in-row plant spacing on Korean native Allium wakegi Araki yield

Plant spacing (cm)	Plants/ha (×1,000)	Fresh plant yield	
		g/plant	t/ha
5	298.5	164.1b	48.9a
10	149.2	147.9b	22.0b
15	99.2	217.8b	21.6b
20	74.2	266.6a	19.7b
Significance		**	***

Mean separation within columns by Duncan's multiple range test at 5% level

,* Significant at $P = 0.01$ and 0.001, respectively

Tachibana and Nakai(1989) reported that *Citrus unshiu* Marc. var. *praecox* grown at a plant population of 1,250 and 2,500/ha resulted in the highest yield (74 t/ha). Our results indicate a similar trend; at higher plant populations that is in-row plant spacing, plant efficiency was highest.

Narrower in-row plant spacing resulted in plants were smaller and produced less fresh biomass production per plant but higher the yield and plants per hectare. These results indicate that an in-row plant spacing closer than the 10 to 20 cm in-row plant spacing recommendation for Korean native *Allium wakegi* may be optimal growth and yield in hydroponic culture. The total biomass production yields per plant were lower but the number of plant per hectare was highest at the narrow in-row plant spacing. As in-row plant spacing increased from 10 to 20 cm, fresh biomass production per plant increased significantly, while the number of plants per hectare decreased. The lowest and highest fresh plant yields were for the plants grown at the 20 and 10 cm plant spacing, respectively. Stofella and Bryan (1988) suggested that bell pepper production increases at higher plant populations. The results of the present study suggest that in-row plant spacing affects plant growth and yield and that this factor may be important in determining optimum plant population density for harvesting Korean native *Allium wakegi* mechanically. Also, further studying is necessary to access the effects of cultivation type, growing period, field conditions, and various factors associated with the growth and yield in Korean native *Allium wakegi.*

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