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Effect of Vernalizing Temperature on Growth and Yield of Globe Artichoke

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Abstract. This study was conducted to produce heads of artichoke in July in Korea. The artichoke was planted in the Autumn and it could be reaped heads of artichokes in late of May in Korea. It can inform us that the artichoke need under some low temperature during the Winter to open flowers. In order to harvest heads of artichoke in the Summer two kinds of cultivar 'Green Globe' and 'Imperial Star' those were grown for 4 weeks in green house of 17°C which were treated at 3, 6, 9 and 12°C chamber for 4 weeks and then planted the 8th April. Plant distance was 150 × 50 cm. After 3 months most of artichoke of 'Imperial Star (IS)' made heads. Especially, the artichokes 'IS' were treated at 6°C made heads 63% of plants but those at 12°C made heads 33% and the artichokes (no treatment at low temperature) grown in greenhouse at 17°C for 8 weeks made heads 5% of plants. 'Green Globe (GG)' made heads 28% of plants at 9°C and 10% at 12°C, and 'GG' grown in greenhouse at 17°C for 8 weeks never had made any head. The weights of head were 97 g and 86 g in 'IS' and 'GG' respectively. The yield of heads were 215 and 108 kg/10a in 'IS' and 'GG' respectively.

Additional key words : cold treatment, imperial star, green globe, greenhouse

Introduction

Globe artichoke (*Cynara cardunculus* var. *scolymus* L.) is an allogamous and entomophylous plant belonging to the *Asteraceae* family. It is cultivated in the Southern Europe around Mediterranean basin and North-Western Africa for the consumption of its flower bud. The edible portions are the fleshy bases of the bracks and the tender, thickened receptacle. Due to the lack of suitable seed-planted cultivars and the large quantity if propagation material present in a plant (Cardarelli et al., 2005), globe artichokes are generally propagated vegetatively by offshoots, stumps, or dried shoots harvested from commercial fields at the end of the production cycle. Although this vegetative propagation seems to be economically profitable, the potential for the spread if disease is very high. Many pests and viruses frequently have been observed in globe artichoke fields (Amenduni et al., 2005; Greco et al., 2005; Pasquini and Barba, 2005; Acquadro et al., 2010).

Vernalization has been induced in globe artichokes by stratifying seed (Gerakis et al., 1969) or by exposing transplants to a cold treatment in a controlled environment or cold frame (Husain and Stewart, 1996). The low number of cultivated globe artichoke germplasm respect to the large diversity originally existent is index of a genetic erosion process. In addition, there is a great confusion in *Cynara* germplasm due to the fact that over years of cultivation in various geographical sites, each cultivar has been named according to the place where it was cultivated. The collections need to be rationalized by improving core collections and removing both redundant germplasm and a large number of synonyms. Vernalization is a floral induction by low temperatures. This concept has led to the practice of substituting artificial chilling for the natural winter exposure to induce of hasten the ability to flower. The first report on globe artichoke vernalization came from Russia, where to induce flowering during the first year after sowing, the pregerminated seeds were placed in snow for a period of 12 days before field planting (Panov, 1949) The promotion of flowering of globe artichoke by substituting artificial vernalization was then studied in some experiments as reported by Harwood and Markarian (1968), Gerakis et al. (1969) and Basnizki and Goldschmidt (1994). The results obtained have often led to contrasting conclusions showing that cold requirements vary greatly in relation to genotype and environment. The purpose of this study was to evaluate the possibility of reducing the negative effect of late sowing on harvest time and yield by improving the effectiveness of

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chilling seedlings in new seed grown hybrids.

These studies explored yield differences by variety, efficacy of both natural and controlled vernalization techniques, and overall potential to produce globe artichokes in Jeju Island.

Materials and Method

Two cultivars of artichoke 'Green Globe' and 'Imperial Star' were employed for this experiment. Both of these varieties have been evaluated in other parts of the countries as well as South Korea (Seong et al., 2008; Rangarajan et al., 2000). The seeds were sowed in 72 holes plugtray in the greenhouse with 17°C and grown for 4 weeks until the stage of 3th~4th true leaf before moved into 3, 6, 9, and 12°C chamber for 4 weeks and then hand-transplanted in the open field. The chamber had LED (Light Emitting Diode) lights and 16 hours day and 8 hours night per a day, The LED formed white light with 40 $\mu molm^{-2}s^{-1}$. The controls were grown in a glass greenhouse with 17°C for 8 weeks. All seedlings were transplanted on 8th of April and plant spacing was 150 cm between rows and 50 cm within rows. Plots about 40 m^2 each containing 80 plants were arranged in the randomized block design replicated three times. Globe artichokes need a certain cold temperature for inducing floral, and in order to find a proper low-temperature required for floral induce globe artichoke seedlings grown at 17°C of four weeks in the greenhouse were transplanted in a open field at 1-week intervals from March 11, 2009. Globe artichokes transplanted on the ridge installed a drip hose in the center and with ridge width 130 cm intrarow space 50 cm and mulched with black non-woven fabrics. Plants were received fertilizer with P 21 kg, K 21 kg, N 24 kg and compost 2,500 kg per 10a. Fertilizer as basal was applied 2/3 of fertilizer nitrogen, potassium and total of the phosphorus before transplanting. Top dressing of nitrogen and potassium fertilizer had two times at 15-day intervals after transplanted.

Completely randomized design was scheduled with three replicate plots of 20 seedlings planted per plot. It was irrigated during the dry from time to time with a drip irrigation line installed in the middle of the ridge.

Result and Discussion

Globe artichokes are generally planted from July through September and grown year-round as perennials and can be reaped globes (flower buds) from May through June. Globe artichoke production when grown outdoors in the expanding low-temperature processing is required for the formation of flower buds (Gerakis et al., 1969). Generally globe artichokes have been shown to have a low temperature requirement when after 250 h of less than 7°C when 'Imperial Star' was 205 h of less than 10°C, 85% of that could produce flower buds (Welbaum, 1994). To extend the harvest time there is a need to understand what the low temperatures required for vernalization, using these characteristics of globe artichokes.

Grobe artichoke seedlings were grown four weeks in greenhouse with at 17°C, this temperature could not break out vernalization of globe artichokes and then planted on open field at 1-week intervals from March 11. Between two cultivars, 'Imperial Star' and 'Green Globe' have been compared to the budding, while 'Imperial Star' planted on March 11 which 100% of it had budding, planted on March 18 which 67% of it had budding, planted on March 25 which 13% of it had budding and planted on April 1 after which 0% of it had budding. 'Green Globe' was lower overall budding rate and planted on March 11 and 18 which 53% of it had budding while planted on March 25 which 20% of it had budding. planted on April 1 those 0% of both of 'Imperial Star' and 'Green Globe' had budding (Fig. 1).

The result of vernalizion treatment at a temperature of 4 weeks each globe artichoke seedlings that were trans-

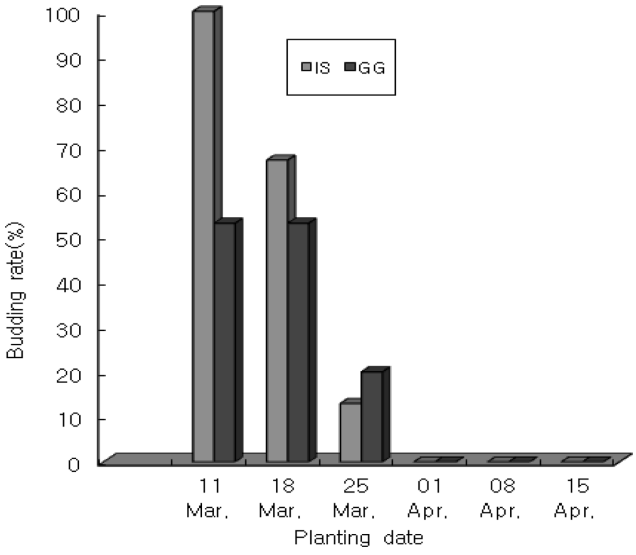

Fig. 1. Globe artichokes budding rate according to planting time.

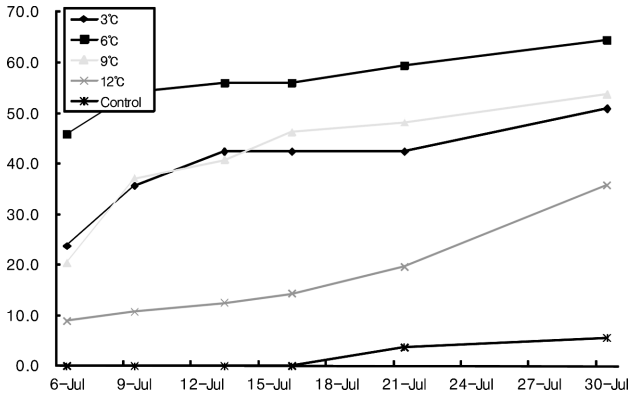

Fig. 2. 'Imperial Star' budding rate according to vernalization treatment.

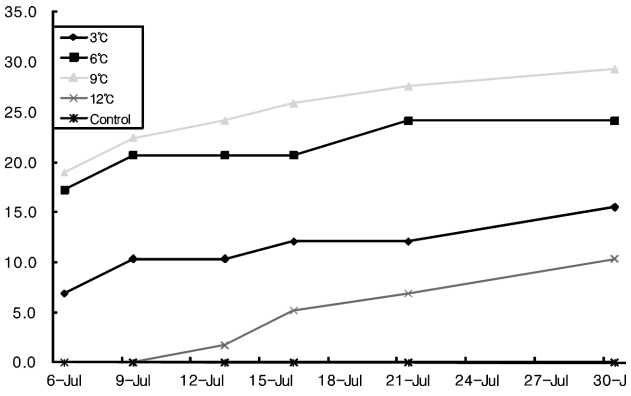

Fig. 3. Green Globe budding rate according to vernalization treatment.

planted on April 8, Budding was completed on July 30, starting July 6. Budding rate 'Imperial Star' was higher than that of the 'Green Globe'. 'Imperial Star' in the treatment of 9 and 6°C in the process, the 'Green Globe' was budding rate 'Imperial Star' was observed in untreated budding less of than 9°C was higher than the overall budding rate of 'Green Globe'. The 'Green Globe' at 12°C of 4 weeks had delayed budding and had low budding rate and the budding rate was 3°C < 6°C < 9°C in order. The cultivar 'Green Globe' picking the survival, plant height, leaf length, leaf width and growth was better than the 'Imperial Star' but effect of vernalization was of satisfaction due to

Table 1. Globe artichoke growth according after vernalization treatment.

Varieties	Vernalizing temperature	Survival rate (%)	Plant height (cm)	Leaf length (cm)	Leaf width (cm)
Imperial Star	3°C	98.3	40.4	33.9	18.3
	6°C	98.3	43.2	34.8	22.2
	9°C	90.0	39.0	33.7	16.9
	12°C	93.3	39.9	34.3	16.8
	Control	100.0	40.7	34.0	24.8
Green Globe	3°C	96.7	43.3	36.0	21.8
	6°C	96.7	46.2	37.8	23.1
	9°C	96.7	43.5	36.2	21.0
	12°C	96.7	45.6	37.6	21.4
	Control	98.1	52.3	44.3	26.5

Table 2. Globe artichoke budding rate according to vernalization treatment.

Varieties	Vernalizing temperature	Flower buds			Number of buds per plant	Budding rate (%)	Yield of buds (kg/10a)
		Length (mm)	Width (mm)	Weight (g)			
Imperial Star	3°C	75.0	89.9	145.5	5.0	51.7	501.3 b
	6°C	73.9	96.1	151.5	6.8	64.4	884.2 a
	9°C	73.8	87.9	135.1	5.9	54.7	581.3 b
	12°C	75.2	82.7	118.8	5.6	35.7	316.5 c
	Control	73.0	84.1	146.1	1.5	6.9	141.1 d
Green Globe	3°C	67.0	89.3	138.5	4.5	15.5	128.8 c
	6°C	72.6	96.4	154.3	3.6	24.1	178.4 b
	9°C	76.2	100.3	170.2	4.0	29.8	270.4 a
	12°C	86.3	101.9	207.1	3.9	10.3	110.9 c
	Control	73.1	99.9	169.7	2.0	2.3	10.4 d

DMRT P = 0.05.

be low budding rate and quantity of 'Green Globe' (Fig. 2, 3). During the vernalization growth of plant was less than control in both of two cultivars. The vernalization treatment restrained growing plant height, leaf length and leaf width but the treatment could not affect to survival rate of globe artichoke (Table 1). The temperature for vernalizing at 6°C treatment made heavy weight of flower buds of 'Imperial Star' but in case of 'Green Globe', at 12°C treatment heavy weight of flower buds. The yield of flower buds of 'Imperial Star' heavier at 6°C treatment but the 'Green Globe' produced flower buds best at 9°C treatment (Table 2).

The vernalization treatment of globe artichoke seedling, performed to extend the harvest period of the artichoke bud. The higher the temperature for chilling of globe artichoke vernalization, the growth was better after the vernalizing processing. The budding of globe artichokes were of difference according to varieties and the temperature for floral induce. Globe artichokes seedling grown more than 17°C in a glass greenhouse without any chilling were transplanted 1-week intervals from March 11. 'Imperial Star' transplanted after March 18 had been declined budding rate gradually. 'Imperial Star' transplanted after April 1 had not been budding. 'Imperial Star' budding rate tended to be better than 'Green Globe'. These results leaded when the 'Imperial Star' has been transplanting before March 10 that doesn't need a vernalization. If the low-temperature processing is required since mid-March to transplant. But, in the case of 'Green Globe' should be required sufficient seedling period and low temperature for achieving effect of vernalizing.

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Effect of Vernalizing Temperature on Growth and Yield of Globe Artichoke

아티초크 저온처리가 생육 및 수량에 미치는 영향

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적 요. 아티초크는 가을에 정식하여 겨울철 월동 중에 화아분화가 이듬해 5월경에 수확이 가능하다. 본 시험은 아티초크 육묘 중 저온처리를 하여 생산시기를 7월로 늦추고자 수행하였다. 시험품종은 '그린글로브' 및 '임페리얼스타'를 이용하였다. 파종은 72공 플러그 트레이를 이용하여 2월 10일에 파종하였고 4주간 17ºC에서 육묘한 후 3, 6, 9, 12ºC에서 4주간 육묘하였으며 4월 8일에 노지 포장에 정식하였다. 재식거리는 이랑폭 150cm에 주간거리 50cm(1,523주/10a), 1조식으로 하였다. 온도 처리별로는 6ºC 처리에서 화뢰 발생이 63%로 가장 많았고 12ºC에서는 33%로 가장 낮았으며 무처리의 경우는 5%의 화뢰가 형성되어 저온에 민감한 품종임을 알 수 있었다. '그린글로브' 품종의 경우 9ºC에서 화뢰 형성율이 가장 높아 28%였고 12ºC에서는 10%로 가장 낮았으며 무처리의 경우는 화뢰가 전혀 형성되지 않았다. 화뢰중은 '임페리얼스타' 품종이 97g 내외였고 '그린글로브' 86g 내외로 자랐다. 수량은 '임페리얼스타'에서 215kg, '그린글로브'에서는 108kg을 보였다.

추가 주제어 : 화아분화, 임페리얼스타, 그린글로브, 온실