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Pre-planting Temperature Treatments for Breaking Dormancy of Garlic Cloves

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Abstract: Dormancy of garlic (*Allium sativum* L.) creates a problem in physiological and tissue culture experiments. A study was conducted to determine whether sprouting of garlic could be enhanced by pre-planting temperature treatments of the cloves. The effects of various temperature grades and duration on the sprouting and growth behavior were investigated using a local and an exotic cultivar of garlic. Three weight grades of garlic cloves were treated with low (8-10°C), high (40°C), room (27°C), alternate high-low or low-high temperature for 14 days. The cultivars exhibited differential responses to temperature treatments before planting. Between the two cultivars, the exotic one completely failed to sprout under the experimental condition. The local cultivar showed enhanced sprouting and emergence, number of leaves/plantlet, plantlet height, number of roots, root length and percentage of normal plantlets. The low temperature and alternate high-low temperature treated cloves gave the highest percentage of sprouting (40%) whereas, low-high alternate temperature produced the lowest percent of sprouting (8.89%). The results revealed that treatments of cloves with different temperature levels have the potentiality to break dormancy and accelerate sprouting in garlic.

Key words: *Allium sativum* L., dormancy, emergence, sprouting, temperature

Introduction

Garlic is an aromatic bulb and herbaceous annual spice crop (Kurian, 1995). It is the second most widely used cultivated *Allium* after onion (Bose and Som, 1990). In addition to its use as a spice, garlic preparations are administered as a care against some long and lingering stomach diseases and sore eye, lowering blood pressure, cardiovascular diseases and ear ache. Aqueous extract of garlic contains allicin which has a hypocholesterolamic action and reduces the cholesterol concentration in human blood (Augusti, 1997). Cloves of garlic do not grow immediately after harvesting due to dormancy that gradually diminishes during storage (Ledesma *et al.,* 1980). Dormancy is controlled by a balance between growth inhibitors, such as Abscisic Acid (ABA) and growth regulators, especially GA_3 (Wareing and Saunders, 1971). Thomas (1969) found that both growth inhibitors and gibberellin activities decreased before sprouting, but there was an increase in gibberellin and auxin activities as soon as sprouting had begun. Dormancy in garlic created problem concerning physiological and tissue culture experiments. Explants from dormant cloves failed to respond or respond poorly in tissue culture (Haque, unpublished data). Although dormancy helps in storing garlic for long time in store, it is a problem for physiological and bio-technological experiments.

The optimum temperature for sprouting of garlic is in the range of 10 to 20°C (Miedema, 1994). Sprouting is delayed or completely inhibited by continuous exposure to temperature above 25°C. Several researchers have reported the involvement of growth regulators in dormancy and producing of garlic bulbs. In bulbs stored at 5-9°C considerable changes in the levels of endogenous hormones have been demonstrated during the storage period (Thomas, 1969; Thomas and Wurr, 1976). Temperature stimulates sprouting, growth and bulbing as well as its development (Moon and Lee, 1980). However, there is no information regarding the effects of temperature on breaking dormancy and sprouting of garlic in Bangladesh. The present study was therefore, carried out to investigate the role of temperature in breaking dormancy and sprouting behavior of garlic.

Materials and Methods

Garlic (*Allium sativum* L.) bulbs of a local cultivar and an exotic cultivar were used in this study. The cloves of each bulb were separated out and divided into three size classes viz. large, medium and small on the basis of weight. The average weight of the large, medium and small cloves was 1.665, 0.817 and 0.546 g, respectively in local and 6.285, 3.01 and 2.033 g, respectively in the exotic cultivar.

The thermal treatments of the study included: (1) the low temperature (8-10°C for 14 days), (2) the high temperature (40°C for 14 days), (3) the alternate high-low temperature (40°C for 7 days and 8-10°C for 7 days), (4) alternate low-high temperature (8-10°C for 7 days and 40°C for 7 days) and (5) room temperature (27°C for 14 days) as a control. The experiment was laid out in completely randomized design (CRD) with three replications. The treated cloves were planted in pots filled with a potting medium composed of soil, cow dung and fertilizer. The cloves of medium and small size group were planted in pots containing soil with a spacing of 3 x 4 cm^2 accommodating 15 cloves in each pot and large sized cloves were planted at a spacing of 4 x 4.5 cm^2 accommodating 10 cloves per pot. The large and medium size cloves were dibbled at 2 cm depth of soil while the small cloves were dibbled at 1 cm depth of soil. There were 90 pots used for four different temperature levels and the control with three replications. The pots were placed in natural environment out side the laboratory. The plantlets were kept under careful observation. The pots were watered at 3 to 5 days interval. Plants were scored at 15, 20 and 25 days from planting for sprouting (emergence of new leaves from the cloves). Plantlet height, number of leaves per plantlet, number of root per plantlet, root length and percentage of the normal plantlets were recorded at 25 days after planting. The collected data were analyzed following factorial experiment in CRD. The analysis of variances were performed following Duncan's multiple range test (DMRT).

Results

After 14 days treatment at various temperatures, the cloves were planted on pots containing soil. Data on the emergence percentage were recorded on 15, 20 and 25 days after planing of the cloves. In the local cultivar, the treated cloves emerged earlier than control (Table 1). Significant variation on the emergence percentage was observed between treated and the control cloves. After 15 days of planting, the highest percentage of emergence (31.67) was found in medium clove treated with low temperature. The same higher emergence percentage was observed on 25 days after planting. On this day, the low temperature had 40% of sprouting with the medium sized cloves and the same percentage of emergence was recorded in alternate high-low temperature treatment of large clove. The alternate high-low temperature treatment had higher emergence of small sized cloves also. Among the treatments, alternate low high temperature was the most inefficient in sprouting and emergence of the cloves. In case of control (room temperature) the percentage of emergence was only 3%. Unlike the local cultivar, the exotic cultivar completely failed to emerge after the temperature pre-treatments.

After emergence of the cloves, further growth of the plantlets was observed. The number of leaves per plantlet was recorded on 25 days after planting. The data revealed that the pre-planting temperature treatment has non

Table 1: Effect of pre-planting temperature treatment on the percentage of emergence of garlic cloves

Size of clove	Temperature	Emergence percent 15 DAP	20 DAP	25 DAP
Large	Room (27°C)	0.00g	0.00i	5.00e
	Low (8-10°C)	30.00a	31.67ab	35.00a
	High (40°C)	25.00ab	31.67ab	38.33a
	High-low	30.00a	33.33a	40.00a
	Low-high	8.33de	13.33efg	15.00d
Medium	Room (27°C)	3.33efg	3.33hi	3.33e
	Low (8-10°C)	31.67a	35.00a	40.00a
	High (40°C)	20.00bc	25.00bc	28.33b
	High-low	18.33c	21.67cd	25.00bc
	Low-high	10.00d	10.00fgh	15.00d
Small	Room (27°C)	0.56fg	3.33hi	3.33e
	Low (8-10°C)	17.78c	20.00cde	22.22c
	High (40°C)	11.11d	15.55def	20.00cd
	High-low	24.67a	25.55bc	25.55bc
	Low-high	6.67def	6.67ghi	8.89 e
Significance		*	*	*

Values with different letters within a column differ significantly at 5% level of significance (DMRT), DAP = Days After Planting.

Table 2: Effect of pre-planting temperature treatment of cloves on height, leaf number and appearance of garlic plantlets after 25 days of planting

Size of cloves	Temperature	Plantlet height (cm)	Number of leaves per plantlet	%normal plantlets
Large	Room (27°C)	0.00e	0.00	5.00fg
	Low (8-10°C)	7.67a	4.50	28.33a
	High (40°C)	4.67bc	5.17	33.33a
	High-low	6.17ab	5.67	33.33a
	Low-high	3.33cd	3.33	13.33cd
Medium	Room (27°C)	2.00d	1.00	0.00g
	Low (8-10°C)	5.83ab	4.67	33.33a
	High (40°C)	4.67bc	5.83	26.67a
	High-low	4.00c	5.00	20.00b
	Low-high	3.50cd	2.50	11.67de
Small	Room (27°C)	0.67e	1.00	0.00g
	Low (8-10°C)	7.33a	4.50	16.67bcd
	High (40°C)	5.83ab	4.83	13.33bcd
	High-low	5.00bc	5.67	18.89bc
	Low-high	3.83cd	2.83	6.66ef
Significance	*	*	*	

Values with different letters within a column differ significantly at 5% level of significance (DMRT)

Table 3: Effect of temperature on number of roots and root length of garlic

Size of clove	Temperature treatments	Root characters Number of roots	Root length (cm)
Large	Room (27°C)	0.00f	0.00c
	Low (8-10°C)	9.00ab	5.00ab
	High (40°C)	6.33cde	6.67ab
	High-low	8.00bc	5.50ab
	Low-high	4.33e	6.17ab
Medium	Room (27°C)	0.00f	0.00c
	Low (8-10°C)	8.00bc	7.00ab
	High (40°C)	8.33ab	4.83b
	High-low	8.00bc	6.00ab
	Low-high	5.00de	6.83ab
Small	Room (27°C)	0.00f	0.00c
	Low (8-10°C)	6.50cd	7.00ab
	High (40°C)	6.33cde	7.33a
	High-low	10.33a	7.17ab
	Low-high	6.00cde	4.67b
Significance		*	*

Values with different letters within a column differ significantly at 5% level of significance (DMRT) significant influence on number of leaves per plantlet (Table 2). However, the pre-treated cloves had considerably higher number of leaves per plantlet compared to the control.

The height of the plantlets developed from the pre-treated and control cloves was recorded at the final sampling on 25 DAP. Among the treatments, low temperature (8 to 10°C) produced the longest plantlet and the control cloves produced the shortest plantlets (Table 2). The low temperature treatment efficiently elongated stem of garlic plantlets from all three grades of cloves. A significant grading difference in plantlet height was documented at different temperature levels. The longest plantlets were found in large cloves treated with low temperature. However, low temperature, high temperature and the alternate high-low temperature treatments became comparable.

The plantlets were graded into normal and abnormal at the final recording (25 DAP) on the basis of their morphological view. Some of the plantlets were not growing normally. They had abnormal shoots. It was observed that the percentage of normal plantlets was significantly different at different treatments of temperature (Table 2). The maximum number of normal plantlets was found with low temperature whereas the alternate low-high temperature showed the minimum number of normal plantlets. However, the other treatments were comparable to the low temperature treatment in respect of producing normal plantlets. The effect between grades and different temperature levels on the percentage of abnormal plantlets was non-significant (data not shown).

Number of roots per plantlet was counted after careful uprooting of the plantlets at the final harvest and the result has been presented in Table 3. Different treatments of temperature under the study showed highly significant variations in the number of roots per plantlet. Among the treatment the highest number of roots per plantlet was found at alternate high-low temperature level in case of small sized cloves. Low-high alternate temperature treatment induced the lowest number of roots in all the three size groups of the cloves.

The variation of root length of the plantlets due to different temperature pre-treatments of the cloves was recorded at 25 DAP (Table 3). The longest root was observed at high temperature pre-treatments of the large and small cloves whereas the shortest root was found with alternate low-high temperature treatment of the small cloves. Three grades exhibited significant difference in root length at all the treatments.

Discussion

The present study was carried out to observe the effect of temperature on breaking dormancy of garlic. It reveals from the result that a continuous low temperature or a low temperature preceded by a high temperature (alternate high-low) is effective in breaking dormancy as was revealed by their highest emergence percentage. Cui *et al.* (1997) reported that chilling (5 or 8°C) of tissue cultured microbulbs for 0 to 6 weeks promoted sprouting after planting. Sprouting of >85% was observed after chilling at 8°C for four weeks. *In vitro* propagated microbulbs showed that the stored microbulbs at low temperature before planting helped breaking dormancy. Xiaodong *et al.* (1996) stored dormant garlic cloves (cv. Caijiapo) at 5, 20 or 35°C. Dormancy was broken earlier resulting highest sprouting percentages in cloves stored at 5°C; those stored at 35°C did not sprout. However, the low temperature and an alternate high-low temperature was found equally effective in inducing sprouting and breaking dormancy in the present study. A low temperature induced GA activity may be responsible for breaking dormancy in the present study. The optimum temperature for sprouting of garlic, is in the range of 10 to 12°C (Miedema, 1994). However, we found temperature below 10 can also be effectively used in breaking dormancy.

Number of leaves per plant did not differ significantly. However, the high temperature for 14 d or high temperature for 7 d followed by a low temperature for another 7 d had comparatively higher number of leaves per plant. Pre-planting cold treatment of the mother cloves was reported to be effective in generating higher number of leaves in garlic (Haque, 1989).

The longest plantlets were found in large cloves treated with low temperature. However, low temperature, high temperature and the alternate high-low temperature treatments became comparable. Siddique and Rabbani (1985) found that plantlet height was influenced by low temperature treatments that enhanced tallness of garlic plants. The tallest platlets of the cold treated cloves in the present study might be due to production of GA and other growth substances due to the cold treatment.

Low temperature pre-treatment for 14 d or the alternate high-low temperature, each for 7 d, induced number of roots/plant. An alternate low-high temperature treatment showed the lowest number of roots in case of large, medium and small sized cloves. In an experiment, 50% rooting of dormant onion bulbs was reported to be 10°C in the four cultivars investigated by Miedema (1994).

We report here that treatment of the mother cloves at a low temperature for 14 d or at an alternate high-low temperature, each for 7 d released dormancy in garlic. The cloves kept in normal temperature (control) failed to emerge within 25 d of planting indicating that the cloves are still dormant. Although the percentage of the emergence is low, it will be sufficient for the physiological and tissue culture experiments.

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