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Effect of leaf knotting practice in relation to source sink relationship on yield and quality traits in garlic (*Allium sativum*)*

ARPITA GANGULY[1] and G L BANSAL[2]

C S K Himachal Pradesh Krishi Vishvavidyalaya, Palampur 176 062

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Garlic (*Allium sativum* L.) is a versatile remunerative cash crop grown worldwide under varied agro-climatic conditions. It is an important bulb crop grown primarily as a spice or condiment. Garlic has higher nutritive value than the other bulb crops as it is rich in proteins, phosphorus, potassium, calcium, magnesium and carbohydrates and hence also finds its medicinal usage ranging from anti-carcinogenic to antibiotic effects and especially in treating intestinal diseases. Garlic is gaining popularity with farmers owing to good monetary returns and high market demand. In India, in spite of being a major garlic producing country but has very low productivity. The available data pertaining to 2007–08 shows that total area under garlic in India is 171.45 ha with a production of 923 million tonnes (NRCOG 2008). Looking at the demand of garlic in the home front as well as for export purposes, there is a need to enhance the yield by developing the cultivation technology. Maximum economic yield requires the optimum partitioning of photosynthates into the plant organs that constitute the economic yield. Appropriate relationship between source and sink, and their capacity leads to higher productivity. An optimum diversion of photosynthates into the plant organs can help in regulation of partitioning processes and thus management of source sink relationships.

One of the practices in some parts of India and particularly in Himachal Pradesh is to knot garlic leaves towards maturity, i e 15 to 20 days before harvest. The objective of the present study was to evaluate the effect of knotting of leaves on the partitioning efficiency of garlic yield, quality aspect and bulb storage life.

'GHC 1' garlic was grown during winter (*rabi*) season of 2003–04 under mid hill conditions of Himachal Pradesh. The site of study is 1 290 m above mean sea level situated at 32°N latitude and 76.3°S longitudes. The minimum temperature was 2.0°C and maximum 30°C. The annual rainfall in the area is 3000 mm and wind velocity ranged from 4.0 to 9.0 km/hr.

Recommended cultivation practices for the crop were followed. In one set of garlic plants knotting of leaves was done 4 weeks before harvest and in another set knotting of leaves was done 2 weeks before harvest. Nine plants were picked up at random from the plots at 14 days interval. The plants were washed and fresh weight of leaves and bulbs were recorded and dried in oven to record their dry weight.

Relative growth rate and partitioning coefficient of leaves and bulbs were calculated from plant dry weight. At harvest, bulb fresh and dry weight and yield were recorded. Polar and equatorial diameters were recorded with the help of vernier caliper.

Moisture content of the bulbs was determined following the oven drying method (AOAC 1970). Quality parameters, ie carbohydrate content was estimated according to methods, followed by Yemm and Willis (1954), sulphur content by Chestnin and Yien (1950), chlorophyll content of the leaves as per Hiscox and Israelstam (1979), anthocyanin by Ranganna (1986), ascorbic acid (AOAC 1970) and total carotenoids as per Roy (1973).

The garlic bulbs with (intact) and without leaves were cured and kept in laboratory at room temperature for 3 months to observe its storage life.

Knotting of leaves 2 weeks before harvest reduced leaf weight (7.68) significantly, followed by plants knotted 4 weeks before harvest (Table 1). The control plants produced maximum leaf weight (8.83). Partitioning coefficient of leaves was also maximum in control and minimum for plants knotted 4 weeks before harvest. Knotting of leaves significantly enhanced bulb fresh and dry weights, effect being more pronounced in plants where knotting was done 2 weeks before than 4 weeks treatment. Partitioning coefficient in bulbs in knotting 2 weeks before harvest was also maximum. Garlic plants knotted 4 weeks before harvest

*Short note

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[1]MSc student, [2]Professor of Plant Physiology (e mail: glbansal @hillagric.ernet.in)

Table 1 Effect of knotting of leaves on some parameters of growth, development and yield in garlic

Treatment	Leaf weight (g)		Bulb weight (g)		Days to maturity	Diameter of bulb (cm)		Partitioning coefficient		Yield (tonnes/ha)	Correlation coefficient
	Fresh	Dry	Fresh	Dry		Polar	Equatorial	Leaves	Bulbs		
Knotting 4 weeks before harvest	8.03	2.42	42.26	14.34	191.55	3.86	4.81	14.43	85.47	20.12	0.251*
Knotting 2 weeks before harvest	7.68	2.28	53.94	17.89	198.33	4.51	5.66	11.30	88.60	25.64	–0.970*
Control	8.83	2.85	35.03	12.60	203.88	3.25	4.45	18.44	81.46	18.68	0.936*
CD (*P*=0.05)	0.27	0.29	2.13	1.33	1.35	0.28	0.27	1.12	1.17	4.94	

P=0.05% level

matured earliest but produced low yields. Both polar and equatorial diameters were maximum in garlic knotted 2 weeks before harvest. The correlation between bulb weight and leaf weight was positive and significant for control plants and plants knotted 4 weeks before harvest but it was negative for plants knotted 2 weeks before harvest.

Knotting of leaves 2 weeks before harvest reduced leaf fresh (7.68) and dry weight (2.28) at harvest, while it was maximum in control plants (8.83 and 2.85). It would appear that knotting stopped the leaf growth and translocated the photosynthates to the bulbs while in the control plants the increase in leaf weight may be due to continuous leaf growth. Partitioning coefficient of leaves was also more in control garlic plants than knotted ones.

At harvest, bulb fresh and dry weight was more in plants knotted 2 weeks before harvest, followed by knotting treatments 4 weeks before harvest. Knotting of leaves perhaps restricted the leaf growth and diverted maximum assimilates to the developing bulbs. In a similar study on bulbous onion crop, Rosen and Tong (2001) reported an increase in bulb weight when scapes were removed from onion plants. The removal of scapes for higher bulb yield in onion by Hickey (2005) and garlic by Peter *et al*. (2000); and Rosen *et al*. (2010) has also been reported. Likewise, periodic removal of inflorescence improved fresh root and yield in safed musli possibly due to greater allocation of photosynthates to the sink (Kothari and Singh 2003). Bulb fresh and dry weight of garlic knotted 4 weeks before harvest restricted the photosynthesis and accumulation of threshold level of assimilates showing suppression in bulb weight. Knotting of garlic leaves resulted in an increase in the bulb yield and this increase was more pronounced in plants knotted 2 weeks before harvest. Kapka *et al*. (1973) also reported that delaying topping date in onion increased the bulb weight.

The results on knotting of garlic leaves revealed that knotting garlic at an appropriate time are infact of use in enhancing yield and quality of garlic. Thus, garlic plants knotted 4 weeks before harvest matured earliest but produced low yield than those treated 2 weeks before harvest. Infact, the manipulation of the source sink relationship at a proper time is the key for conservation of photosynthates in the economic parts. The ultimate yield depend on the translocation of assimilates from source to sink. Bhatt *et al*. (1998) also observed that garlic varieties that reached maturity earliest showed lowest yield. Both polar and equatorial diameter was increased by knotting garlic leaves 2 weeks before harvest. Brewster (1977) explained that as bulbing progress, leaf blades cease to form and scale leaves swell to form the inner storage tissue of the bulb thus increasing the bulb diameter.

The plants with leaves knotted 2 weeks before harvest showed minimum moisture and maximum dry matter, carbohydrate content was significantly high in plants knotted 2 weeks before harvest over 4 weeks before knotting treatment (Table 2). Sulphur, anthocyanin and ascorbic acid and total carotenoids were also significantly more in plants knotted 2

Table 2 Effect of knotting of leaves on some biochemical parameters in garlic

Treatment	Moisture content (%)	Carbohydrates (%)		Sulphur (%)		Total chlorophyll in leaves (mg/100 g)	Anthocyanin (mg/100 g)	Ascorbic acid (mg/100 g)	Total carotenoids (mg/100 g)
		Fresh	Dry	Fresh	Dry				
Knotting 4 weeks before harvest	67.42	3.14	16.36	0.15	0.27	9.16	0.24	8.29	24.14
Knotting 2 weeks before harvest	66.68	4.35	26.61	0.19	0.30	9.72	0.26	8.39	33.06
Control	65.25	3.47	20.78	0.11	0.24	10.23	0.22	6.96	22.71
CD (*P*=0.05)	2.16	0.26	1.56	0.015	0.02	0.65	0.023	1.03	4.59

Table 3 Effect of knotting of leaves on post-harvest per cent moisture loss in garlic during storage

Treatment	Time interval (days)											
	15		30		45		60		75		90	
	With leaves	Without leaves	With leaves	Without leaves	With leaves	Without leaves	With leaves	Without leaves	With leaves	Without leaves	With leaves	Without leaves
Knotting 4 weeks before harvest	2.48	1.74	3.35	3.30	4.66	5.93	5.51	6.94	7.52	8.36	9.55	10.19
Knotting 2 weeks before harvest	2.50	1.96	4.98	4.16	5.75	6.24	8.00	7.91	9.41	9.44	12.12	11.77
Control	2.01	1.05	3.82	4.13	4.20	5.31	5.90	6.81	8.43	8.82	9.48	9.95
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS						

weeks before harvest. Chlorophyll content slightly decreased in plants where leaves were knotted 4 week before harvest but remained unaltered in knotting of leaves done 2 weeks before harvest.

Garlic plants knotted 2 weeks before harvest showed maximum moisture loss, followed by plants knotted 4 weeks before harvest. There were no losses due to rotting or sprouting.

Moisture content was more (67.42%) in plants knotted 4 weeks before harvest, followed by control (65.25%) and plants knotted 2 weeks before harvest showed minimum moisture content. Carbohydrate content and sulphur in both fresh (4.35 and 0.19) and dry (26.61 and 0.30) garlic cloves was significantly maximum in plants knotted 2 weeks before harvest. Knotting of leaves 2 weeks before significantly enhanced the anthocyanin content but knotting treatments 4 weeks before did not significantly affect the anthocyanin content. Ascorbic acid and carotenoids content were also maximum in bulbs knotted 2 weeks before harvest. Nagai (1967) also established that the leaves of onion export minerals, nitrogenous compounds and carbohydrates to the bulb as they senescence.

Knotting of leaves 2 weeks before harvest showed maximum moisture loss (Table 3). The results were non-significant with both the treatments. In an earlier study Sharma *et al*. (2010) reported that knotting of leaves in garlic in this institution, however, did not affect the quality in terms of storage losses.

SUMMARY

The impact of knotting of leaves 2 to 4 weeks before harvest on yield, quality and bulb storage life of garlic was investigated. Knotting of leaves was done 4 weeks before harvest in one set of garlic plants and 2 weeks before harvest in another set. The maximum benefits for all criteria were observed for plants knotted 2 weeks before harvest. This treatment increased the bulb fresh and dry weight and advanced maturity than control. Leaf fresh and dry weights were more in control plants. Knotting of leaves 2 weeks before harvest increased both polar and equatorial diameters. The treatment enhanced bulb yield in plants knotted 2 weeks before harvest. It also enhanced the carbohydrates, sulphur, ascorbic acids, carotenoids and anthocyanin pigment of the bulb, which enhanced its marketability. Garlic knotted 2 weeks before harvest showed maximum moisture loss during storage. There were no losses due to rotting or sprouting.

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