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Effect of pre-harvest treatments and indigenous practices on enhancing storage life of garlic (*Allium sativum*)*

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Garlic (*Allium sativum* L.) is vegetatively propagated through the division of bulbs into bulblets called cloves and through aerial bulbils. Garlic has antibacterial (Arora and Kaur 1999), antifungal (Hughes and Lawson 1991), antiviral (Meng *et al.* 1993) and antiprotozoal (Reuter *et al.* 1996) activity; is beneficial to the cardiovascular and immune system and has antioxidant and anticancer properties (Harris *et al.* 2001). During storage under ordinary conditions, losses due to rotting, sprouting and drying can occur. During times of oversupply at harvesting time in May–June, market price is reduced. It is necessary to increase shelf-life without compromising quality so that supply can be maintained and producers receive a fair profit. Maleic hydrazide, the commonly used growth inhibitor for extending shelf-life of garlic has been banned since 2004. Therefore, it is imperative to study other chemicals and local/indigenous practices, viz knotting of tops of garlic plants about 1 month before harvest and hanging of bulbs. The effect of these practices on post-harvest storage quality is not well understood. The present study was undertaken to determine to improve the storage life of garlic bulbs under ambient temperature conditions and making the produce available for sale during lean period. This would in turn stabilize the prices in the market and can bring remunerative returns to the farmers.

The cloves of 'GHC 1' garlic variety were sown in 51 plots of size 3.0 m × 2.7 m with inter- and intra-row spacing of 20 cm and 15 cm, respectively, during the first week of October 2005 at Vegetable Research Farm, Department of Vegetable Science and Floriculture, Himachal Pradesh Agricultural University, Palampur (32° 8′N latitude and 76° 3′E longitude at an elevation of 1, 296 m above mean sea level with clay soil having soil *p*H 5.7) and High Hill Agricultural Research and Extension Centre, Bajaura, Kullu (30° 5′N latitude and 77° 2′E longitude at an elevation of 1 090 m above mean sea level with sandy loam soil having soil *p*H 6.8). The treatment combinations comprised knotting garlic tops one month prior to harvesting (indigenous practice) and no knotting of garlic tops, followed by application of iron sulphate and borax @ 500, 1 000 and 1 500 ppm and maleic hydrazide @ 2 000 ppm (check) each two weeks prior to harvesting of bulbs, indigenous practice of hanging bulbs and no chemical spray on both knotting and no knotting plots (checks). These 17 treatments were evaluated in randomized complete block design, replicated thrice for storage life of garlic bulbs during 2005–06 in both the locations. The bulbs after harvested in June were cured in open for 1 week, followed by curing in shade for 10 days with tops. After curing, tops were cut except indigenous practice of hanging bulbs leaving 2.5 cm of the stalk. These cured bulbs were stored under ambient temperature conditions from June to October and periodic storage losses were recorded up to October.

The data were recorded on physiological loss of weight (total weight loss in storage due to moisture loss or any infection or sprouting), incidence due to rotting (fungal and bacterial), drying and sprouting of bulbs in storage at an interval of 1 month from June to October in both the years at both the locations and is converted into per cent. The data were analyzed by using arc sine and square root transformations by following standard procedure (Gomez and Gomez 1984).

On the basis of results obtained pertaining to storage life of garlic bulbs, no significant differences in storage up to July end were observed and thereafter, significant effects were noticed on storage life. Significant minimum loss in physiological weight was observed in treatment of hanging bulbs up to October at pooled over locations (Table 1). Amongst the chemical treatments, application of borax @ 1 000 ppm showed minimum physiological weight loss at par with that of maleic hydrazide application in both combinations of knotting or no knotting of tops but had significant low weight loss over no chemical application at

*Short note

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Table 1 Effect of different treatments on storage life of garlic bulbs during 2005–06 at Palampur and Bajaura (pooled data)

Treatment		Physiological loss of bulb weight (%)			Sprouting incidence (%)		Rotting incidence (%)	Dry bulb incidence (%)
		Aug. end	Sept. end	Oct. end	Sept. end	Oct. end	Oct. end	Oct. end
T_1	Knotting + iron sulphate @ 500 ppm	10.40 (3.36)	18.70 (4.43)	31.07 (33.81)	5.31 (2.49)	20.83 (4.67)	2.78 (1.94)	3.51 (2.10)
T_2	No knotting + iron sulphate @ 500 ppm	10.96 (3.43)	18.50 (4.40)	31.89 (34.31)	4.74 (2.39)	19.54 (4.53)	2.82 (1.94)	4.18 (2.26)
T_3	Knotting + iron sulphate @ 1000 ppm	10.27 (3.34)	18.24 (4.38)	30.80 (33.66)	4.73 (2.38)	18.99 (4.46)	2.73 (1.92)	4.10 (2.25)
T_4	No knotting + iron sulphate @ 1000 ppm	11.25 (3.49)	17.70 (4.32)	31.86 (34.33)	3.94 (2.22)	18.38 (4.40)	2.87 (1.96)	4.00 (2.23)
T_5	Knotting + iron sulphate @ 1500 ppm	12.02 (3.60)	20.28 (4.60)	34.23 (35.77)	5.16 (2.46)	18.86 (4.45)	2.95 (1.98)	3.66 (2.15)
T_6	No knotting + iron sulphate @ 1500 ppm	12.40 (3.65)	20.58 (4.63)	36.64 (37.20)	5.16 (2.47)	18.12 (4.36)	3.13 (2.02)	3.70 (2.16)
T_7	Knotting + Borax @ 500 ppm	8.89 (3.14)	14.81 (3.97)	28.60 (32.30)	2.86 (1.96)	15.40 (4.05)	3.17 (2.04)	4.43 (2.32)
	No knotting + Borax @ 500 ppm	9.91 (3.30)	14.06 (3.87)	29.11 (32.62)	3.21 (2.04)	14.95 (3.99)	3.04 (2.00)	3.52 (2.11)
T_8	Knotting + Borax @ 1000 ppm	9.94 (3.30)	14.20 (3.89)	26.74 (31.11)	1.66 (1.62)	13.98 (3.87)	1.90 (1.70)	1.97 (1.71)
T_9	No knotting + Borax @ 1000 ppm	9.62 (3.26)	15.16 (4.01)	26.51 (30.95)	2.00 (1.72)	13.72 (3.83)	2.05 (1.74)	2.23 (1.79)
T_{10}	Knotting + Borax @ 1500 ppm	10.91 (3.44)	16.90 (4.21)	33.40 (35.28)	3.24 (2.03)	16.91 (4.22)	2.63 (1.90)	4.10 (2.24)
T_{11}	No knotting + Borax @ 1500 ppm	11.19 (3.48)	16.09 (4.12)	32.40 (34.66)	3.10 (2.00)	16.15 (4.17)	3.19 (2.05)	4.23 (2.27)
T_{12}	Knotting + MH @ 2000 ppm (C)	8.02 (3.00)	12.98 (3.73)	26.90 (31.21)	2.11 (1.76)	13.69 (3.81)	2.00 (1.72)	2.44 (1.85)
T_{13}	No knotting +MH @	9.04 (3.16)	13.39 (3.79)	27.06 (31.28)	2.10 (1.76)	12.77 (3.70)	1.98 (1.72)	2.96 (1.98)
T_{14}	Knotting + no spray (C)	11.48 (3.51)	17.99 (4.35)	34.90 (36.18)	5.86 (2.60)	21.32 (4.72)	3.26 (2.06)	4.98 (2.44)
T_{16}	No knotting + no spray (C)	11.44 (3.52)	16.46 (4.15)	37.38 (37.66)	6.68 (2.77)	22.10 (4.80)	3.53 (2.13)	5.69 (2.56)
T_{17}	Hanging bulbs	1.96 (1.60)	5.64 (2.55)	12.73 (20.65)	0.55 (1.22)	4.26 (2.29)	0.00 (1.00)	0.00 (1.00)
	CD ($P \leq 0.05$)	0.28	0.34	1.82	0.28	0.30	0.17	0.25

MH and C represent maleic hydrazide and check, respectively; Values in the parentheses are arc sine and square root transformed

both the locations. Borax helps in reducing membrane plasticity that checks the inflow of substances and nutrients, and thereby reduces the rate of respiration and transpiration in the storage.

It is pertinent to mention that the indigenous practice of hanging bulbs had shown about 2 times less weight loss over the borax and maleic hydrazide application at both the locations and pooled over locations, while these losses were to the tune of about 3 times less over no spray. Further, it was noticed that application of borax and maleic hydrazide resulted in 25% less weight loss over no chemical spray in pooled over locations up to October. This might help in enhancing the shelf-life of garlic bulbs. Hardenburg *et al.* (1986) in garlic while Goburdhun (1995) and Benkeblia (2004) in onion reported enhanced shelf-life through pre-harvest application of maleic hydrazide. Similarly, Adamicki (2005) reported that storage temperature and maleic hydrazide treatments not only have an influence on marketable amount of onion after storage period but also on further shelf-life by reducing sprouting and rotting.

The sprouting incidence was observed in September and increased afterwards (Table 1). Indigenous practice of hanging bulbs resulted in significant low sprouting incidence up to October over all other treatments, which was about five times less over no chemical spray and 3 times over borax and maleic hydrazide application at both the locations. Application of borax @ 1000 ppm showed sprouting incidence at par with that of maleic hydrazide but it was significantly less than that of no chemical application. Application of these chemicals reduced sprouting incidence to the tune of about 40% over no chemical application, thus indicating the importance of these chemicals in prolonging the post-harvest life of garlic under storage.

It was interesting to note that storage losses were at par in treatments, irrespective of knotting or no knotting of tops (Table 1). Thus, it suggests that there is net saving of labour charges by not using knotting practice. Similarly, treatment of hanging bulbs had shown no incidence of rotting and drying of bulbs, which further indicated its superiority over all other treatment combinations of chemical application. Good airflow might have resulted in minimum weight loss and incidence of drying, sprouting and rotting of bulbs. Application of borax @ 1 000 ppm also resulted in

Table 2 Economics of different treatments of storage of garlic bulbs during 2005–06 at Palampur and Bajaura (pooled data)

Treatment	Loss of physiological weight (%)		Bulb yield after storage (tonnes/ha)		Gross returns (Rs in lakhs)		Advantage over June harvest (Rs in lakhs)	
	Sept.	Oct.	Sept.	Oct.	Sept.	Oct.	Sept.	Oct.
Knotting + spray of Borax @ 1 000 ppm	14.20	26.74	12.9	11.0	5.16	5.5	1.36	1.70
No knotting + spray of Borax @ 1 000 ppm	15.16	26.51	12.7	11.0	5.08	5.5	1.32	1.74
Knotting + no spray (C)	17.99	34.90	12.3	9.8	4.92	4.9	1.12	1.10
No knotting + no spray (C)	16.46	37.38	12.5	9.4	5.0	4.7	1.25	0.95
Hanging bulbs	5.64	12.74	14.2	13.1	5.68	6.55	1.83	2.70

*Average bulb yield is 150 q/ha in Himachal Pradesh (India) and sold at a premium of Rs 2 000/q in June, while the rates from September onward remains around Rs 4 000–5 000/100 kg.

significantly low incidence of rotting and drying of bulbs similar to that of maleic hydrazide but significantly lesser over no spray. The incidence of rotting and drying of bulbs were significantly less in knotting of tops with borax @ 1 000 ppm and maleic hydrazide application while sprouting incidence also exhibited the similar trend in the former treatment. This indicated that knotting of tops might have resulted in better physiological drying of neck that resulted in narrow neck formation. This further helped in reducing the physiological processes of respiration and transpiration along with checking the invasion of fungi and resulted in low incidence of rotting, drying and sprouting of bulbs under ambient storage conditions.

Hanging bulbs had significant effect on the gross returns /ha with an additional advantage of about Rs 1 75 000 and Rs 1 00 000 over normal storage in net bags and borax application, respectively by selling the produce during October end in comparison to June immediately after harvest (Table 2). On the other hand, it was observed that the application of borax gave a net gain to the tune of Rs 79 000 over no chemical spray. Further, it was observed that delaying the storage up to October though had more loss of physiological weight but had advantage in terms of monetary gains. Application of borax involved an additional cost of Rs 1 000/ha only, which includes cost of Rs 300 of borax (750 g) and Rs 700 for spraying the chemical.

It can be concluded that indigenous practice of hanging bulbs in storage is beneficial for enhancing the shelf-life of garlic bulbs which resulted in minimum loss of weight and incidence of sprouting, rotting and drying of bulbs under ambient conditions. Large-scale storage of garlic bulbs can be a limitation in adopting this practice for want of space. However, it can be a suitable preposition for storage of garlic bulbs on small scale either for seed purposes or for sale during lean periods. However, application of borax @ 1000 ppm 2 weeks prior to harvesting can be beneficial for large-scale storage of garlic bulbs.

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SUMMARY

A suitable storage technique for enhancing shelf-life of garlic bulbs can help in reducing oversupply and stabilize prices. This can further provide an opportunity to the growers to sell their produce during lean period which results in high net returns. Therefore, to study the storage life of recommended garlic cultivar 'GHC 1', an experiment consisting of 17 treatment combinations was evaluated at 2 different locations of Himachal Pradesh, namely Palampur and Kullu. Treatments comprised knotting tops one month prior to harvesting (indigenous practice) and general practice of no knotting of tops, followed by application of iron sulphate and borax @ 500, 1 000 and 1 500 ppm and maleic hydrazide @ 2000 ppm (check) each 2 weeks prior to harvesting of bulbs, indigenous practice of hanging bulbs and no chemical spray on both knotting and no knotting plots under ambient temperature storage conditions in a dark room. The indigenous practice of hanging bulbs in storage significantly resulted in minimum loss of weight and incidenceof sprouting, rotting and drying of bulbs compared to all other treatments. On the other hand, application of borax @ 1 000 ppm was effective in reducing physiological loss of weight up to October to the extent of 25% over no chemical application and also recorded low incidence of sprouting, rotting and drying of bulbs. The use of borax could be beneficial for minimizing the storage losses for large-scale storage of garlic bulbs, while indigenous practice could be a suitable preposition for small-scale storage compared to no chemical spray by selling the bulbs during October end.

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