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Influence of Different Harvesting Times on Shelf Life of Garlic

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ABSTRACT

The present investigation was executed at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during rabi 2013-14 to study the effect of different time of harvesting on shelf life of garlic (Allium sativum L.). In the concerned experiment, Randomized Block Design with four replications was used, where five treatments of harvesting time viz., harvesting the garlic crop 150, 157, 164, 171 and 178 days after planting were applied. The observations were recorded on storage characteristics like physiological loss in weight (%), decay loss on both number and weight basis (%), per cent sprouting on number as well weight basis, average sprout length (cm) and weight (mg). The lowest value for physiological loss in weight (21.69%), decay loss on both number and weight basis (1.53 and 1.36%) was observed in treatment where harvesting was done at 178 days after planting as compared to treatment where harvesting was done at 151 days after planting while per cent sprouting on both number and weight basis (15.38 and 12.62%), sprout length (1.33 cm) and sprout weight (53 mg) was observed minimum in treatment where harvesting was done at 171 days after planting which was found statistically at par with treatment where harvesting was done at 164 and 178 days after planting. Therefore, based on the present study it may be concluded that for better storage of garlic, harvesting should be done at 164 days after planting.

Key words: *Garlic, bulb, harvesting time, losses, storage characteristics*

INTRODUCTION

Garlic (*Allium sativum* L.) is an herbaceous annual and the second most important bulb crop after onion. It originated in Central Asia and later spread to Mediterranean region[27]. Its pungent flavour makes it used mainly as a spice, seasoning and flavoring for foodstuff involving both green tops and bulbs. Its medicinal value is also well recognized in the control and treatment of hypertension, worms, germs, bacterial and fungal diseases, diabetes, cancer, ulcer, rheumatism, *etc*.[15]. Its cultivation has been encouraged in India on commercial scale due to its multiple uses and export potential. It is grown in many countries, like Egypt, United States of America, China, India, Korea, Thailand, France, Spain, *etc*. The area and production of garlic in India during 2012-2013 was 230.5 thousand hectares and 1251.88 thousand MT with productivity of 5.43 t/ha, respectively[1] contributes 14% of the world area and 5% of the production.

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India is the second largest producer of garlic after China and a major exporter of bulb, dehydrated flakes, powder, oil and oleoresins all over the world. It is grown on large scale in Madhya Pradesh, Gujarat, Orissa, Rajasthan, Karnataka, Tamil Nadu, Maharashtra, Bihar, *etc*. Madhya Pradesh is the leading state since it is contributing 30% of the total production of garlic in India. In Haryana, garlic-growing districts are Kurukshetra, Ambala and Karnal.

Garlic exhibits greater susceptibility to agro-techniques and environmental conditions and possesses a wide range of variability in bulb and yield traits as well as storability in spite of being vegetatively propagated crop. In Haryana, garlic is gaining increasing popularity during recent years on accounts of higher returns and least problems in its cultivation. Here, it is planted in September-October and harvested in April-May. Identification of optimum time of harvesting is very important for better storage of garlic. Physiological loss in weight (PLW), sprouting and rotting are the main causes of losses during storage, and adverse weather conditions affect its quality and storability. Sometimes, farmers harvest the crop early to fetch better price but early harvesting results in poor quality bulbs, which cannot be stored longer. The garlic crop usually considered ready for harvesting when the tops turn yellowish or brownish since harvesting of crop at this stage gives good quality bulb with better keeping quality. Garlic becomes ready for harvesting when the tops are dry and the neck begins to soften and partly dry[14]. Delayed harvesting also leads to splitting as well as sprouting of bulb, which also affect storage life adversely. Excessive drying of outer skin because of delayed harvesting causes splitting and cracking of outer skin during packaging and handling, due to which, a large quantity of garlic goes waste every year. Therefore, farmers do not store bulbs on large scale and sell their produce in glut season even at throwaway price. However, prolonging storage life results in remunerative price to both producer and traders, which makes garlic available to the consumer in off-season. The time of harvesting of garlic is also governed by is subsequent uses. Therefore, it is important to select a suitable time of harvesting the crop for obtaining better shelf life of garlic. The objective of study was to standardize the time of harvesting for better storage life of garlic.

MATERIALS AND METHODS

The experiment was carried out at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *rabi* season 2013-14. The general features of this region are semiarid climate with hot and dry winds during summer and dry severe cold in winter. During whole experimental period the maximum temperature was ranged between 19.5 to 41.0 °C, while the minimum was ranged between 5.6 to 26.9 °C. The soil of the experimental field was sandy loam in texture with pH and EC of 8.2 and 0.39 dS/m, respectively. The soil was having available nitrogen, phosphorus and potassium (129, 21 and 291.61 kg/ ha, respectively). The planting of garlic cultivar HG-17 was done on October 25, 2013. The experiment was laid out in Randomized Block Design. Five treatments of harvesting were applied *viz*., harvesting the crop 150, 157, 164, 171 and 178 days after planting replicated four times in well-ploughed beds of 4 × 4 m^2 size with a planting distance 15 cm × 10 cm. A basal dose of well rotten farmyard manures @ 15 tonnes/ha was incorporated in the soil before one month of planting. In addition to this, a uniform dose of 80 Kg N through urea, 50 kg P_2O_5 through SSP (single super phosphate) and 25 kg K_2O through MOP (muriate of potash) per hectare was applied for better growth and proper nutrition of garlic. The half amount of nitrogen with full doses of P_2O_5, K_2O were applied at the time of planting, while remaining nitrogen was top dressed at 30 day after planting. Irrigation was applied at 10 to 15 days interval and last irrigation was given 15 days before harvesting. First hoeing was given 20 days after planting. Two more hoeing were given at 40 and 65 days after planting to control the weeds. The recommended plant protection

measures were adopted as and when required for raising healthy crop. Harvesting was done manually by hand digger on March 24, April 1, 8, 16 and 23, 2014 according to treatments. The observations were recorded on storage characteristics like cumulative physiological loss in weight (%), decay loss on both number and weight basis (%), per cent sprouting on number as well weight basis, average sprout length and weight after curing of 20 days. The cumulative PLW, decay loss on number as well as weight basis was recorded at 20 days interval. The sprouting (%) on number as well weight basis, average sprout length (cm) and sprout weight (mg) was recorded at the end of storage period, *i*.e., 240 days. The data recorded on different parameters were subjected to statistical analysis in OPSTAT, statistical software developed by CCS Haryana Agriculture University, Hisar (Haryana), India[25] and the mean differences were evaluated by critical difference (C.D.) test at 5% level of significance.

RESULTS AND DISCUSSION

Due to loss of moisture from the garlic bulbs through the process of transpiration, the cumulative physiological loss in weight (PLW) increased significantly with the advancement of storage period (Table 1). The data regarding physiological loss in weight of garlic were recorded at 20 days interval during storage period of 240 days and expressed as cumulative physiological loss in weight in percentage. The perusal of data presented in Table 1 reveals that the physiological loss in weight increased consistently with the increase in storage period from starting to end of the experiment. The rate of loss was very rapid in the starting of experiment, but thereafter, it decreased slowly up to the end of storage period (240 days) in all the treatments of harvesting time. The physiological loss in weight of garlic exhibited a significant variation among all the treatments of harvesting time (Table 1). The lowest value for cumulative physiological loss in weight (21.69%) was registered with treatment where harvesting time was 178 days after planting.

Table 1: Effect of harvesting time on cumulative physiological loss in weight (%) of garlic bulbs recorded at 20 days interval during storage

Treatment/ harvesting time (days after planting)	**Storage period (days)**											
	20	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**
150	20.81	21.73	22.73	24.25	26.23	27.30	28.51	29.56	30.72	31.74	32.50	33.32
157	17.57	19.50	21.37	22.97	23.60	24.81	26.17	27.98	28.86	30.35	31.31	31.64
164	14.04	16.46	18.19	19.38	20.47	21.49	22.39	23.36	24.28	25.20	26.45	28.50
171	11.21	13.79	14.78	16.19	17.16	18.38	19.97	21.03	22.04	22.97	24.06	25.20
178	7.05	8.23	9.44	10.80	12.78	14.46	15.54	16.34	17.78	18.45	20.76	21.69
C.D. at 5% level of significance	**1.47**	**1.77**	**1.71**	**1.67**	**1.76**	**1.77**	**1.11**	**0.79**	**0.81**	**0.91**	**0.83**	**2.79**

The results are in close conformity with the results of Sargent *et al*[24]., who reported that the fully developed onion bulbs lost least weight since the state of maturity greatly influenced the weight loss during storage. The highest (33.32%) was noted at the end of storage period where the harvesting was done 150 days after planting. The results are in close confirmatory with the results of Apeland[2], Kumar and Sung[17], Vazquez-Barrios *et al*[32]., Nuevo and Bautista[19] and Portela *et al*[20]., who noticed greatest weight loss when

the crop was harvested early. On the contrary, Colby *et al*[7]., observed lesser storage losses in early than the late maturing onion. Rubatzky and Yamaguchi[23] also observed loss in dry matter and moisture content during storage because of utilization of carbohydrates in respiration, which is in agreement with the current results. The external factors affecting the transpiration are air temperature, humidity and air circulation in storehouse. The reason for PLW during storage might be utilization of reserve food material in respiration[31]. Further, Tucker and Drew[30] also stated that the weight loss might be resulted from desiccation of bulb. More losses observed during earlier part of the storage might be due to increased water loss and respiration because of higher temperature and low humidity[3,21]. According to Simekova and Horcin[26], the respiration rate was negatively correlated with storability and positively correlated with weight loss in storage. The maximum weight loss in treatment where early harvesting was done might be due to immaturity and maximum water content of the bulbs. The contents of constituents in bulbs during storage increased with the decrease in moisture content. The results are in line with the findings of Chung[6] and Hassan[10] who reported that higher moisture content in bulb increases wastage during storage of onion.

Microbial spoilage together with water loss and biochemical changes is responsible for the deterioration of freshly harvested produce during storage[8]. Decay loss on number and weight basis (Table 2 and Table 3) showed a decreasing trend with delay in harvesting. The decay loss might be due to vulnerable nature of garlic bulbs to different disease causing organisms and the attack of pests during storage or carried over from the field, which got sufficient time to multiply and grew with increasing storage period. No significant decay loss on both number and weight basis was recorded from starting to 200 days of storage period. Only slight decay loss was observed at 220 days onwards in all the treatments of harvesting time. The results are in line with the findings of Chavan[5] and Menniti[18] who stated that decay loss of onion bulbs increased with the lengthening of storage period due to the attack of fungi *viz*., *Aspergillus niger*, *A. tumigatus, pennicillium rubrum* and *Fusarium* spp., and bacterium, *i*.e., Erwinia *carotovora*.

Table 2: Effect of harvesting time on decay loss (%) during storage (on number basis)

Treatment/ harvesting time (days after planting)	**Storage period (days)**											
	20	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**
150	0	0	0	0	0	0	0	0	0	0	2.48	2.66
157	0	0	0	0	0	0	0	0	0	0	2.21	2.38
164	0	0	0	0	0	0	0	0	0	0	1.92	2.09
171	0	0	0	0	0	0	0	0	0	0	1.68	1.86
178	0	0	0	0	0	0	0	0	0	0	1.30	1.53
C.D. at 5% level of significance	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.21**	**0.22**

The minimum decay loss on both number and weight basis (1.53 and 1.36%) at the end of storage period, *i.e.*, 240 days was recorded where harvesting time was done 178 days after planting, which differed significantly from all other treatments of harvesting time and the maximum (2.66 and 2.37%) was noted when harvesting was done 150 days after planting.

Table 3: Effect of harvesting time on decay loss (%) during storage (on weight basis)

Treatment/ harvesting time (days after planting)	Storage period (days)											
	20	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**
150	0	0	0	0	0	0	0	0	0	0	2.28	2.37
157	0	0	0	0	0	0	0	0	0	0	2.01	2.15
164	0	0	0	0	0	0	0	0	0	0	1.75	1.92
171	0	0	0	0	0	0	0	0	0	0	1.51	1.69
178	0	0	0	0	0	0	0	0	0	0	1.22	1.36
C.D. at 5% level of significance	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.23**	**0.18**

The results are in close confirmatory with the findings of Woldetsadik and Workneh[33] who reported that in mature onions, as the foliage dries, the neck shrinks with good closure that reduces incidence of diseases and improves storage longevity. Sargent *et al*[24]., reported that the maximum storage life and least rotting in storage occurred when the onion bulbs were harvested after complete drying of foliage. The similar results have also been reported by Romanowski[22], Nuevo and Bautista[19], Portela *et al*[20]., and Hoyle[12] who stated that decaying and total losses were lowest in onion harvested with tops either down and green or up and green. The reason for maximum decay loss on weight and number basis because of earlier harvesting might be that the bulbs had high moisture content and were more prone to be attacked by fungi and bacteria because of that they had relatively short shelf life also[33].

Some of the undesirable changes that may occur during sprouting are weight loss, shrinkage and loss of nutritive value. The sprouting behaviour of garlic bulbs was studied on weight as well as number basis, average sprout length and sprout weight at the end of storage period, *i.e*., 240 days. The sprouting behaviour of garlic bulb was significantly influenced by different treatments of harvesting time (Table 4 and 5, respectively). The trend followed by data shows that the sprouting (%) of garlic cloves decreased with the delay in harvesting. Transpiration, respiration, microbial infection, physiological disorders like watery scales[11], rooting and sprouting are the major causes of losses during storage[29]. Sprouting is a very serious problem in garlic crop after 4-5 months of storage under ordinary room conditions since the dormancy starts breaking due to the conversion of inhibitor (ABA) to the promoter (GA_3). Proper curing allows the bulbs to develop tough skin and cause shrinking and closing of neck, which limits the exchange of gases and reduces the oxygen availability, which is essentially required for shoot growth and emergence. The induction of dormancy might be due to the translocation of growth inhibitory substances from leaves to the onion bulbs at crop maturity and curing[16].

Table 4: Effect of harvesting time on sprouting (%) at 240 days of storage (on number and weight basis)

Treatments/time of harvesting (days after planting)	Sprouting (%)	
	Number basis	**Weight basis**
150	23.84	18.51
157	20.72	16.17
164	17.72	14.08
171	15.38	12.62
178	15.78	12.89
C.D. at 5% level of significance	**2.48**	**1.84**

The per cent sprouting on number and weight basis (15.38 and 12.62%), average sprout length (1.33 cm) and sprout weight (53 mg) were recorded minimum with treatment harvesting time 171 days after planting at the end of storage period, while all four (23.84 and 18.51%, 1.61 cm and 61 mg, respectively) were observed maximum in treatment where harvesting was done 150 days after planting. The results are in accordance with the findings of Nuevo and Bautista[19], Komochi[16], Suojala[29] and Portela *et al*[20]. Further, Kumar and Sung[17] also stated that sprouting and weight loss were comparatively slower in cv. Ho-mei, when bulbs were harvested at over-mature stage after 100% drying of foliage. On the contrary, Brecht[4], Grieve[9], Apeland[2] and Kamenetsky[14] stated that late harvesting at over-mature stage was symbolized by bulb-wrapper scale destruction, splitting of cloves, sprouting (if harvesting coincides with rain), a defective colour and poor storability. Another reason for more sprouting in treatments where the crop was harvested at early stage might be that the bulbs harvested at immature stage took more time to be dry than the bulbs harvested at mature stage and their neck remained soft because of that the inner leaves continued to grow[13].

Table 5: Effect of harvesting time on average sprout length (cm) and weight (mg) at 240 days of storage

Treatments/time of harvesting (days after planting)	Average sprout length (cm)	Average sprout weight (mg)
150	1.61	61
157	1.52	59
164	1.39	56
171	1.33	53
178	1.36	55
C.D. at 5% level of significance	**0.07**	**3**

The onion bulbs that were harvested before 50% maturity resulted in high storage loss and a high level of sprouting[29], which is in accordance with the sprouting inhibitors hypothesis of Stow[28] who found that the substances, which are responsible for dormancy, are produced in leaves and translocated to the onion bulbs during later part of the growing season, hence, if harvesting is done too early, too little the sprouting inhibitor is translocated to the growing point of bulb, conversely, too late harvesting can destruct the inhibitor, which means that too early and late harvesting may lead to severe sprouting.

Different harvesting times also affected soil moisture content. The data regarding soil moisture content (%) were significantly influenced by harvesting time at different days after planting (Table 6).

Table 6: Effect of harvesting time on soil moisture content (%) at the time of harvesting

Treatments/time of harvesting (days after planting)	Soil moisture content (%)
150	12.43
157	11.84
164	10.58
171	9.78
178	9.37
C.D. at 5% level of significance	**0.27**

The perusal of data reveals that the maximum soil moisture content (12.43%) was registered with treatment where harvesting was done 150 days after planting, while the minimum soil moisture content (9.37%) was recorded in treatment where the time of harvesting was 178 days after planting.

CONCLUSION

Based on the present study, it may be concluded that for better storage of garlic, harvesting should be done at 164 days after planting.

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