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Effect of exogenous application of phytohormones and fungicides on yield, quality storability and economics of garlic (*Allium sativum* L.)

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Abstract

In garlic, compactness, firmness and healthy state are important quality attributes that determine market value and consumer preference. Phytohormones (cycocel and ethrel) and fungicides (carbendazim and benomyl) are known to play important role in checking post-harvest losses like physiological weight in loss (PLW), rotting, sprouting etc in long stored crops. Main aim of the study was to investigate the effects of their preharvest application on growth, yield, quality and storability of garlic cv. Agrifound Parvati. Results suggested that exogenous application of CCC at 1000 ppm applied at 90 days (bulb development stage) and 150 days (50% neck fall stage) significantly increased growth and yield related parameters in garlic. This hormone maintained higher levels of sulphur content after harvest, which proved helpful in reducing PLW of bulbs significantly during ambient storage period of 4 months. Economically, cost benefit ratio in this treatment was high, both at harvest and after storage as compared to other treatments and control. Fungicides on the other hand, had more or less similar effect on growth and yield parameters but showed significant effect on post-harvest losses of garlic as compared to control. Hence, application of CCC at critical stages of alliums can be tried for reducing post-harvest losses during long periods of ambient storage.

Key words: Garlic, phytohormones, fungicides, yield, quality, storability, economics**.**

Introduction

India produced 16.93 lakh MT of garlic over an area of 3.2 lakh ha during 2016-17 (Anonymous 2018). J&K state has a commendable area under Allium production but in spite of that, per capita availability of garlic is quite low because of post-harvest losses which account for about 25% to 30% of production as per ICAR Vision 2030. Besides, quality of a sizable quantity of produce also deteriorates by the time it reaches the consumer. This is mainly because of perishable nature of the produce which requires maintaining the quality and extending the shelf-life, if consumption is not meant immediately after harvest. Due to excessive post-harvest losses, the farmers are forced to sell garlic immediately after harvest which results in low price realization. Garlic bulbs are normally stored at ambient temperatures after harvest (April-September) and there is a sequence of physiological and biochemical changes occurring in the bulbs during this period. These months experience high temperatures and relative humidity which cause heavy damage and physiological loss in weight at rapid rates. To check these losses, phytohormones like CCC and ethrel can improve/ modify the growth of plants and help in maintaining biochemical and physiological state of the bulbs at harvest and during storage (Grossman 1990 and Moore 1980). These hormones are organic substances, which are produced naturally in plants, synthesised in one part and usually translocated to other part where in every small quantity affect the growth and other physiological function of the plants (Thimone 1948).Exogenous application of growth hormones have shown good results in other crops with respect to growth, yield and storage (Prakash et al. 2003 and Memane et al. 2008).

Long storage of bulbs also promotes storage rots, surface moulds caused by *Aspergillus* and *Penicillium* spp. (Gubb and MacTavish 2002). Fungicides like carbendazim and benomyl have greatly facilitated the maintenance of bulb quality in storage with respect to sprouting and rot losses. These chemicals are often used to control fungal infections in vegetable seeds and other crop seeds during storage. Keeping in view the above mentioned problems, the present study was conducted to observe and evaluate the effect of some pre-harvest treatments of phyto-hormones and fungicides in

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increasing yield, quality and storage life of garlic bulbs under subtropical conditions.

Materials and Methods

The present investigation was carried out at Advanced Centre for Horticultural Research, Udheywalla, SKUAST, Jammu during 2015-16.The area falls in subtropical zone of Jammu and Kashmir $32^0 40^1$ North Latitude and 74^0 58^1 East longitudes at an elevation of 332 m above mean sea level. Pre-harvest sprays with two fungicides and two growth regulators, each at different levels, were applied to garlic variety Agrifound Parvati (G-313). Sowing of cloves was done at a spacing of 15x10cm in a plot size of 2.0m×2.0m. Plant hormone solutions were prepared fresh and sprayed twice i.e., at 90 days (bulb development stage) and 150 days (50% neck fall) during morning hours for effective absorption. Fresh stock of cycocel (1200 ppm) and ethephon (3000 ppm) were prepared by diluting the required quantity of each hormones i.e. CCC (3.6 ml) and ethephon (6 ml) in 3 liters of distilled water twice at two different sprays. Hormone CCC was first dissolved in 5 ml acetone (99%) and then diluted as per the concentration. In control plots only distilled water was used.Tween-20@ 1ml/litre of plant hormone was added for sticking purpose. There were total thirteen treatment combinations such as T1 (Carbendazim@800 ppm), T2 (Carbendazim @1000 ppm), T3 (Carbendazim @1200 ppm), T4 (Cycocel @800 ppm), T5 (Cycocel @1000 ppm), T6 (Cycocel @1200 ppm), T7 (Ethrel@ 1000 ppm), T8 (Ethrel@ 2000 ppm), T9 (Ethrel @3000 ppm), T10 (Benomyl@ 1000 ppm), T11(Benomyl@ 1200 ppm), T12 (Benomyl @1500 ppm), and T13 (Distilled water spray as control). The experiment was conducted in RBD design in three replicates with 13 number of treatments and data with respect to growth, yield, quality and storability was tabulated and analyzed as suggested by Gomez and Gomez (1984).

Results and Discussion

Growth and yield parameters: Plant height ranged between 31.42 to 37.72 cm among 13 treatments (Table 1) which was highest (37.72cm) in treatment having T_3 (Carbendazim @1200 ppm) and was statistically at par with T_{13} (37.58 cm), T_{10} (36.99cm), T_2 (36.80cm), T_5 (36.48cm), T_{11} (36.04cm), but was statistically superior to T_7 (33.84cm), T_8 (33.07 cm) and T_9 (31.42 cm). Reduction in plant height in all the ethrel treatments might be due to slowing down of cell division and reduction in cell expansion. Ethrel (2-chloroethyl phosphonic acid) helps in promoting epinasty, inhibit growth and retard transverse cell division particularly in cambium which is the zone of meristematic activity at the base of internode (Grossman 1990). Similar reports have been quoted by Deotale and Sorte (1996), Mehetre and Lad (1995), Garai and Dutta (2003) in green gram.

The leaf is considered as an important functional unit which contributes to yield through its functional activity. In the present experiment, number of leaves per plant ranged between 11.33-14.22 (Table 1). It was recorded highest (14.22) with cycocel 1000 ppm (T_5)which was statistically at par with cycocel @800ppm (14.13) (T_1), Cycocel @1200ppm (T_6) (13.93), Benomyl @1200 ppm (T_{11}) (13.42), but was statistically superior to rest of the treatments. This might be due to ability of growth retardant cycocel to delay senescence by arresting the chlorophyll degradation and protease activity and promoting the synthesis of soluble protein and photosynthetic enzyme. Canor and Prado (1983), Srivastava and Goswami (1988) also reported that application of cycocel @500 ppm increased the number of leaves in green gram. Lakshmi Narasimhan (2002), Prakash et al (2003), and Hanchinamath (2005) reported increase in the number of leaves by growth regulators in black gram, cluster bean and sun flower. In the present investigation, maximum weight of bulbs (36.66g) with highest yield per hectare (110.60 q/ha) in significantly more number of days after sowing (196.66) was obtained with (T_5) cycocel 1000 ppm (Table 1). This treatment was statistically at par with cycocel @800 ppm (T_4) (36.46 g and 109.5q/ha), cycocel 1200 ppm (T_3) (36.35g and 108.7q/ha) but was statistically superior to rest of the treatments as well as control. The production of large sized bulbs may be mainly attributed to the fact that CCC remained physiologically more active to build up sufficient food reserves which ultimately led to increased total yields (Memane et al., 2008). Similar findings regarding yield accelerating properties of cycocel have also been reported by Rahim and Fordam (1994) in garlic.

Quality Parameters: Generally, the pyruvate levels of garlic bulbs increased continuously after harvesting although the bulbs are dormant during storage period thereby changing its flavour quality. In the present experiment, sulphur content remained significant and recorded low value with cycocel (1000 ppm) treated bulbs(T_5) (Table 2). This might be attributed to the encouraging effects of cycocel on the utilization of minerals in the leaf metabolism (Pandita and Hooda 1979). Similar results were recorded by Ganie and Solanki (2010). There was a gradual increase in total sugar content in all the treatments during the storage period. The maximum total sugar content of onion has

Table 1: Effect of pre-harvest treatment of phytohormones and fungicides on morphological and yield parameters of garlic

Notation	Treatments	Plant height (cm)	Number of leaves per plant	Days to harvest	Average bulb weight (g)	Yield per ha (q)	B: C ratio
T_1	Carbendazim@800 ppm	36.48	13.12	192.00	33.90	92.40	2.66
T_2	Carbendazim @1000 ppm	36.80	13.02	192.00	33.57	90.20	2.57
T_3	Carbendazim @1200 ppm	37.72	13.25	192.33	33.03	86.70	2.43
T_4	Cycocel @800 ppm	34.89	14.13	194.00	36.46	109.50	3.26
T_5	Cycocel @1000 ppm	33.97	14.22	196.66	36.63	110.60	3.28
T_6	Cycocel @1200 ppm	33.64	13.93	192.66	36.35	108.70	3.19
T_7	Ethrel@ 1000 ppm	33.84	11.80	186.00	30.83	72.00	1.72
T_8	Ethrel@ 2000 ppm	33.07	11.60	181.33	29.25	61.50	1.22
T_9	Ethrel @3000 ppm	31.42	11.33	180.66	27.55	50.20	0.73
T_{10}	Benomyl@ 1000 ppm	36.99	13.18	192.66	33.01	86.60	2.42
T_{11}	Benomyl@ 1200 ppm	36.04	13.42	193.33	33.61	90.50	2.56
T_{12}	Benomyl @1500 ppm	35.33	13.27	192.66	33.93	92.70	2.64
T_{13}	Distilled water spray (control)	37.58	13.33	193.33	33.68	91.00	2.62
	SEM±	0.93	0.39	0.83	1.14	2.24	-
	CD(P = 0.05)	2.74	1.13	2.43	3.36	7.61	-

Table 2: Effect of pre-harvest treatment of phytohormones and fungicides on quality parameters of garlic

Notation	Treatments	Dry matter (%)	Sulphur content (μ moles pyruvate/g of tissue)	TSS (°B)	Total sugars (%)
T_1	Carbendazim@ 800 ppm	50.50	76.62	28.43	11.34
T_2	Carbendazim@ 1000 ppm	51.42	77.38	28.49	11.06
T_3	Carbendazim@ 1200 ppm	50.70	76.79	28.87	11.00
T_4	Cycocel@@ 800 ppm	51.32	79.62	29.00	12.30
T_5	Cycocel @1000 ppm	50.60	80.39	28.80	12.78
T_6	Cycocel @1200 ppm	50.74	80.12	28.66	12.59
T_7	Ethrel@ 1000 ppm	51.18	74.04	29.26	13.10
T_8	Ethrel@ 2000 ppm	50.43	73.19	28.53	13.53
T_9	Ethrel@ 3000 ppm	51.04	73.17	29.90	13.74
T_{10}	Benomyl@ 1000 ppm	51.44	76.72	28.36	11.47
T_{11}	Benomyl@ 1200 ppm	50.15	76.86	29.33	11.28
T_{12}	Benomyl@ 1500 ppm	50.81	76.85	28.20	11.06
T_{13}	Distilled water spray(control)	51.15	74.42	28.83	11.51
	SEM±	0.46	0.44	0.71	0.61
	CD (P = 0.05)	N.S.	1.31	2.16	1.27

been reported to be positively correlated with the ratio of sucrose to monosaccharaides and keeping quality of bulbs during storage (Patil and Kale 1989). Islam et al. (2007) and Dhotre (2009) reported that as bulb weight and diameter loss increased cumulatively, the garlic bulb TSS, pungency and dry matter content decreased, which reduced its quality with decreased shelf life. However, the present study showed contrary results, thus established positive links of CCC with quality parameters of garlic.

Storage Parameters: In the present investigation, sprouting, rotting and physiological loss in weight showed significant values. The minimum loss in weight of garlic during storage is considered one of the most desirable factors to increase storage life. In the present investigation, lowest physiological loss in weight was recorded with cycocel 1000 ppm (T_5) (Table 3). The highest physiological loss in weight was recorded in control. The highest physiological loss in weight in control may be attributed to more respiration and transpiration. In case of sprouting, lowest value was recorded with ethrel 3000 ppm treated bulbs (T_9) which might be due to more integrity and less moisture loss from bulbs. The highest sprouting in control might be attributed to more aeration and wide fluctuation in storage temperature. Chope et al. (2006) reported significant changes during storage of onions and concluded that ratio of monosaccharide to disaccharides and concentrations of zeatin riboside are important factors in discriminating between sprouting and pre sprouting of bulbs. Stage of bulb development, premature defoliation, and skin integrity conditions during growth, maturation, harvesting, curing and storage are main factors contributing to quality of bulbs in postharvest

Table 3: Effect of pre-harvest treatment of phytohormones and fungicides on sprouting loss, rot loss and PLW of garlic

Notation	Treatments	Sprouting loss (%)	Rot loss (%)	PLW (%)
T_1	Carbendazim@ 800 ppm	12.53	9.96	17.61
T_2	Carbendazim@ 1000 ppm	11.96	9.07	17.37
T_3	Carbendazim@ 1200 ppm	12.02	9.25	16.93
T_4	Cycocel @800 ppm	12.16	11.69	15.35
T_5	Cycocel @1000 ppm	11.40	10.75	14.52
T_6	Cycocel @1200 ppm	11.31	10.88	14.93
T_7	Ethrel @1000 ppm	9.46	12.24	17.41
T_8	Ethrel@ 2000 ppm	9.35	14.03	16.99
T_9	Ethrel@ 3000 ppm	9.16	15.66	16.79
T_{10}	Benomyl@ 1000 ppm	14.27	10.27	18.78
T_{11}	Benomyl @1200 ppm	13.74	9.20	18.40
T_{12}	Benomyl@ 1500 ppm	11.49	9.48	18.73
T_{13}	Distilled water spray(control)	16.15	12.86	22.75
	SEM±	0.79	0.23	0.04
	CD (P = 0.05)	2.29	0.68	0.88

Note: Cumulative data after125 days (4 months) of storage under ambient conditions

storage. Rotting is another aspect in pre-harvest storage of garlic and among the pre harvest treatments lowest rotting loss in weight was recorded with carbendazim 1000 ppm(T_2) which was at par with cycocel 1000 ppm (T_5). The highest rotting was recorded in control (T_{13}). The least rotting in pre-harvest carbendazim treatment may be attributed to anti- fungal properties of carbendazim in reducing rotting.

Economics: In the present investigation, highest cost benefit ratio of 3.28 was recorded with cycocel treatment at 1000 ppm (T_5) which resulted in highest yield per hectare (110.60 q/ha) (Table 2). The possible reason for higher yield is directly correlated with increased bulb weight and possibly of reduced rotting of bulbs in the field. During storage, a significant effect of pre-harvest application of growth hormones and fungicides was recorded with respect to the reduction of storage losses of bulbs (Table 4). The sale rate of garlic at the time of sowing had been almost double as compared to the rates, when it is harvested. Hence, CCC proved significantly helpful in the saving of precious propagating material of garlic for next sowing with a sale rate of Rs/150.00 per kg. Among all the treatments tested,CCC @ 1000 ppm application (T_5) recorded less post-harvest losses resulted in saving of 63.33% of the bulbs after 4 month of ambient storage as compared to 42.24% in control (T_{13}). By this treatment, an additional benefit in terms of returns per rupee spent was recovered (1.54) as compared to control (1.18) (Table 4).The findings of Abdul, 1988 are inconformity with the present study.

Table 4: Economics of pre harvest treatments of phytohormones and fungicides on stored bulbs of garlic

Particulars	Treatments												
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Cost of pre harvest spray (Rs)	5.84	6.92	8.63	30.68	37.97	46.37	108.33	253.66	466.14	15.66	17.17	20.97	0.00
Cost of bulbs per quintal (Rs)	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Cost of storage per quintal (Rs)	50	50	50	50	50	50	50	50	50	50	50	50	50
Cost of handling per quintal (Rs	20	20	20	20	20	20	20	20	20	20	20	20	20
Cost of marketing per quintal (Rs)	50	50	50	50	50	50	50	50	50	50	50	50	50
Total expenditure (Rs)	6125.8	6126.90	6128.60	6150.60	6157.90	6166.30	6228.30	6373.60	6586.10	6135.60	6137.10	6140.90	6120.00
Total saleable bulbs (kg)	59.9	61.60	61.80	60.80	63.33	62.88	60.89	59.63	58.39	56.68	58.66	60.30	48.24
Gross returns @ 150/kg	8985.0	9240.0	9270.00	9120.00	9499.50	9432.00	9133.50	8944.50	8758.50	8502.00	8790.00	9045.00	7236.00
Net Returns (Rs)	2859.2	3113.1	3141.40	2979.40	3341.60	3265.70	2905.20	2570.90	2172.40	2366.40	2661.90	2904.10	1116.00
B:C ratio	1.46	1.50	1.51	1.48	1.54	1.53	1.47	1.40	1.33	1.39	1.43	1.47	1.18

Note: Rate of carbendazim = Rs 520/kg, Cycocel =Rs 700/100ml, Ethrel= Rs1300/100 ml, Benomyl=Rs1080/kg

सारांश

लहसुन में कसावट, दृढ़ता और स्वस्थ अवस्था महत्वपूर्ण गुणवत्ता घटक हैं जो बाजार मूल्य और उपभोक्ता वरीयता निर्धारित करते हैं। पादप वृद्धि कारकों (साइक्लोसेल और एथ्रेल) और कवक नाशकों (कार्बेन्डाजिम और बेनोमाइल) को फसल के बाद नुकसान की जाँच में महत्वपूर्ण भमिका निभाने के लिए जाना जाता है जैसे नुकसान (पी.डल्लू.एल.), लम्बे समय से संग्रहित फसलों में फटना, सड़ना आदि। अध्ययन का मुख्य उद्देश्य लहसुन (किस्म एग्रीफाउंड पार्वती) की वृद्धि, उपज, गुणवत्ता और भण्डारण क्षमता पर उनके खुदाई पूर्व प्रयोग के प्रभवों की जाँच करना था। परिणामों से स्पष्ट हुआ कि 90 दिनों (कंद विकास अवस्था) और 150 दिनों (50 प्रतिशत ग्रीवा के गिरने की अवस्था) पर 1000 पीपीएम सीसीसी के बहिर्जात प्रयोग से लहसुन में वृद्धि और उपज संबंधी मापदंडों में काफी वृद्धि होती है। इस पादप वृद्धि कारक ने फसल के बाद गन्धक सामग्री के उच्च स्तर को बनाए रखा, जो 4 महीने की परिवेशी भण्डारण अवधि के दौरान कंदों के पी.एल.डब्लू. को कम करने में मददगार साबित हुआ। अन्य उपचारों और नियंत्रण की तुलना में आर्थिक रूप से, इस उपचार में लागत लाभ अनुपात, दोनों कटाई और भण्डारण के बाद अधिक था। दूसरी ओर कवकनाशकों का विकास और पैदावार मापदंडों पर कमोबेश समान प्रभाव था लेकिन नियंत्रण की तुलना में लहसुन की फसल के बाद के नुकसान पर महत्वपूर्ण प्रभाव दिखा। इसलिए, लम्बी अवधि के भण्डारण के दौरान फसल कटाई के बाद के नुकसान को कम करने के लिए लहसुन के महत्वपूर्ण धरणों में सीसीसी 1000 पीपीएम के प्रयोग की कोशिश की जा सकती है।

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