Eco. Env. & Cons. 28 (November Suppl. Issue) : 2022; pp. (S95-S100)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i07s.016

Efficacy of Prohexadione calcium and Paclobutrazol on Storage Life of Clapp's Favorite Pear

Manmohan Lal*[1], M.M. Mir[2], Umar Iqbal[2], Amit Kumar[2], G I Hassan[2] and Umer Basu[3]

[1]Division of Fruit Science, SKUAST-Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India
[2]Division of Fruit Science, SKUAST-Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir
[3] Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu 180 009, India
Corresponding address: University Institute of Agriculture, Chandigarh University- Gharuan, Mohali, Punjab, India

(Received 13 February, 2022; Accepted 21 April, 2022)

ABSTRACT

Present investigation was carried out to study the efficacy of growth retardants *viz.,* prohexadione calcium and paclobutrazol on storage life of pear cv. 'Clapp's Favourite' during the year 2015-2016. The experiment was laid out with thirteen treatments replicated thrice on 12-year-old-pear tree with uniform vigor and health under uniform cultural practices. The treatment comprises of single and double spray of growth retardants, i.e., prohexadione calcium (100 ppm, 200 ppm and 300 ppm) and paclobutrazol (100 ppm, 200 ppm and 300 ppm). The orchard soil was moderately deep with good fertility status. Data was recorded on storage life of the pear at (7, 14, 21 and 28) day's interval and results revealed that both the growth retardants prohexadione calcium and paclobutrazol had showed a significant influence on total sugars, TSS, acidity and physiological loss in weight. After 28 days of storage minimum physiological loss in weight (14.17 %) and acidity (0.20 %) was recorded with the application of prohexadione calcium @ 200 ppm sprayed twice closely followed by prohexadione calcium @ 200 ppm sprayed twice. Application of prohexadione calcium @ 200 ppm and paclobutrazol @ 200 ppm had also showed a significant influence on TSS (15.31 % and 15.17 %, respectively) and total sugars (13.48 % and 13.40 %). Minimum values for all the characters were observed in control. Results revealed that application of prohexadione calcium @ 200 ppm and 300 ppm sprayed twice will enhance the shelf life of Clapp's Favourite pear.

Key words: *Clapp's Favourite, Growth retardants, Prohexadione-calcium, Paclobutrazol, Storage life*

Introduction

Pear (*Pyrus communis* L.) occupies second place among temperate crops of India, both in respect of area and production. The acerage under the fruit crop has been steadily increasing because of its high yielding potential and economic returns. Because of hardy nature of pear and tolerance to wide range of soil, it needs less care and can be grown under different agro-climatic conditions. It is successfully grown in both temperate and sub-tropical regions of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and sub-tropical regions of Punjab, Assam and South India. Pear can tolerate as low as -26 ºC during dormant period and as high as 45 ºC growing period. Prohexadione calcium (Rademacher *et al.*, 2006) and paclobutrazol (Arzani and Roosta, 2004) both are novel plant growth regu-

lators that emerged as important management tools that an orchardist has available to manage tree canopy volume. Prohexadione-Ca (Costa *et al.*, 2006) it is a plant bio-regulator that is primarily used to inhibit excessive vegetative growth in fruit trees and other crop plants. Furthermore, the compound may reduce abortion of fruitlets, thereby increasing fruit set. Prohexadione-Ca is relatively short-lived and possesses very favorable toxicological and eco-toxicological features.Prohexadione calcium foliar application @ 100 ppm during the month of April-May on 'Willamette Raspberry' increases the fruit quality, yield and anthocyanin content (Poledica *et al.*, 2004). Apart from controlling excessive vegetative dormant growth and reducing summer pruning, the most important effects of prohexadione-calcium are to inhibit gibberellin metabolism and ethylene formation. Lowered levels of ethylene reduces fruit senescence process. It also increased calcium content in fruit and improved a good ratio between calcium and potassium and also damage of fruit in storage period was reduced. Prohexadione-Ca improved the fruit yield and quality and the fruit shelf life storage (Kupferman, 2008). Pear with improper maturity is more susceptible to internal browning disorder and has a shorter storage life.

Keeping in view the benefits of prohexadione calcium and paclobutrazol, the present study was conducted to determine the effects of growth retardants on storage life of Clapp's Favorite pear.

Materials and Methods

Experimental site and material involved

The present study wasconducted on 12 year oldpear cv. Clapp's Favourite grafted on seedling rootstock at private orchard during the year 2015-2016 near SKUAST-Kashmir, Shalimar, Srinagar (J&K). The experimental orchard was situated at an altitude of 1685 m amsl which is lying between 34°75'N latitude and 74°50'C longitude. The orchard had proper soil drainage and good fertility status. Trees of similar vigor and size were selected, marked and maintained under uniform cultural practices and trained as a modified leader system at a spacing of 5 ×5 meter. Most of the precipitation received from the month of October to April and rest is erratically distributed. Winters are severe extending from December to March and temperature often goes below freezing point during this period.

Treatment Details

The experiment was laid out in a completely randomized block design (RCBD) with three trees representing a treatment. There are thirty nine healthy trees grouped into three replications and thirteen treatments including a control (water spray) were marked as per the treatments. Three concentrations (100, 200, 300 ppm) each of prohexadione calcium and paclobutrazol with their active ingredients 10 and 23, respectively were sprayed (details given in Table 1). The first spray of these plant growth retardants was given at petal fall stage and second at four weeks after first spray.

Observations recorded and statistical analysis

The observations were recorded on storage life of pear. The physiological loss in weight was determined by labeling the fruits in each treatment and were weighed prior to storage and subsequently at each stage of analysis during storage. Reduction in weight was determined and loss in weight expressed on percentage basis.

$$\text{PLW (\%)} = \frac{\text{Initial weight of fruit– Final weight of fruit} \times 100}{\text{Initial weight of fruit}}$$

Total soluble solids of fruits during storage were determined from fresh strained thoroughly stirred fruit juice on each sampling date with the help of a digital hand refractometer (AOAC, 2000). The acidity was determined by diluting the known volume of pear juice and titrating the same against 1N sodium hydroxide solution using the phenolphthalein as an indicator. It was expressed in terms of per cent malic acid. Total sugars were estimated by titrating boiling mixture containing 5 ml each of Fehling's A and B solutions against a hydrolyzed aliquot using methylene blue dye asindicator (AOAC, 2000). The data collected on various parameters were statistically analyzed.

Results and Discussion

Physiological loss in weight

Figure 1 depicts the effect of growth retardants on physiological loss in weight of pear cv. Clapp's Favourite. Physiological loss in weight is the parameter that most obviously affected by prohexadione calcium and paclobutrazol applications. Minimum physiological loss in weight (PLW) was recorded in the treatment $T_{10}S_2$ (2.87 %), i.e. prohexadione cal-

cium @ 300 ppm sprayed twice at 7th day's after storage which was statistically at par with T_9S_2 (2.97%), i.e. prohexadione calcium @ 200 ppm sprayed twice and maximum PLW was noticed under control (6.17 %), i.e. T_1S_0 treatment. However, it has been also noticed that minimum value for physiological loss in weight right from first day, i.e. harvesting day to 28th days after storage is recorded in plants treated with double spray of plant growth retardants. At 28th days after storage, it has been noticed that double spray of prohexadione calcium @ 300 ppm ($T_{10}S_2$) recorded 14.17 per cent physiological loss in weight which was statistically superior among all other treatments whereas, maximum value for physiological loss in weight was recorded in treatment T_1S_0 (18.22 %), i.e. control. The reason attributed to this is that calcium is known to be effective in terms of membrane functionality and integrity maintenance, which resulted in minimum physiological loss in weight of fruit or may be due the reason that calcium delayed senescence and reduced the rate of transpiration and respiration (Mahajan and Dhatt, 2004).

Total soluble solids

Significant results of Prohexadione-Ca and paclobutrazol on total soluble solids of Clapp's Favourite pear is presented in Table 2. Total soluble solids percentage of pear fruit was most obviously affected by Prohexadione-Ca and paclobutrazol applications. Maximum total soluble solids in freshly harvested fruits was recorded in treatment T_9S_2i.e. prohexadione calcium @ 200 ppm sprayed twice which was statistically at par with the treatment $T_{10}S_2$, i.e. prohexadione calcium @ 200 ppm sprayed twice, however minimum total soluble solid was recorded in control (T_1S_0). After 7, 14, 21 even 28 days of storage of Clapp's Favourite pear, same trend was continued for maximum and minimum values of total soluble solids in all the treatments except control. After 28 days of storage maximum total soluble solids were recorded in treatment T_9S_2, (15.31 %) when the trees were sprayed twice with prohexadione calcium @ 200 ppm which was statistically at par with $T_{12}S_2$ (15.17%) and $T_{10}S_2$ (15.16%). Minimum total soluble solids were recorded in the treatment T_1S_0 (11.62 %), i.e. control. Under treatment T_1S_0 i.e. control an increasing trend was recorded for total soluble solids with advancement in the storage periodupto 21 days however, prolongation of storage to 28 days, total soluble solids declined only in treatment control. With the advancement in the storage period under treatment T_1S_0, i.e. control the total soluble solid content declined which might be due to the conversion of starch and other photosynthates into sugars (Stern *et al*., 2007). Guak

Table 2. Effect of prohexadione calcium and paclobutrazol on total sugars of pear under ambient storage conditions

Treatments	Total sugars (%)				
	0	7	14	21	28
S_0	8.35	8.97	9.14	9.73	10.23
T_2S_1	8.62	10.33	11.08	11.67	11.99
T_3S_1	8.98	10.91	11.63	12.14	12.24
T_4S_1	8.89	10.57	11.57	11.93	12.08
T_5S_1	8.52	10.41	10.36	11.39	11.76
T_6S_1	8.99	10.16	11.40	12.01	12.44
T_7S_1	8.99	10.16	11.18	11.94	12.30
T_8S_2	9.13	10.53	10.95	12.36	12.96
T_9S_2	10.23	11.68	12.46	13.01	13.48
$T_{10}S_2$	10.11	11.12	11.29	12.76	13.19
$T_{11}S_2$	9.01	10.11	11.00	12.06	12.66
$T_{12}S_2$	9.89	10.93	12.17	12.66	13.40
$T_{13}S_2$	9.67	10.56	11.77	12.41	13.15
$CD_{0.05}$	0.35	0.69	0.74	0.45	0.42

Table 1 Treatment details:

Treatments	Chemicals concentrations	Treatments	Chemicals concentrations
T_1 S_0	Water spray		
	Single spray (S_1)		Double spray (S_2)
T_2 S_1	Prohexadione Ca 100 ppm	T_8 S_2	Prohexadione Ca 100 ppm
T_3 S_1	Prohexadione Ca 200 ppm	T_9 S_2	Prohexadione Ca 200 ppm
T_4 S_1	Prohexadione Ca 300 ppm	T_{10} S_2	Prohexadione Ca 300 ppm
T_5 S_1	Paclobutrazol 100 ppm	T_{11} S_2	Paclobutrazol 100 ppm
T_6 S_1	Paclobutrazol 200 ppm	T_{12} S_2	Paclobutrazol 200 ppm
T_7 S_1	Paclobutrazol 300 ppm	T_{13} S_2	Paclobutrazol 300 ppm

(2013) also obtained similar results in apple cv. 'Golden Delicious'. Prohexadione calcium inhibits the late stage of gibberellic acid biosynthesis that resulted in reduction of vegetative growth and consequently facilitates more photosynthetic assimilates towards fruit, thus increase more starch and sucrose along with mineral level in fruits that further leads to increase in total soluble solids in the fruit (Mesa *et al*., 2012).

Acidity

Acidity recorded at different intervals decreased with an increase in storage period with the application of prohexadione calcium as well as paclobutrazol, however, results were significant only at 7 and 14 days of storage (Table 2). Minimum acidity in the freshly harvested fruits was recorded in the treatment T_9S_2, $T_{10}S_2$ and $T_{12}S_2$, i.e. 0.44 per cent and maximum under treatment T_1S_0 (0.52 %), however the results were non-significant among different treatments. After 7 and 14 days of storage, T_9S_2 recorded minimum acidity, i.e. 0.37 per cent and 0.36 per cent, respectively which was statistically at par with $T_{10}S_2$ and $T_{12}S_2$ treatments. After 28 days of storage, the results for acidity among treatments were non-significant and minimum acidity was recorded in T_9S_2 treatment, i.e. 0.20 per cent followed by $T_{10}S_2$ (0.22 %), $T_{12}S_2$ (0.22 %) and T_6S_1 (0.22 %). Mata *et al*. (2006) in 'Royal Gala' and 'Fuji', Guak (2013), also noticed the relative decrease in acidity percent in apple cv. 'Golden Delicious'. Prolongation of storage period from 10 to 30 days resulted in progressive decrease in acidity of the pear cv. Bartlett (Bhat *et al.*, 2010). Cares *et al*. (2004) also found similar results in sweet cherry cv. 'Lappins' and 'Sweet heart'. The decrease in acidity in fruits by the application of prohexadione calcium might be due to the conversion of organic acids into sugars that decreases the level of acidity in fruits (Mesa *et al.*, 2012).

Total sugars

Total sugars of Clapp's Favourite pear were also influenced by the prohexadione calcium and paclobutrazol applications (Table 3). Maximum total sugars (10.23 %) in the freshly harvested fruits was recorded in the treatment T_9S_2 when prohexadione calcium was sprayed twice @ 200 ppm and this treatment was statistically at par with treatment $T_{10}S_2$ (10.11 %) and $T_{12}S_2$ (9.89 %), however minimum total sugar was recorded in T_1S_0(8.35 %) treatment. An increasing trend was noticed for total sugar during the storage period under ambient conditions and same trend was continued even after 28 days of storage among the treatments, where maximum total sugars was recorded in T_9S_2(13.48 %) treatment, i.e. prohexadione calcium @ 200 ppm sprayed twice which was statistically at par with $T_{12}S_2$ (13.40 %) treatment, i.e. paclobutrazol @ 200 ppm sprayed twice, $T_{10}S_2$ (13.19 %) treatment, i.e. prohexadione calcium @ 300 ppm sprayed twice and $T_{13}S_2$ (13.15 %) treatment, i.e. paclobutrazol @

Table 3. Effect of prohexadione calcium and paclobutrazol on total soluble solids and acidity of pear under ambient storage conditions

Treatments	Total soluble solids (%)					Acidity (%)				
	0	7	14	21	28	0	7	14	21	28
T_1S_0	9.72	10.83	11.91	12.16	11.62	0.52	0.48	0.46	0.42	0.37
T_2S_1	11.12	11.43	12.72	13.01	13.90	0.48	0.45	0.41	0.31	0.26
T_3S_1	12.14	12.83	13.91	14.49	14.84	0.47	0.40	0.38	0.28	0.22
T_4S_1	11.80	12.37	13.62	14.17	14.52	0.47	0.43	0.39	0.30	0.23
T_5S_1	11.01	11.26	12.61	12.72	13.41	0.51	0.43	0.42	0.29	0.25
T_6S_1	12.00	12.30	13.71	14.27	14.73	0.45	0.40	0.38	0.27	0.22
T_7S_1	11.71	12.00	13.49	14.02	14.37	0.47	0.42	0.40	0.28	0.23
T_8S_2	11.91	12.60	13.97	14.1	14.96	0.47	0.41	0.39	0.29	0.24
T_9S_2	13.21	13.76	14.71	15.06	15.31	0.44	0.37	0.36	0.26	0.20
$T_{10}S_2$	13.06	13.33	14.53	14.95	15.16	0.44	0.38	0.37	0.27	0.22
$T_{11}S_2$	11.73	12.20	13.62	13.71	14.71	0.49	0.41	0.39	0.28	0.27
$T_{12}S_2$	12.92	13.46	14.39	14.98	15.17	0.44	0.38	0.36	0.26	0.22
$T_{13}S_2$	12.74	13.10	14.37	14.67	15.01	0.46	0.40	0.37	0.27	0.23
$CD_{0.05}$	0.34	0.43	0.39	0.36	0.22	NS	0.02	0.01	NS	NS

300 ppm sprayed twice. However, minimum value for total sugars was registered in treatment T_1S_0(10.23%). An increased in percent of total sugar was attributed to the reason that increased sucrose, starch and sugar levels due to reduction in vegetative growth and thus absence of other potentially competitive actively growing sinks, which resulted in more nutrients portioning toward fruits (Guak, 2013).

TSS/acid ratio

Significant results were obtained with the application of prohexadione Calcium and paclobutrazol for TSS/acid ratio (Fig.1). Maximum TSS/acid ratio was recorded in the treatment T_9S_2 (30.02), i.e. prohexadione Calcium @ 200 ppm sprayed twice which was statistically at par with $T_{10}S_2$ (29.68) and $T_{12}S_2$ (29.36), however minimum TSS/acid ratio was recorded under control (18.69), i.e. treatment T_1S_0. Treatment T_9S_2 recorded maximum values for TSS/acid ratio after 7 days (37.19), 14 days (40.86), 21 days (57.92) and 28 days (76.55) of storage. After 7 days and 28 days of storage treatment T_9S_2 was statistically higher among all other treatment whereas T_9S_2 treatment was statistically at par with treatment $T_{10}S_2$ and $T_{12}S_2$ after 14 days and 21 days of storage. Minimum TSS/acid ratio was noticed in Treatment T_1S_0, i.e. control with the increasing trend of storage periods. These differences in TSS/acid ratio may be due to differences in total soluble solid and acidity as TSS/acid ratio is directly influenced by these two attributes (Drake *et al.*, 2004).

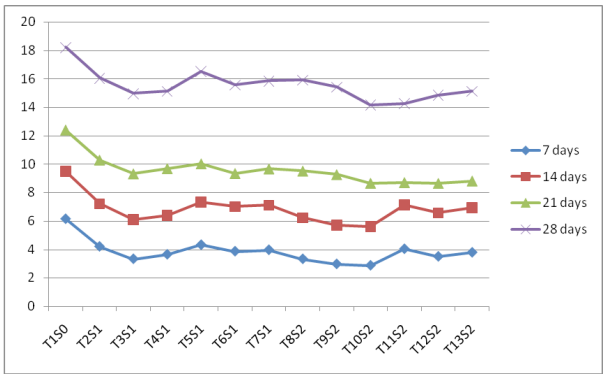

Fig. 1. Effect of prohexadione calcium and paclobutrazol on physiological loss in weight (%) of pear under ambient storage conditions

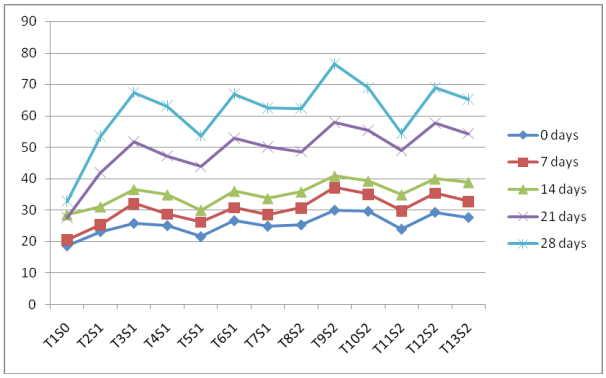

Fig. 2. Effect of prohexadione calcium and paclobutrazol on TSS/acid ratio of pear under ambient storage conditions

Conclusion

From the present study it is concluded that foliar spray of prohexadione calcium @ 200 ppm and 300 ppm at two times (first at petal fall stage and second at four weeks after first spray) resulted in increase in total soluble solids (TSS), total sugars and decreased acidity as well as physiological loss in weight percentage as photosynthetic assimilates are save (due to reduction in vegetative growth) and translocated more towards fruit of Clapp's Favourite pear.

References

AOAC. 2000. *Official Methods of Analysis*, 15th edition. Association of Official Analytical Chemists, Washington, DC, U.S.A.

Arzani, K. and Roosta, H.R. 2004. Effects of paclobutrazol on vegetative and reproductive growth and leaf mineral content of mature apricot (*Prunusarmeniaca* L.) trees. *J. Agri.Sci. Tech.* **6**: 43-55.

Bhat, M.Y., Ahsan, H., Ahmad, F., Dar, M.A., Banday, F.A., Khan, F.A. and Sharma, M.K. 2010. Influence of harvest dates and storage period on physico-chemical characteristics of pear fruit cv. Bartlett. *Appl. Biol. Res.* **12**(1): 33-37.

Cares, J., Sagredo, K.X., Cooper, T. and Retamales, J. 2014. Effect of prohexadione calcium on vegetative and reproductive development in sweet cherry trees. *ActaHorti.* **1058**: 43.

Costa, G., Andreoti, C., Spineli, F. and Rademacher, W. 2006. Prohexadione Ca, more than a growth regulator for pome fruit. *ActaHorti.* **727**: 107-116.

Drake, S.R., Mielke, E.A. and Elfving, D.C. 2004. Maturity and storage quality of 'Concorde' pears. *Hort. Tech.* **14**(2): 250-256.

Guak, S. 2013. Effects of Prohexadione- calcium, ehephon, and water stress on growth and productivity of Golden Delicious/M.9 apple. *Korean J. Horti. Sci. Tech.* **31**(1): 38-49.

Kupferman, E. 2008. Progress towards control of storage Scald in d'Anjou pears. *Acta Horti.* **800:** 971-978.

Mahajan, B.V.C. and Dhatt, A.S. 2004. Studies on postharvest calcium application on storage behaviour and quality of Asian pear during cold storage. *Internatl. J. Food Agri. Environ.* **2**(3-4): 157-159.

Mata, A.P., Val, J. and Blanco, A. 2006. Differential effects of prohexadione calcium on red colour development in 'Royal Gala' and 'Fuji' apples. *J. Horti. Sci. Biotech.* **81**: 84-88.

Mesa, K., Reginato, G., Contador, L. and Infante, R. 2012. prohexadione calcium and naphthalene acetic acid sprays improve fruit size and maintain fruit quality of 'Castlebrite' apricot. *European J. Hort. Sci.* **77**.

Poledica, M.M., Milivojevic, J.M., Radivojevic, D.D. and Maksimovic, 2004. Prohexadione**-**Ca and young cane removal treatments control growth, productivity, and fruit quality of the Willamette raspberry. *Turkish J. Agril. Sci.* **36**: 680-687.

Rademacher, W, Spinelli, F. and Costa, C. 2006. Prohexadione- ca: modes of action of a multifunctional plant bioregulator for fruit trees. *Acta Horti.* **727:** 97-106.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods*. English edition. East-West Press, New Delhi. pp. 503

Stern, R.A., Doron, I. and Ben, A.R. 2007. Performance of Coscia pear (*Pyrus communis*) on seven rootstocks in a warm climate. *J.Horti. Sci. Biotech.* **82(5):** 798-802