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SHORT COMMUNICATION

FRUIT COLORATION, MATURITY AND QUALITY OF RED DELICIOUS APPLES AS INFLUENCED BY ETHEPHON

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Ethephon (2-choloroethyl phosphonic acid) is used to improve fruit colour and enhance maturity in fresh fruits. However its concentration and time of application depends upon cultivar, altitude and climate of the area. Therefore the experiment was carried out to standardize the concentration and time of application of ethephon for enhancing maturity and improving colour and quality of most commercial apple cultivar 'Red Delicious' under Kashmir valley conditions having true temperate climate. Minimum number of days (128) was taken to maturity by the fruits treated with 1000 ppm ethephon + 20 ppm naphthalene acetic acid (NAA) having more colour and total soluble solids content (TSS). Fruit yield, weight, length and diameter were higher in control plants. Fruit drop at maturity was highest (23.88%) with 800 ppm ethephon. Among the time of ethephon application various parameters recorded were significantly higher in fruits sprayed two weeks before harvest, except fruit firmness which was higher in the fruits sprayed four weeks before harvest. It was concluded that 1000 ppm ethephon + 20 ppm NAA applied four weeks before harvest resulted in early maturity with better colored fruits.

***Key words*: Ethephon, fruit colour, maturity, quality.**

Apple is an important fruit crop of Kashmir valley and more than 75% of area is under Red Delicious cultivar grown from lower to higher altitudes in the valley. However, fruits grown at lower altitude mature earlier due to higher temperature but does not develop proper colour hence fetches poor price in the market. Major factors which influence fruit colour are cultivar, light, temperature and ethylene production. A light requirement must first be met after which anthocynin biosynthesis is apparently initiated by phenylalanine ammonia lyase (PAL) enzyme (Faragher 1983). Ethylene enhances PAL activities in many tissues inducing pre-climacteric apples (Faragher and Brohier 1984). On other hand apple growing at higher altitude develops good colour due to lower temperature and better sun shine, but matures late and fetch low price due to glut in the market. Endogenous ethylene is also known to enhance red colour development and anthocynin accumulation in fruit skin and help in triggering early maturity and it's regulation (Wale and Singh 2007). However, the response of ethephon varies with altitude and climatic conditions of the area. Therefore the present investigations ware carried out to standardize the time and concentration of ethephon for hastening maturity and improving the colour of Red Delicious apples under Kashmir valley conditions.

Experiment was executed on 12-year old Red Delicious apple cultivar grafted on M-9 rootstock under high density planting system growing at experimental orchard of Division of Pomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of

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Kashmir, Shalimar, Srinagar, (J&K) during two consecutive years i.e. 2005 and 2006. Experiment comprised of four concentrations of ethephon including control (T_1-500ppm ethephon, T_2-800ppm ethephon, T_3-1000ppm ethephon +20ppm NAA (applied to reduce the excessive fruit drop) and T_4 (Control). Treatments were applied as foliar sprays directly on the fruits on three dates of application (D_1- Four weeks before the harvest, D_2- Two weeks before harvesting and D_3 – One week before harvest). There were twelve treatment combinations with three replications having two trees in a unit. The design of the experiment was two factors Factorial Randomized Block Design. Before the application of chemicals, optimum harvest date of the fruit was predicted on experience basis for record of days after full bloom under Kashmir valley conditions for the cultivar. The maturity of fruit was determined by using the starch iodine test by picking fruits from each treatment every day after the application of ethephon till each treatment attained full maturity. Per cent blush on fruit surface was assessed visually on individual fruits (18 fruits per replicate) and scores were given. Physical characteristics of the fruits were recorded at time of maturity (10 fruits in each replicate). Fruit firmness was recorded with the help of Penetrometer where as fruit TSS with the help of Erma hand refractrometer. Fruit acidity and total sugar was estimated as per the procedure described by Mazumdar and Majumdar (2003). The data recorded were pooled and subjected to statistical analysis.

The results obtained revealed that minimum days after full bloom (128) were taken to maturity by the fruits treated with 1000ppm ethephon + 20ppm NAA in comparison to other treatments (Table 1). However maximum days (146.25) were taken in untreated control (T_4). Fruits treated with 1000ppm ethephon + 20ppm NAA attained more colour (94.44%) in comparison to the fruits treated with other ethephon concentrations (Table 2). The earlier fruit maturity obtained with application of 1000ppm ethephon + 20ppm NAA as compare to other treatments may be due to higher concentration of ethylene produced with this treatment which resulted in autocatalytic production of internal ethylene and anthocynin biosynthesis and initiate the repining due to higher catabolic activities in fruits (Faragher and Brohier 1984). Fruit yield, weight, length and diameter were highest in control than the fruits treated with other ethephon concentrations. This may be due to the fact that in control, fruits had more duration for their growth and development. The results are in conformity with the finding of Gobind (1984). Fruit firmness was adversely affected by ethephon application. Treatment 1000ppm ethephon + 20ppm NAA recorded higher T.S.S and lower acidity which may be due fast repining of the fruits with higher concentration of ethephon. The similar results have been reported by Govind (1984). However, total sugar was higher in fruits treated with 800ppm ethephon. Different concentrations of ethephon significantly reduced the shelf life of Red Delicious apples. Lowest shelf life was recorded in fruits treated with 1000ppm ethephon + 20ppm NAA. However shelf life was higher (62.67 days) in fruits harvested from untreated (control) plants. Fruit drop at maturity was highest (23.88%) in 800 ppm ethephon treated fruits. Drop was lowest in fruits treated with 1000ppm ethephon + 20ppm NAA. Among the time of ethephon application, the various parameters recorded were significantly higher in plants sprayed two weeks before harvest, except fruit firmness which was significantly higher in the fruits sprayed 4 weeks before harvest. However, acidity and shelf life of fruits was not significantly influenced by the time of ethephon application. This might be due to the triggering of ethylene production with exogenous ethephon application in fruits which enhanced the ripening rate and catabolic activities resulting in the rapid cell wall break down as well as reduce the fruit firmness (Murphey and Dilly, 1988). This might due to lower production of auxin by the exogenous application of ethylene.

The interaction between ethephon concentration and time of application had no significant influence on the various parameters were except weight, length and shelf life of the fruits (Table 3). However minimum number of days from full bloom (121) was taken to maturity by the fruits treated with 1000ppm ethephon + 20ppm NAA, 4 weeks before harvest. This may be due to higher release of ethylene and early trigger of maturity due to catabolic effect of ethylene. Fruit colour was higher when treated with 1000ppm ethephon + 20ppm NAA, 3 weeks before harvest. This might be due to the fact that

Table 1. Effect of different concentration of ethphon on fruit maturity and quality of apple cv. Red Delicious (pooled data for two years)

Treatments	Days taken to maturity after full bloom	Fruit colour (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit firmness (lbs/inch^2)	TSS (^{o}Brix)	Acidity (%)	Total sugar (%)	Shelf life under ambient storage (days)	Fruit drop (%) at maturity	Yield (kg /tree)
T_1	134.78	87.33	162.78	58.22	68.78	16.97	16.66	0.252	10.26	50.52	8.50	40.22
T_2	131.44	91.77	150.67	52.84	61.68	16.50	17.69	0.232	10.98	48.77	23.88	39.33
T_3	128.00	94.44	147.11	52.91	56.97	15.47	18.44	0.217	10.50	45.44	7.06	38.55
T_4	146.25	74.11	183.88	67.70	71.07	18.69	14.90	0.285	9.70	62.67	8.33	43.33
CD at 5%	**0.87**	**1.13**	**2.69**	**1.43**	**1.30**	**0.44**	**0.35**	**0.008**	**0.01**	**0.65**	**0.29**	**1.002**

T_1 = 500 ppm ethephon, T_2 = 800 ppm ethephon, T_3 = 1000 ppm ethephon (+ 20 ppm NAA to avoid the drastic fruit drop), T_4 = Control

Table 2. Effect of time of application of ethephon on fruit maturity and quality of apple cv. Red Delicious (pooled data for two years)

Treatments	Days taken to maturity after full bloom	Fruit colour (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit firmness (lbs/inch^2)	TSS (^{o}Brix)	Acidity (%)	Total sugar (%)	Shelf life under ambient storage (days)	Fruit drop (%) at maturity	Yield (kg /tree)
D_1	130.97	86.41	151.66	56.97	60.93	17.45	16.31	0.249	10.43	51.58	5.75	39.50
D_2	135.83	87.08	158.33	57.90	62.50	16.75	17.06	0.249	10.94	51.83	14.50	41.50
D_3	138.25	87.25	172.42	58.89	65.94	16.43	17.45	0.241	11.50	52.00	15.58	42.33
CD at 5%	**0.75**	**NS**	**2.33**	**1.23**	**1.12**	**0.38**	**0.30**	**NS**	**0.21**	**NS**	**0.25**	**0.83**

D_1 = 4 weeks before harvest, D_2 = 2 weeks before harvest, D_3 = One week before harvest

Table 3. Effect of different concentration and time of application of ethephon on fruit maturity and quality of apple cv. Red Delicious(pooled data for two years)

Treatments	Days taken to maturity after full bloom	Fruit colour (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit firmness (lbs/inch^2)	TSS (^{o}Brix)	Acidity (%)	Total sugar (%)	Shelf life under ambient storage (days)	Fruit drop (%) at maturity	Yield (kg /tree)
T_1D_1	131.00	86.66	148.33	56.30	61.68	16.83	16.00	0.260	10.40	50.00	4.83	39.33
T_1D_2	135.67	87.00	156.66	57.95	62.26	17.51	16.91	0.250	11.01	51.00	10.00	40.00
T_1D_3	137.66	88.33	183.33	60.42	64.70	16.58	17.08	0.247	11.10	49.66	10.66	41.33
T_2D_1	125.67	91.66	140.33	51.59	56.79	16.26	17.00	0.237	11.05	50.00	10.00	39.00
T_2D_2	132.33	91.66	147.66	53.76	58.00	17.66	17.83	0.230	11.58	48.33	29.66	40.00
T_2D_3	136.33	92.00	164.00	53.17	57.26	15.58	18.25	0.230	11.86	48.00	32.00	41.33
T_3D_1	121.00	94.00	142.33	52.76	55.55	15.25	17.83	0.216	11.58	45.33	3.66	38.00
T_3D_2	130.00	95.33	147.66	54.64	59.41	16.51	18.66	0.216	12.12	45.66	8.83	39.00
T_3D_3	133.00	94.00	157.33	51.33	55.95	14.75	18.83	0.220	12.00	45.33	9.00	40.66
T_4D_1	146.00	73.33	181.66	67.24	70.00	18.66	14.38	0.283	9.34	61.00	4.83	42.44
T_4D_2	145.33	74.33	183.33	65.33	71.12	18.58	14.83	0.30	9.44	62.33	9.50	43.00
T_4D_3	146.00	74.66	185.00	70.64	72.10	18.83	15.50	0.273	10.07	65.00	10.67	43.25
CD at 5%	**2.51**	**3.28**	**2.25**	**2.47**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.12**	**NS**	**1.32**

in Red Delicious apples, ethylene is considered to stimulate PAL enzyme increased simultaneously and the concentration of chlorophyll *a* and *b* and total chlorophyll were highest during the early stages of growth and declined during development and ripening to very low concentration (Blankenship and Unrath 1988). More fruit yield, weight, length, diameter, firmness and shelf life were recorded in untreated control plants, 2 weeks before harvest. This may be due to larger growing period and late initiation of catabolic activities in lack of ethylene triggering and anthocynin biosynthesis in these plants. TSS was higher in fruits treated with 1000 ppm ethephon + 20 ppm NAA 4 weeks before harvest. Fruit drop at maturity was minimal (3.66 %) when treated with 1000ppm ethephon + 20ppm NAA, 4 weeks before harvest and highest (32.00 %) with 800ppm ethephon, 2 weeks before harvest.

It is concluded that 1000 ppm ethephon + 20ppm NAA applied 4 weeks before harvest resulted in early maturity and better coloured fruits. However, the untreated control has been found to be superior for all the traits but fruits mature late and had poor colour.

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