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Effect of Growth Regulators on Growth, Yield and Quality of Pear cv Carmen under High Density Planting

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A B S T R A C T

The present investigation entitled, Effect of Growth Regulators on growth, yield and quality of Pear cv Carmen under High Density Planting, was carried out during the years 2016 and 2017 in experimental field of SKUAST-K, Shalimar. The experiment was laid out in Randomized Block Design with three replications and two plants per replication. Four year old pear plants cultivar Carmen were planted on Quince-c rootstock at a distance of 3x3 m.Vegetative growth parameters consisting of plant height, plant spread, and annual extension growth were measured as per the standard procedures. Fruit yield was calculated by weighing all the fruits harvested individually from each experimental tree and average yield was expressed as kg/tree. Fruit length and fruit diameter were measured by vernier caliper and fruit firmness was measured with pressure penetrometer. Fruit weight was determined by individually weighing the fruits obtained from each experimental plant on a common monopan balance and the average weight was recorded by using the procedure given by Rangana (1986). TSS was measured with the help of Zeiss hand refractometer. Titrable acidity was determined by titration method and values were expressed as percentage of malic acid (Rangana, 1986). Total sugars were determined by Lane and Eynan method (A.O.A.C., 1984). The data obtained was subjected to the statistical analysis in S-plus software. Growth regulators were found to have a significant effect on growth parameters like Incremental extension growth, increment in plant height and increment in plant spread. Maximum increment in plant height (22.01 and 23.95 cm), spread (45.19 and 46.14 cm), and annual extension growth (32.36 and 33.57 cm) was recorded with 20ppm promalin, however, average fruit yield was higher in pear trees sprayed with 20 ppm promalin followed by 10 ppm and 30 ppm, however with the application of Gibberllic acid, fruit yield was found highest with 25ppm. Fruit length, fruit diameter and fruit weight were found highest with 20 ppm promalin, however the pear fruits harvested from the trees sprayed with 25 ppm Gibberllic acid were found bigger in size than control. Average fruit firmness was found highest with 50ppm promalin, however, in case of Gibberllic acid pear fruit firmness was found highest with 25 ppm. TSS, Titrable acidity and Total sugars were found highest with 20 ppm promalin, while in case of Gibberllic acid it was found highest with 25 ppm followed by 50 ppm and control. From the foregoing research, it was concluded that pear trees cv Carmen resulted in better productivity and quality by the use of growth regulators like, Promalin @ 20 ppm and Gibberllic acid @ 25 ppm, and hence proved to be beneficial for sustainable development of farmers as they have provided better yield and efficient fruit set.

Introduction

Among temperate fruits, pear is next only to apple in importance, acreage and production with high degree of adaptability under varied climatic conditions. In India pear is predominantly grown in Kashmir valley and cooler areas in the hills of Himachal Pradesh and Uttrakhand (Chattopadhyay, 2009). Some low chilling pear cultivars are also being grown in the sub-tropical areas. It can grow under wider temperature conditions ranging from -26^{o}C when dormant to as high as 45^{o}C during growth period. Temperate pears can be grown from foothills to high hills (600-2700 amsl) experiencing 500-1500 chilling hours, while the sub-tropical pears require only 200-300 chilling hours. In Jammu and Kashmir, pear occupies an area of about 14475 hectare with an annual production of 105935 MT with productivity of 7.31 MT/hectare. While alone Kashmir occupies an area of about 6869 hectare with an annual production of 72660 MT with productivity of 10.57 MT/hectare (Anonymous, 2018-19).The Carmen pear is a European variety of *Pyrus communis*. It is a cross between two Italian varieties, the Guyot and Bella di Giugno. It was later patented in 2006, under the name of "Carmen", following a tradition by the breeders in choosing famous opera's names (as Tosca, Norma, Aida, Boheme) to give a name to new fruit varieties. Carmen is an Italian pear that bears early with a large size, yellow green colour fruits with red blush. The fruits are long lasting, juicy with aromatic flesh. It is harvested at the end of July and the fruits of this variety are quite resistant to handling and transport. It keeps well if stored in the refrigerator. Yields on such pears are influenced by the no. and quality of flowers produced, by the efficiency of pollination and fruit set, by the severity of natural or induced abscission of fruitlets and by the degree and rate of cell division and expansion, in the persisting fruits. These component factors that together determine pear yields are themselves influenced by Genetic (Scion cultivar and Rootstock), Environmental (Climate and soil) and many management (Training, pruning, plant growth regulators) factors. These plant growth regulators are the tools for modifying tree growth and structure, removing excess fruit, improving fruit quality, altering fruit maturity or preventing preharvest drop. Studies have revealed that pears growth, yield and quality is greatly influenced by plant growth regulators. So in order to assess the effect of plant growth regulator Promalin (BA+ GA4+7) on quality characteristics of pear and Gibberllic acid on fruit set and fruit retention, the present investigation was undertaken at Shalimar campus on Pear cv Carmen grafted on Quince-c rootstock.

Materials and Methods

Research location and climate

The investigations were carried out at the Experimental Farm of Division of Fruit Science, SKUAST-Kashmir, during the years 2016 and 2017 on pear cv. Carmen. Here the climate is temperate cum Mediterranean and of continental type. Winter is severe extending over 100days from the middle of December to March, during which the temperature often goes below the freezing point and the whole valley remains covered with snow.

The valley is marked by extreme of temperature, ranging from a maximum of 35^{0}C in summer to a minimum of -10^{0} C in winter. The annual mean temperature is 15^{0}C. The climate is cold and rainfall is optimum, well distributed about 80 cm per annum, mostly in the form of snow during winter (Anonymous, 2018-19). So an experiment was laid out in a randomized block design with thirty six treatment combinations. There were three replications and 2 plants per replication.

Growth and fruit characteristics

During these two years vegetative growth consisting of plant height, plant spread, and annual extension growth were measured as per the standard procedures. Fruit yield was calculated by weighing all the fruits harvested individually from each experimental tree and average yield was expressed as kg/tree. Fruit length and fruit diameter were measured by vernier caliper and fruit firmness was measured with pressure penetrometer.

Fruit weight was determined by individually weighing the fruits obtained from each experimental plant on a common monopan balance and the average weight was recorded by using the procedure given by Rangana (1986). TSS was measured with the help of Zeiss hand refractometer. Titrable acidity was determined by titration method and values were expressed as percentage of malic acid (Rangana, 1986). Total sugars were determined by Lane and Eynan method (A.O.A.C., 1984). The data obtained was subjected to the statistical analysis in S-plus software.

Results and Discussion

Growth Characteristics

Growth regulators were found to have a significant effect on growth parameters like Incremental extension growth, increment in plant height and increment in plant spread, Table 1.

Maximum increment in plant height (22.01 and 23.95 cm), spread (45.19 and 46.14 cm), and annual extension growth (32.36 and 33.57 cm) was recorded with 20 ppm promalin followed by 10ppm, 30ppm, 40 ppm and 50 ppm promalin. In case of Gibberllic acid maximum increment in plant height (19.07 and 20.86 cm), spread (43.96 and 44.29 cm), and annual extension growth (30.53 and 31.61 cm) was recorded with 25ppm GA3 followed by50 ppm GA3 and control.

Fruit Yield and Fruit characteristics

Average fruit yield was higher in pear trees sprayed with 20 ppm promalin followed by10 ppm and 30 ppm, however with the application of Gibberllic acid, fruit yield was found highest with 25ppm followed by50 ppm and lowest with control.

Fruit length and fruit diameter were found highest with 20 ppm promalin and lowest with 50 ppm promalin, however the pear fruits harvested from the trees sprayed with 25 ppm Gibberllic acid were found bigger in size than control. Fruit weight was found lowest with 50 ppm promalin application while highest was found with 20 ppm promalin and in case of Gibberllic acid lowest was found with control and highest was found with 25 ppm Gibberllic acid. Average fruit firmness was found highest with 50 ppm promalin followed by 40, 30 and 10 ppm, however, in case of Gibberllic acid pear fruit firmness was found highest with 50 ppm followed by 25 ppm and control.

Chemical characteristics of pear fruits like TSS, Titrable acidity and Total sugars were found highest with 20 ppm promalin followed by 10 and 30 ppm, while in case of Gibberllic acid it was found highest with 25 ppm followed by 50ppm and control.

Growth characteristics

Incremental increase in plant height, incremental increase in plant spread, and annual extension growth were noticed maximum in T_2 (20 ppm promalin). Minimum values were observed in T_1 (10 ppm promalin) followed by T_3, (30 ppm promalin) T_4(40 ppm promalin) and T_5, (50 ppm promalin), however lowest value was observed in control.

Table.1 Effect of Promalin and GA_3 on vegetative growth characteristics of pear cultivar Carmen

Treatments		Annual shoot extension growth (cm)		Incremental increase in Plant height (cm)		Incremental increase in Plant spread (cm)	
		2017	2018	2017	2018	2017	2018
T_1	Promalin @ 10 ppm	31.48	32.36	21.23	21.47	44.54	45.43
T_2	Promalin @ 20 ppm	32.36	33.57	22.01	23.95	45.19	46.14
T_3	Promalin @ 30 ppm	30.73	31.87	20.13	20.35	43.25	43.85
T_4	Promalin @ 40 ppm	30.52	31.77	19.64	19.84	43.13	43.43
T_5	Promalin @ 50 ppm	30.45	31.68	19.24	19.45	42.73	43.08
T6	Control	29.18	30.33	18.62	18.68	42.32	42.83
CD (p≤0.05)		**0.71**	**0.74**	**0.77**	**0.79**	**1.24**	**0.91**
T_1	GA_3 @ 25 ppm	30.53	31.61	19.07	20.86	43.96	44.29
T_2	GA_3 @ 50 ppm	30.22	31.11	18.84	19.65	42.60	43.16
T6	Control	28.76	29.02	17.39	18.17	41.06	42.44
		0.53	**0.62**	**0.73**	**0.84**	**0.94**	**1.03**

Table.2 Effect of Promalin on physical characteristics and on fruit set and yield of pear cultivar Carmen

Treatment		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness (kg cm^{-2})		Fruit weight (g)		Fruit set (%)		Yield (kg/plant)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1	Promalin @ 10 ppm	11.13	11.21	7.73	7.81	13.16	13.22	194.07	195.29	30.03	31.07	9.58	10.91
T_2	Promalin @ 20 ppm	13.31	14.41	7.85	7.93	12.53	12.58	195.49	196.73	31.28	32.41	9.89	11.72
T_3	Promalin @ 30 ppm	10.77	10.88	7.54	7.68	13.62	13.67	187.45	188.08	27.68	28.82	9.26	10.14
T_4	Promalin @ 40 ppm	10.68	10.82	7.51	7.61	13.71	13.86	186.33	187.38	27.07	28.12	9.12	10.02
T_5	Promalin @ 50 ppm	10.62	10.76	7.41	7.56	13.83	13.87	186.06	187.13	26.32	26.74	9.03	9.62
T6	Control	10.55	10.69	7.37	7.45	12.03	12.10	185.04	186.07	25.33	26.45	8.86	9.23
CD (p≤0.05)		**0.12**	**0.15**	**0.09**	**0.07**	**0.36**	**0.38**	**1.37**	**1.28**	**1.00**	**1.11**	**0.27**	**0.46**

Table.3 Effect of GA_3 on physical characteristics and on fruit set and yield of pear cultivar Carmen

Treatment		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness (kg cm^{-2})		Fruit weight (g)		Fruit set (%)		Yield (kg/plant)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1	GA_3 @ 25 ppm	11.24	11.31	7.74	7.81	12.83	13.07	192.62	193.72	34.52	35.36	11.17	12.43
T_2	GA_3 @ 50 ppm	11.07	11.11	7.57	7.61	12.14	12.94	189.74	190.52	32.64	33.11	10.47	11.61
T3	Control	10.58	10.78	7.22	7.27	11.11	12.27	186.68	187.34	26.36	27.21	8.78	9.14
CD (p≤0.05)		**0.13**	**0.14**	**0.10**	**0.12**	**0.43**	**0.45**	**1.16**	**1.43**	**0.97**	**0.95**	**0.30**	**0.39**

Table.4 Effect of Promalin and GA_3 on chemical characteristics of pear cultivar Carmen

Treatments		TSS (%)		Titratable Acidity (%)		Total Sugar (%)	
		2017	2018	2017	2018	2017	2018
T_1	Promalin @ 10 ppm	13.81	13.88	0.45	0.46	12.32	12.41
T_2	Promalin @ 20 ppm	14.11	14.24	0.43	0.44	13.07	13.11
T_3	Promalin @ 30 ppm	12.81	12.89	0.51	0.52	11.68	11.77
T_4	Promalin @ 40 ppm	12.73	12.77	0.55	0.56	11.62	11.65
T_5	Promalin @ 50 ppm	12.39	12.45	0.58	0.59	11.21	11.27
T6	Control	12.26	12.36	0.60	0.61	11.02	11.06
CD (p≤0.05)		**0.28**	**0.32**	**0.12**	**0.13**	**0.36**	**0.43**
T_1	GA_3 @ 25 ppm	13.18	13.33	0.46	0.45	12.23	12.35
T_2	GA_3 @ 50 ppm	12.65	12.71	0.52	0.51	11.66	11.73
T_3	Control	12.31	12.37	0.59	0.60	11.02	11.07
CD (p≤0.05)		**0.27**	**0.31**	**0.10**	**0.07**	**0.32**	**0.41**

In case of Gibberllic acid maximum value of growth parameters was observed in 25 ppm followed by 50 ppm and control. These results are in conformity with Canli and Pektas, 2015 and Negi, 2002.

Flowering parameters

Percent fruit set

Percent fruit set was recorded maximum in T_2 (20 ppm promalin) and minimum was noticed inT_6 (control), however, by the application of Gibberllic acid it was found maximum with 25 ppm as compared to 20 ppm promalin. These results are in line with Deckers and Schoofs, 2002, Honeyborne, 1996 and Lombard and Richard, 1982.

Physical parameters

Yield attributes of fruit viz; fruit length, fruit diameter and fruit weight were recorded maximum by the application of promalin (20ppm) and in case of Gibberllic acid these parameters were recorded highest in 25ppm compared to control treatment. These results are in congruence with Deckers *et al.,* 2005 and Dussi, 2011.

Maximum fruit firmness (13.83 kg/cm^2) was recorded in T_5 (50 ppm promalin). while lowest firmness (12.03 kg/cm^2) was observed in T_6 (control), however by the application of Gibberllic acid it was found maximum with 25 ppm(12.83 kg/cm^2) followed by control. Large fruit tend to be softer than small fruits. This influence of size on firmness is generally thought to be a consequence of differences in cell expansion.

Large fruits tend to have large cell size thus large cell vacuole so exhibit less cell to cell contact and more air spaces. Both larger cells and air spaces provide more stress to cell walls resulting in less firm fruits (Stern, 2008) support the findings that firmness is less in large fruits because of loss of cell to cell adhesion. These results are in line with Nicotra, 1982 and Stern, 2008.

Chemical parameters

Total soluble solids

Maximum TSS (14.24 %) was recorded in T_2 and minimum was observed in control (12.36%) while by the application of Gibberllic acid it was found highest in 25 ppm (13.33 %). The improvement in fruit TSS is because of balanced and enhanced supply of macro and micro nutrients. Increased TSS could be due to beneficial effect on total leaf area of the plant which reflected in more carbohydrates production through photosynthesis process. These results are in conformity with Yamada *et al.,* 1991.

Total sugars

Maximum total sugars (13.11%) was recorded in T_2 (20 ppm) by the application of promalin, while minimum total sugars (11.06%) was recorded in fruits harvested from trees under T_6(control). In case of Gibberllic acid it was found maximum with 25 ppm (12.35%). Increased total sugars content may be due to increased rate of absorption of macro and micro nutrients available in balanced dose and also application of growth regulators have helped in increasing total sugars in fruits.

Increased total sugars might have resulted due to absorption of macro and micro nutrients and by the application of growth regulator which may have exerted regulatory role as an important constituent of endogenous factors in affecting the quality of fruits in which carbohydrate is important and during ripening of fruits the carbohydrates reserves of root and stems are drawn upon heavily by fruits which resulted in sugar content in fruits.

Acidity

Maximum total acidity (0.60%) was recorded in control, while minimum total acidity (0.43%) was recorded in fruits harvested from trees under T_2 (20 ppm Promalin). In case of Gibberllic acid it was found maximum with control and minimum with T_1 25 ppm (0.45%). These results are in conformity with Vercammen *et al.*, 2015. From the foregoing discussion, it can be concluded that pear trees cv carmen resulted in better productivity and quality by the use of growth regulators like, Promalin @ 20 ppm and Gibberllic acid @ 25 ppm, and hence proved to be beneficial for sustainable development of farmers as they have provided better yield and efficient fruit set.

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