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Influence of Nutrient Sprays on Yield and Fruit Quality Attributes of Apple under High Density Plantation Var. Gala Redlum

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ABSTRACT: The present investigation was carried on seven year old plants of Apple cv. Gala Redlum grafted on M9-T337 rootstock at experimental farm, Division of fruit science, SKUAST-K, Shalimar. Foliar sprays with nutrients consisting of seven treatments T_0 (control), T_1 (Macarena@1.5ml/l), T_2 (Plentigrow@4ml/l), T_3 (Cytored@4ml/l), T_4 (Macarena + Cytored@1.5+4 ml/l), T_5 (Plentigrow + cytored@4 + 4 ml/l), T_6 (Macarena + Plentigrow + Cytored@ 1.5 + 4 + 4 ml/l). The experiment was laid out in a randomized complete block design and replicated thrice. Foliar sprays of nutrients (Macarena and Plentigrow) were carried twice during the season at 50% bloom and one month after first spray and Cytored was sprayed at beginning of fruit color change (2nd week of July). Amongst nutrient sprays, (T_6) combination of (Macarena + Plentigrow + Cytored@ 1.5 + 4 +4 ml/l) recorded highest yield attributes in terms of fruit set, retention and yield whereas fruit drop was minimum. The fruit attributes like fruit length, fruit diameter, L/D ratio, fruit weight, SSC and reducing sugars were maximum under combined application of (Macarena + Plentigrow + Cytored@ 1.5+4+4 ml/l) however titrable acidity and fruit firmness were less. The foliar application is the quick method due to which we get instant results because it get directly penetrated to the target sites where it is applied.

Keywords: Apple, *Malus* × *domestica,* yield characters, foliar application, nutrient concentration, Gala Redlum.

INTRODUCTION

Apple (*Malus* × *domestica* Borkh.) is the most important temperate fruit of the North-Western Himalayan region. It has existed in Europe, both in wild and cultivated forms since prehistoric times and has been there at the beginning of Christian era. The important apple producing states in India are Jammu and Kashmir, Himachal Pradesh and Uttarakhand. In Jammu and Kashmir, it is grown over an area of 1,64,742 ha with a production of 18,82,319 metric tonnes (Anonymous, 2022). The relation between the adequate nutritional status of the fruit tree and the overall fruit quality has been well documented. Several nutrients like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) exert a notable influence upon several yield and fruit quality parameters. The sufficient supply of macro- and micronutrients can be achieved via the use of soil surface application of fertilizers, fertigation or even via foliar spray application (Nicola *et al.*, 2009). Foliar application has been characterized as the most appropriate method of nutrient application in fruit trees, providing rapid plant response and uniform distribution upon the foliage.

Foliar application has the potential to provide a higher status of nutrient bioavailability compared with soil application (Li, 2018). Great body of experimental data has focused upon the beneficial effect of foliar application of nutrients toward fruit yield and the improvement of the overall fruit quality. Keeping in view our demands at the national and global levels the present investigation entitled "Influence of nutrient sprays on yield and quality of apple under high density plantation" var. Gala Redlum was undertaken with the objective to improve production efficiency and fruit quality in HDP apple orchard.

MATERIAL AND METHODS

The present investigation was carried out at experimental farm of the Division of fruit science at Sher-e-Kashmir University of Agricultural Sciences and Technology of Shalimar campus Kashmir. The selected trees were seven years old on M9-T337 rootstock of uniform vigor and age. The experiment

comprises of six treatments *viz.,* Control (T_0), Macarena @ 1.5 ml/l (T_1), Plentigrow@ 4ml/l(T_2), Cytored@ 4ml/l (T_3), Macarena + cytored@ 1.5 + 4 ml/l(T_4), Plentigrow + Cytored @ 4 +4 ml/l (T_5) and Macarena + Plentigrow+ cytored@ 1.5 +4+4 ml/l(T_6) and was laid out in randomized complete design with three replications. The chemicals Macarena and Plentigrow were applied at 50% bloom and one month after first spray and Cytored was applied at beginning of fruit color change (2nd week of July). The chemical composition of the chemicals which were used for the study is as follows.

Chemical	Nutrient Composition
Macarena	N 2.2%, P 0.8%, K 1.0%, Mg 0.30%, S 3.5%, B 0.080%, Co 0.054%, Cu 1.0%, Fe 1.2%, Mn 1.0%, Mo 0.039%, Zn 2.2%
Cytored	N 2%, K 15%, S 1.0%, B 0.015%, Cu 0.14%, Fe 0.20%, Mn 0.15%, Mo 0.0060%, Zn 0.35%
Plentigrow	Ca 9.0%, B 0.75%

Fruit set was calculated as number of fruitlets/number of flowers multiplied by 100. For estimation of fruit retention number of fruitlets at harvest/ number of fruitlets at pea stage multiplied by 100.Fruit drop was estimated as number of fruitlets at pea stage/number of fruits retained at harvest ×100 and yield was expressed as crop harvested from each experimental unit and expressed in kilogram per tree.

The fruit length was measured between calyx and stylerend and fruit diameter was measured between cheeks and the average values were worked out and expressed in millimeter. L/D ratio was calculated by dividing the length of fruit with the diameter of corresponding fruit. For calculating fruit weight, ten randomly selected fruits from each tree were weighed with the help of top pan balance and the average value was expressed in grams per fruit. Fruit firmness was measured with the help of Effegi penetrometer model, Ft-3-27 having 7/16 diameter of the head with a penetration of 5/6. In each treatment, fruits were punched at three different places on its surface after removing about one square inch of peel and firmness was recorded as Kg/cm^2. For calculating SSC and titrable acidity values were estimated (A.O.A.C., 1990). Total and reducing sugars were calculated as per (Ranganna, 1986) method.

Table 1: Influence of nutrient sprays on yield attributes of apple under high density plantation var. Gala Redlum.

Parameters / Treatments	Fruit set (%)			Fruit drop (%)			Fruit retention (%)			Yield/tree (Kg)		
	2018	2019	Pooled	2018	2019	pooled	2018	2019	pooled	2018	2019	pooled
T_0 Control	65.44	65.98	65.71	61.83	61.55	61.69	38.16	38.45	38.30	17.76	17.87	17.81
T_1 Macarena (1.5 ml/l)	71.24	72.99	72.12	57.82	57.33	57.58	42.17	42.66	42.41	20.13	20.44	20.28
T_2 Plentigrow (4 ml/l)	73.15	74.95	74.05	55.87	55.61	55.70	44.13	44.39	44.29	22.65	22.97	22.81
T_3 Cytored (4 ml/l)	65.44	65.98	65.71	61.74	61.45	61.59	38.25	38.54	38.40	17.77	17.88	17.82
T_4 Macarena + Cytored (1.5 ml/l + 4 ml/l)	71.26	72.99	72.12	57.83	57.34	57.58	42.18	42.18	42.18	20.14	20.44	20.29
T_5 Plentigrow + Cytored (4 ml/l + 4 ml/l)	73.16	74.96	74.06	55.86	55.53	55.70	44.13	44.46	44.30	22.66	22.98	22.82
T_6 Macarena + Cytored + Plentigrow (1.5 ml/l + 4 ml/l + 4 ml/l)	76.26	77.86	77.06	54.37	53.86	54.12	45.62	46.13	45.88	24.15	24.66	24.40
C.D (p<0.05)	**0.108**	**0.112**	**0.151**	**0.057**	**0.046**	**0.067**	**0.028**	**0.044**	**0.024**	**0.036**	**0.046**	**0.027**

Table 2: Influence of nutrient sprays on physical parameters of apple fruit under high density plantation var. Gala Redlum.

Parameters / Treatments	Fruit length(mm)			Fruit diameter (mm)			L/D ratio			Fruit weight (g)		
	2018	2019	Pooled	2018	2019	pooled	2018	2019	Pooled	2018	2019	Pooled
T_0 Control	58.13	58.34	58.24	66.36	67.67	67.01	0.87	0.86	0.86	153.44	153.48	153.46
T_1 Macarena (1.5 ml/l)	63.07	64.18	63.62	70.34	71.43	70.89	0.89	0.89	0.89	164.06	165.75	164.90
T_2 Plentigrow (4 ml/l)	62.18	63.04	62.61	69.84	70.34	70.09	0.89	0.89	0.89	159.53	161.76	160.64
T_3 Cytored (4 ml/l)	63.65	64.13	63.89	71.67	72.75	72.21	0.88	0.88	0.88	164.55	166.56	165.56
T_4Macarena + Cytored (1.5 ml/l + 4 ml/l)	65.45	66.93	66.19	73.55	75.02	74.28	0.88	0.89	0.89	167.55	169.85	168.70
T_5 Plentigrow + Cytored (4 ml/l + 4 ml/l)	64.35	65.86	65.11	72.16	73.55	72.86	0.89	0.89	0.89	166.35	168.96	167.65
T_6 Macarena + Cytored + Plentigrow (1.5 ml/l + 4 ml/l + 4 ml/l)	66.93	68.97	67.95	74.43	76.94	75.68	0.89	0.89	0.89	170.33	174.75	172.54
C.D (p<0.05)	**0.086**	**0.058**	**1.081**	**0.040**	**0.035**	**0.019**	**NS**	**NS**	**NS**	**0.204**	**0.132**	**0.196**

Table 3: Influence of nutrient sprays on physical parameters of apple fruit under high density plantation var. Gala Redlum.

Parameters / Treatments	Fruit firmness (Kg/cm^2)			Total titratable acidity (%)			SSC(^{0}Brix)			Reducing sugars (%)		
	2018	2019	Pooled	2018	2019	pooled	2018	2019	Pooled	2018	2019	Pooled
T_0 Control	7.33	7.42	7.37	0.36	0.39	0.37	12.43	12.48	12.45	9.97	10.06	10.01
T_1 Macarena (1.5 ml/l)	7.28	7.21	7.24	0.33	0.31	0.32	13.17	13.25	13.21	10.24	10.31	10.27
T_2 Plentigrow (4 ml/l)	7.36	7.53	7.44	0.36	0.34	0.35	12.75	12.80	12.77	10.11	10.20	10.15
T_3Cytored (4 ml/l)	7.18	7.15	7.16	0.29	0.28	0.28	13.29	13.38	13.33	10.35	10.42	10.38
T_4Macarena + Cytored (1.5 ml/l + 4 ml/l)	6.76	6.74	6.75	0.22	0.20	0.21	13.44	13.55	13.49	10.38	10.45	10.41
T_5Plentigrow+Cytored(4 ml/l + 4 ml/l)	7.33	7.26	7.29	0.32	0.31	0.31	13.28	13.37	13.32	10.31	10.36	10.33
T_6Macarena + Cytored + Plentigrow (1.5 ml/l + 4 ml/l + 4 ml/l)	7.16	7.13	7.14	0.19	0.17	0.18	14.13	14.25	14.19	10.64	10.77	10.70
C.D (p<0.05)	**0.034**	**0.098**	**0.071**	**0.021**	**0.021**	**0.014**	**0.027**	**0.031**	**0.032**	**0.038**	**0.025**	**0.021**

RESULTS AND DISCUSSION

Maximum fruit set (77.06 %) and fruit retention (45.88%) in 'Gala Redlum' apple was observed in trees sprayed with combined foliar application of Macarena + Plentigrow + Cytored @ 1.5 +4 + 4 ml/l and lowest (65.71%) and (38.30%) respectively was recorded in control (Table 1). Increased fruit set and fruit retention was due to the combined application of all essential nutrients in proper amount. Further, boron plays an important role as an activator for many enzymes that promote pollen production, pollen germination, pollen tube growth for successful fruit set and retention. Boron contribute to the formation of sugar-borate complexes which promote absorption, translocation and metabolism of sugars in the pollen (Wojcik and Wojcik 2003). Calcium also support the assumption that the pollen tube cell wall stores excess Ca^{+2} ions. At the extreme apex of a growing pollen tube, new cell wall materials such as methyl- pectin are secreted. Pollen's need calcium in order to keep the cell wall rigid enough not to burst but to be flexible enough to not stop growing (Mosa *et al.,* 2015). Zn is involved in generative processes, pollen grains have high zinc content and during fertilization most of the zinc is incorporated into developing seed. Potassium could have been due to its role in synthesis of proteins, carbohydrates and their translocation in plant. Combination of potassium, boron, calcium and zinc enhanced fruit set per cent (Imam *et al.,* 2010; Simnani, 2012).

Foliar nutrient sprays with combined application of Macarena + Plentigrow + Cytored @ 1.5 +4 +4 ml/l significantly decreased fruit drop to 54.12% from 61.69% in control (Table 1). The nutrients potassium, boron, zinc and calcium are responsible for building and moving carbohydrates from leaves to fruits and encourage biosynthesis of cellulose which positively strengthened cell wall resulting in reduced fruit drop. These results are in conformity with those of Happis and Davis (2001); Wojcik and Wojcik (2003); Imam *et al.* (2010); Simnani (2012); Mosa *et al.* (2015).

Results in Table 1 shows that combined application of Macarena + Plentigrow + Cytored @ 1.5 +4 +4 ml/l significantly increased fruit yield (24.40 kg/tree) in 'Gala Redlum' apple compared to other treatments and the lowest yield was recorded under control (17.81 kg/tree). The increase in fruit yield may be due to the reason that potassium helps in transportation of assimilates and nutrients and also by promoting phloem transport of photosynthates to fruits (Doroshenko *et al.,* 2002). Boron facilitates transport of carbohydrates through cell membrane and is involved in number of metabolic pathways *i.e.,* sugar transport, respiration, RNA, IAA, phenol metabolics and calcium plays building role in the complex polysaccharides and proteins forming cell wall there by reduction in drop improve the fruit yield (Happis and Davis 2001; Asma *et al.,* 2007).

Fruit length, diameter, L/D ratio and fruit weight of 'Gala Redlum' apple was significantly affected by foliar application of Macarena + Plentigrow+ Cytored @ 1.5 +4 + 4 ml/l. Maximum fruit length (67.95mm) , fruit diameter (75.68mm), L/D ratio (0.89) and fruit weight (172.54gm) was observed in T6 and lowest fruit length (58.24mm) , fruit diameter (67.01mm), L/D ratio (0.86) and fruit weight (153.46 gm) was recorded in control (Table 2). The reason for this is that the efflux of sucrose to apoplast is facilitated by potassium availability, which increases sugar translocation to sink tissues and promoting their growth (Anjum *et al.,* 2008; Taiz and Zeiger 2004). The increase in fruit size and fruit weight with boron application could be attributed to the enhancement in cell division, cell enlargement and building and transporting of organic food. Improvement in fruit size and fruit weight with calcium spray might be due to binding role of calcium in the complex polysaccharides and proteins, thereby forming cell wall. Besides, calcium has a stimulating influence on development of root hairs and entire root that are resistant to decay and cell division (Mosa *et al.,* 2015). Nitrogen and potassium results in increasing cell division and cell elongation, thus increasing the fruit length. Zinc might have acted through alteration in photosynthesis and mobilization of metabolites from leaves to fruit thereby improving fruit size and weight (Simnani, 2012).

Fruit firmness of 'Gala Redlum' apple was highest (7.44 kg/cm^2) in trees sprayed with foliar application of Plentigrow @ 4 ml/l and lowest (6.75 kg/cm^2) was recorded under Macarena + cytored @ 1.5 +4 ml/l. (Table 3). The reason for highest firmness is due to the role of Calcium in maintaining membrane integrity of cells and its importance in maintaining structural

integrity of cell walls. Moreover calcium is needed for the synthesis of pectic substances which enhances fruit firmness. Calcium plays an adhesive role in the complex polysaccharides & proteins forming the cell wall. The firmness of fruit has a direct relation with calcium pectate since calcium interact with pectic polymers of cell wall and thereby acts as cementing agent giving high strength to the cell wall. The decrease in fruit firmness in Macarena + cytored @ 1.5 +4 ml/l is due to the presence of more potassium, as a result of which Ca content of fruits sharply decreases with increased K application, since calcium is an essential component of the cell wall, thus low concentration of Ca^{2+} will definitely have an effect on cell wall formation, hence directly affecting fruit firmness. Similar results and findings were observed by Fallahi *et al.* (2010); Mosa *et al.* (2015) whose studies reported that potassium decreased firmness at harvest probably due to increase of K/Ca ratio in fruit.

The present studies reveal that soluble solids concentration was highest (14.19 °brix) in trees sprayed with combined foliar application of Macarena + Plentigrow + Cytored @ 1.5 +4 + 4 ml/l and lowest (12.45°brix) was recorded in control (Table 3). The reason for highest SSC is due to the fact that nitrogen increases the availability of assimilates due to more vegetative growth and potassium enhances rate of hydrolysis in polysaccharides into mono-saccharides. The increase in soluble solids concentration, is also due to the role of potassium in translocation of sugars into the fruit (Stampar *et al*., 2002). These findings are in parallel with those of El-Shazley and Dris (2004) ; Simnani (2012). The rate of photosynthesis in leaf are observed to enhance with the increase in leaf potassium concentrations. This in turn results in enhanced sugar contents in the fruit. Moreover increased phloem loading, rate of transport and sugar unloading by potassium could also lead to enhanced sugar level in fruit (Mosa *et al.,* 2015).

Total sugars were highest (10.70%) in trees sprayed with Macarena + Plentigrow+ Cytored @ 1.5 +4 + 4 ml/l and lowest (10.01%) was recorded in control (Table 3). The reason for higher total sugars is due to the fact that increase in mono and disaccharides from the hydrolysis of starch. Moreover, potassium plays a vital role in the translocation of assimilates to fruit as well as increases the photosynthetic efficiency of the leaves. Boron plays a key role in facilitating short and long distance transport of sugars via formation of borate sugar complexes as well as facilitate sugar uptake by leaves, the nitrogen increases photosynthates due to which total sugars increases (El- Shazley and Dris 2004; Simnani 2012).

Total titratable acidity was lowest (0.18%) in trees sprayed with combined foliar application of Macarena + Plentigrow+ Cytored @ 1.5 +4 + 4 ml/l and highest (0.37%) was recorded in control (Table 3). The reason for lowest acidity is due to highest potassium level, this may be due to conversion of organic acids into sugars and direct effect of potassium on enzymatic activity of cells and precipitation of tartaric acid as K bitartate which is insoluble, thus decreasing acid level in the fruit. These results are in close conformity with those obtained by Neilsen and Neilsen (2006).

CONCLUSIONS

The best combination of foliar application of Macarena + Plentigrow + Cytored (T_6) improved yield and quality parameters in Gala Redlum variety of apple. The main aim of farmer is to get the maximum yield and good quality fruit in order to fetch the maximum return from the market. So, the results confirm that foliar nutrient sprays can be useful tool for orchardists to get the quick response of plants in very less time as compared to other methods of fertilizers. Hence the combined foliar application of macro and micro nutrients are recommended to improve the yield and quality parameters of apple.

FUTURE SCOPE

The study reveals that the foliar application of nutrients can be a useful tool for orchardists to solve the problems faced related to nutrition disbalance of the fruit crops. By foliar application we can provide the nutrients within short period of time and due to which the plants can complete their growth and development within short period of time.

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