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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 16, Issue, 02, pp.27168-27174, February, 2024
DOI: https://doi.org/10.24941/ijcr.46753.02.2024

ISSN: 0975-833X

RESEARCH ARTICLE

EFFECT OF FRUIT BAGGING, REFLECTIVE MULCH AND FOLIAR POTASSIUM SPRAY ON QUALITY OF APPLE CV. FUJI ZEHN AZTEC

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ARTICLE INFO

Article History:
Received 19th November, 2023
Received in revised form
18th December, 2023
Accepted 15th January, 2024
Published online 27th February, 2024

Key words:

Apple, Fruit Bagging,
Foliar potassium Spray,
Petal fall, Reflective Mulch.

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ABSTRACT

An effect of fruit bagging, reflective mulch and foliar potassium spray on quality of apple cv. Fuji Zehn Aztec was studied in high density Apple block of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during 2016-2017. Treatments consisted of fruit bagging done at two time periods (4 and 6 weeks after petal fall), reflective mulch at two different widths (100cm and 75 cm), potassium sulphte spray at two concentrations (0.50% and 0.75%) and the all 4 combinations of reflective mulch and potassium sulphate spray, constituting total 11 treatments. The results revealed that fruit size and yield did not show any significant effect by any treatment, however the improvements with respect to total sugars, ascorbic acid, TSS, TSS: acid ratio and organoleptic rating were observed by all the treatments over control. Fruit firmness and acidity were decreased by all the treatments as compared to control. On overall basis the treatment consisting of potassium sulphate spray@0.75% + polyethylene reflective mulch (100cm) proved to be most appreciating wherein figures regarding fruit weight (178.20g), total sugars (15.04 %), ascorbic acid (5.97 mg/100g), TSS (18.80 %), TSS: acid ratio (89.52) and organoleptic rating (3.80/5) were above the values as recorded under other treatments. The study indicated that Fuji apple showed positive responses to application of fruit bagging, reflective mulch and foliar potassium spray in enhancing the fruit biochemical characters.

Citation: Mohmmad Asif Wani, Shafat Ahmad Banday, Aalia Farooq, Javaid Ahmad Dar, Ejaz Ahmad Parry, Mohsin Ahmad Hajam and Syed Towseef Ahmad. 2024. "Management of Luxation Injuries in Pediatrics - Case Series*". International Journal of Current Research, 16, (02, 27168-27174.*

INTRODUCTION

The cultivated apple (*Malus* × *domestica* Borkh) is the premier table fruit of the world known as King of temperate fruits. Botanically, it is a member of family Rosaceae and sub-family Pomoideae. It is the rich source of carbohydrates, proteins, minerals and vitamin-C. The apple cultivar Fuji was developed in the late 1930s by growers at the Tohoku Research Station Morioka, Japan. Fuji apples are a cross between two classic American apple varieties-Red Delicious and Virginia Ralls Janet. Poor red colouration is often a serious problem in the culture of Fuji apples.

The high popularity of Fuji is due to its good taste and excellent keeping quality. Growers worldwide have developed various management practices like fruit bagging, leaf removal close to individual fruits and reflective mulches as well as growth control practices (fertilization, irrigation, pruning, etc.) to improve quality of fuji apples (Arakawa *et al.*, 1994). Many factors directly or indirectly influence quality development in apples including light (Proctor, 1974; Faragher, 1983), temperature (Creasy, 1968), nutrition (Fallahi and Mohan, 2000), canopy architecture (Elfving *et al.*, 1990) and plant growth regulators (Miller, 1988) etc. Red coloured apples are preferred in the market as they attract the consumers.

However, majority of the farmers use ethrel (2-Chloroethyl Phosphonic Acid) as the pre-harvest foliar spray for colour enhancement of the fruits. Ethrel helps in the development of attractive red colour in apple fruits but it causes several adverse effects. The various methods or strategies which can be used to increase red skin colouration in apple along with other quality parameters are the use of reflective mulch (Proctor, 1974; Moreshet *et al.*, 1975; Mancinelli, 1985; Miller and Greene, 2003), fruit bagging (Arakawa, 1988), (Arakawa, 1991), foliar spray of potassium (Walter, 1967; Saure, 1990; Witney, 1997) and various management practices (proper pruning, irrigation fertilization) etc. The cultivar Fuji Zehn Aztec has been developed in New Zealand by mutation from standard Fuji and has gained considerable popularity worldwide. Fuji Zehn Aztec is a full coloured, blush-type that harvests late season with standard Fuji. The tree is healthy and vigorous and the fruit exhibits the traditional, sweet flavor of Fuji. In the present study effect of fruit bagging, reflective mulch and foliar potassium spray on quality of apple cv. Fuji Zehn Aztec was ascertained during the year 2016-17 under temperate conditions of Kashmir.

MATERIALS AND METHODS

The effect of fruit bagging, reflective mulch and foliar potassium spray on quality of apple cv. Fuji Zehn Aztec was undertaken at the experimental fields of Division of Fruit Science in high density block, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during the years 2016-2017. The experimental site is situated at an elevation of 1685 meters above mean sea level between 34^o 9'0" N latitude, 74^o 52'55" E longitude. The Design of Experiment used was Randomized Complete Block Design with 03 replications. The total number of treatments given were 11 as follows; T_1Control, T_2 Fruit bagging (4 weeks after petal fall), T_3 Fruit bagging (6 weeks after petal fall), T_4 Polyethylene Reflective mulch (100 cm width), T_5 Polyethylene Reflective mulch (75 cm width), T_6 Potassium sulphate spray @ 0.50%, T_7 Potassium sulphate spray @ 0.75%, T_8 Potassium sulphate spray@ 0.50% + Polyethylene Reflective much (100 cm), T_9 Potassium sulphate spray @ 0.5% $_+$ Polyethylene Reflective mulch (75 cm), T_{10} Potassium sulphate spray @ 0.75% + Polyethylene Reflective mulch (100 cm), T_{11} Potassium sulphate spray @ 0.75% + Polyethylene Reflective mulch (75 cm). Moreover, the double layer paper bags consisting of an inner red coloured liner and an outer white bag were placed on fruitlets, 4 and 6 weeks after petal fall. The bags which were placed 4 weeks after petal fall were removed 6 weeks before predicted harvest date and similarly the bags which were placed 6 weeks after petal fall were removed 4 weeks before predicted harvest date. Also, Polyethylene reflective mulch having a width of 100cm and 75cm was placed beneath the tree canopies 40 days before expected date of harvest. Foliar application in the form of potassium sulphate (0.5% and 0.75%) was applied 100 days after petal fall. The physical characteristics recorded were; Fruit length (cm), Fruit diameter (cm) , Fruit volume (cm^3) Fruit weight (g) Fruit firmness (kg/cm^2) Yield (kg/tree) and Organoleptic rating (pts). In order to ascertain Organoleptic rating (pts) a panel of judges was selected from technical staff of Division of Fruit Sciences, SKUAST-Kashmir. Panelists were provided with samples of fruits and were requested to assign scores for taste, flavor and overall acceptability on four point scale where;1 = Very Poor, 2 =Poor, 3 = Good, 4 = Very Good, 5 = Excellent.

The Chemical characteristics of the fruit observed were; Ascorbic acid (mg/100 g): Quantitative determination of ascorbic acid was done by 2, 6-dichlorophenol indophenol visual titration method (Ranganna, 1986). Fruit samples of 10g was homogenized in metaphosphoric acid and volume was made to 100ml with metaphosphoric acid in a volumetric flask. A 10ml of aliquot was titrated against indophenol dye. The end point was determined by the appearance of a rose pink colour which persisted for a few seconds. Titre reading was noted and the content of ascorbic acid was calculated by the following formula:

$$\text{Ascorbic acid (mg/100g fresh weight)} = \frac{T \times D \times V \times 100}{AE \text{ x } WS}$$

T = Titre value, D = Dye factor, V = Volume made up, AE = Aliquot of extract taken for estimation, WS = Weight of sample taken for estimation.

Total Soluble Solids (%): The total soluble solid content in fruits was determined by Erma Hand Refractometer. The hand refractometer was calibrated with distilled water before use and then a few drops of fruit juice were placed on the prism and the reading was recorded. The total soluble solids were expressed as percentage of fresh fruit juice. Total Sugars (%): Total sugars were estimated by Lane and Eynon method (Ranganna, 1986). Fruit sample of (25g) was blended with 50 ml distilled water and transferred to a 250 ml volumetric flask. For the estimation of total sugars, inversion of sample was done by the addition of 10 ml concentrated HCl and then keeping it overnight. Next day it was neutralized with 5 N NaoH using phenolphthalein as an indicator. To it 2 ml of 45 per cent lead acetate was added, shaken well and left undisturbed for 10 min. Then it was deleaded with 2 ml of potassium oxalate and volume made upto 250 ml. The solution was filtered through Whatman No. 4 filter paper and the filterate was marked as solution (A).

Percentage of total sugars was calculated as under:

$$\text{Total sugar} = \frac{(0.5 \times \text{Volume made})}{\text{Weight of sample} \times \text{titre value}} \times 100$$

Fruit acidity (%): Twenty five gram of fruit was thoroughly homogenised with distilled water in an electric blender and volume made up to 250 ml. the mixture was then filtered through Whatman No. 1 filter paper. Twenty five ml of this extract was titrated against 0.1N NaOH solution using phenolphthalein as an indicator (A.O.A.C, 1990) and end point was determined by pink colouration. The total titrable acidity was expressed as per cent acidity and calculated in terms of malic acid using the formula:

$$\text{Percent acidity} = \frac{\text{Titre value} \times \text{N of NaOH} \times \text{Eq. wt of Predominant acid} \times \text{Volume made} \times 100}{\text{Weight/Volume of sample taken for estimation} \times \text{Aliquot taken} \times 1000}$$

Total soluble solids/acidity ratio: T.S.S/acidity ratio was determined by working out the ratio of total sugars and acidity of fruits:

$$\text{TSS/acid ratio} = \frac{\text{TSS}}{\text{Acidity}}$$

Statistical analysis: The observations recorded during the course of investigation were subjected to statistical analysis as per the method of 'Analysis of Variance' (Fisher, 1950). The significance and non-significance of treatment effects were judged with the help of software OP-stat. The significant difference on the means was tested against the critical difference at 5% level.

RESULTS AND DISCUSSION

Fruit size (length, diameter and volume): The data pertaining to fruit size depicts that the application of fruit bagging, reflective mulch and potassium spray alone or in combination had no significant effect on fruit size (Table 1). However, a close examination of data showed that fruit size in terms of fruit length, fruit diameter and fruit volume was increased by the treatment T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch) in comparison to control and other treatments in which fruit length, fruit diameter and fruit volume of 6.55 cm, 7.69 cm and 195.14 cm^3 respectively was observed, which were highest among all the treatments. These results are in agreement with the findings of Iglesias and Alegre (2002) and Prive *et al.* (2011) who reported that reflective mulches does not affect fruit size in apples. Amarante *et al.* (2002) and Tran *et al.* (2015) also reported that bagging fruits of pears (*Pyrus communis*) and red pitaya (*Hylocereus* spp.) with different materials including paper bags does not affect fruit size.

Table 1. Effect of fruit bagging, reflective mulch and foliar potassium spray on fruit length, fruit diameter and fruit volume of apple cv. Fuji Zehn Aztec

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm^3)
T_1	6.00	7.01	175.39
T_2	6.12	7.17	177.17
T_3	6.05	7.03	176.62
T4	6.20	7.34	180.40
T_5	6.15	7.29	179.05
T_6	6.22	7.50	181.07
T_7	6.38	7.54	189.65
T_8	6.28	7.51	186.84
T_9	6.24	7.51	184.11
T_{10}	6.55	7.69	195.14
T_{11}	6.40	7.54	191.44
C.D ($p < 0.05$)	N.S	N.S	N.S

Fruit weight (g): Data reveals that application of fruit bagging, reflective mulch and potassium spray alone or in combination had significant influence on fruit weight. Fruit weight increased with increased concentration of potassium sulphate and with increase in width of reflective mulch (Table 2). The highest fruit weight (178.20g) was observed with treatment T_{10} (0.75% potassium sulphate spray + 100cm wide Polyethylene reflective mulch). The treatment T_8 (0.50% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch) was statistically at par with T_9 (0.50% potassium sulphate spray + 75cm wide Polyethylene reflective mulch) having a fruit weight of 170.17 and 169.18g respectively. The lowest fruit weight (157.39) was observed in treatment T_1 (control). The increase in fruit weight may be attributed to higher photosynthetic activities. Photosynthates are supplied to fruits by leaves and fruit act as metabolic sink, which were higher on account of potassium fertilization (Hansen, 1970). The results are in conformity with the findings of Abd El-Fatah *et al.* (2008) and Yadav *et al.* (2014) who reported that foliar application of potassium increases the fruit weight of persimmon and ber respectively. Costa *et al.* (2003) noted the increment in weight of kiwifruit by using reflective mulch owing to higher light availability through the canopy resulting in an increase in fruit quality due to improved photosynthesis. Yang *et al.* (2009) reported that bagging increased the fruit weight of longan probably due increase in temperature.

Fruit yield (kg/tree): The data pertaining to fruit yield reveals that after the application of fruit bagging, reflective mulch and potassium spray alone or in combination had no significant influence on fruit yield. However maximum fruit yield (11.53 kg/tree) was observed in treatment T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch), whereas the minimum fruit yield (9.02 kg/tree) was observed in Treatment T_1 (control). There are also studies showing that bagging had no effect on fruit size (Hofman *et al.,* 1997; Jia *et al.*, 2005) and yield (Tyas *et al.*, 1998). Similarly Funke and Blanke (2005) reported that fruit size of Braeburn apple fruit at harvest was unaffected by reflective ground cover (Table 2).

Table 2. Effect of fruit bagging, reflective mulch and foliar potassium spray on fruit weight, fruit yield and fruit firmness of apple cv. Fuji Zehn Aztec

Treatments	Fruit weight (g)	Fruit yield (kg/tree)	Fruit firmness (kg/cm^2)
T_1	157.39	9.02	11.78
T_2	158.50	9.39	11.50
T_3	158.01	9.29	11.58
T4	164.06	9.58	11.28
T_5	162.08	9.42	11.36
T_6	166.14	10.00	11.22
T_7	173.13	10.55	10.92
T_8	170.17	10.25	10.25
T_9	169.18	10.15	10.55
T_{10}	178.20	11.53	10.00
T_{11}	176.34	10.98	10.14
C.D ($p < 0.05$)	1.13	N.S	0.71

Fruit firmness (kg/cm^2): It is evident from the data that application of fruit bagging, reflective mulch and potassium spray alone or in combination had a significant influence on fruit firmness (Table 1). The highest fruit firmness (11.78 kg/cm^2) was observed in T_1 (control) whereas the lowest fruit firmness (10.00 kg/cm^2) was observed in T_{10} (0.75% potassium sulphate spray + 100cm wide Polyethylene reflective mulch). The decrease in firmness may be due to the fact that Ca content of fruits sharply decreased due to increased K application, as calcium is an important constituent of cell wall, thus low concentration of Ca^{2+} will definitely tell upon cell wall formation, hence on fruit firmness (Anjum *et al.*, 2008). Similar findings were observed by Fallahi *et al.* (2010) who reported that potassium fertigation decreased firmness at harvest probably due to incrase of K/Ca ratio in fruit. Among the different treatments the highest fruit firmness (11.58 kg/cm^2) was observed in T_3 (fruit bagging 6 weeks after petal fall) followed by T_2 (fruit bagging 4 weeks after petal fall) which was having the fruit firmness of 11.50 kg/cm^2. Bentley and Viveros (1992) reported that fruit firmness of "Granny Smith" apples was improved by brown paper bags when done at golf-size of fruit development. However, Hofman *et al.* (1997) reported that fruit firmness was not affected by white paper bag in mango. The results are also in close conformity with the findings of Mika *et al.* (2007), Vangdal *et al.* (2007) Iglesias and Alegre (2002) and Funke and Blanke (2005).

Organoleptic rating (pts): It is evident from that application fruit bagging, reflective mulch and potassium spray alone or in combination had significant influence on organoleptic rating of fruit (Table 3). The highest organoleptic rating (3.80) was observed in T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch) followed by 3.62 in T_{11} (0.75% potassium sulphate spray + 75 cm wide polyethylene reflective mulch). The minimum organoleptic rating (2.85) was found in treatment T_1 (control). This may be probably due to increase in soluble solids and sugars by these treatments which result in high organoleptic rating of the fruit. These results are in harmony with Yadav *et al.* (2014), Mosa *et al.* (2015) and Jakhar and Pathak (2016).

Chemical characteristics

Ascorbic acid (mg/100g): Studies revealed the application of fruit bagging, reflective mulch and potassium spray alone or in combination had influenced significantly the ascorbic acid content of fruits (Table 3). The maximum ascorbic acid content (5.97 mg/100g) was observed in treatment T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch) followed by treatment T_{11} (0.75% potassium sulphate spray + 75 cm wide Polyethylene reflective mulch). The lowest ascorbic acid content (3.60 mg/100g) was recorded in treatment T_1 (Control). Although light is not essential for the biosynthesis of ascorbic acid in plants, good exposure or high light intensity is, generally, a positive factor for the accumulation of ascorbic acid as observed in many plants (Lee and Kader, 2000) and fruits (Poiroux-Gonord *et al.*, 2010).

This could be due to the fact that ascorbic acid is synthesized from sugars supplied by photosynthesis in plants. Ma and Cheng (2003) reported that sun exposure increased the ascorbate pool by as high as seven-fold in apple peel, with increased activities of ascorbate peroxidase, monodehydroascorbate reductase and dehydroascorbate reductase. In a study on grape berries (Cruz-Rus *et al.*, 2010), the expression of the GalUR gene, encoding for D-galacturonate reductase, showed up-regulation with high light and, simultaneously, the content of ascorbic acid in fruits increased by two-fold compared to the fruits grown under low light. Therefore, both the increased availability of carbohydrates in leaves grown at high light intensity and a direct effect of light on the expression of ascorbate biosynthesis genes could contribute to the regulation of the biosynthesis and pool size of ascorbate (Smirnoff and Pallanca, 1996). Higher concentration of potassium was more effective in increasing the ascorbic acid content. Similar results have been reported by Singh *et al.* (1981) and Singh and Chauhan (1982).

Total sugars (%): On investigating the effect of fruit bagging, reflective mulch and potassium spray alone or in combination on total sugars, significant increase in total sugars was recorded (Table 3). Highest value of total sugar (15.04%) was recorded with treatment T_{10} (0.75% potassium sulphate spray + 100cm wide Polyethylene reflective mulch) followed by treatment T_{11} (0.75% potassium sulphate spray + 75cm wide Polyethylene reflective mulch) having value of 14.58% which was statistically at par with T_{10}.

Table 3. Effect of fruit bagging, reflective mulch and foliar potassium spray on anthocyanin content, ascorbic acid, total sugars, and organoleptic rating content of apple cv. Fuji Zehn Aztec

Treatments	Ascorbic acid (mg/100g)	Total sugars (%)	Organoleptic rating (pts 1-5)
T_1	3.60	12.40	2.85
T_2	4.05	12.93	2.95
T_3	3.89	12.43	2.93
T4	4.35	13.60	2.99
T_5	4.24	13.19	2.97
T_6	4.48	13.85	3.01
T_7	4.91	14.07	3.12
T_8	5.20	14.09	3.31
T_9	5.01	14.08	3.21
T_{10}	5.97	15.04	3.80
T_{11}	5.52	14.61	3.62
C.D ($p < 0.05$)	0.43	0.50	0.32

The lowest total sugar content (12.40 %) was recorded in treatment T_1 (Control). The possible reason for this increment is due to increase in light intensity which enhanced photosynthesis. Hanrahan *et al.* (2011) concluded that in apple, reflective ground covers made of white woven mulch cloth have been shown to increase photosynthtically active radiation within the canopy, thus increasing the total photosynthesis which would definitely increase the sugar content of fruit. Further reflective ground covers are reported to increase sugar content of apples (Grout *et al.*, 2004; Solornakin and Blanke, 2007). Moreover potassium helps in the translocation of assimilates to fruits as well as increases the photosynthetic efficiency of the leaves (Singh *et al.,* 1982). These observations are in conformity with the findings of Kaur and Dhillon (2006), Yadav *et al.* (2014), Mosa *et al.* (2015).

Total soluble solids (%): The investigation revealed that highest total soluble solids (18.80%) were recorded with treatment T_{10} (0.75% potassium sulphate spray + 100cm wide Polyethylene reflective mulch) (Table 4).Whereas the lowest total soluble solids (15.50%) were recorded in treatment T_1 (Control). The increase in total soluble solid content of fruits may be attributed to higher photosynthetic rates in response to higher light intensity (Taiz and Zeiger, 2006). Dokoozlian and Kliewer (1996) also reported that the content of fructose and glucose increased from 50-60 mg/g fresh weight fresh weight to 70-80 mg/g fresh weight in grapes while comparing shaded plants to light exposed ones. Leaf photosynthesis rates are reported to increase with increased leaf K concentrations and this results in increased sugar contents in fruit (Terry and Ulrich, 1973; Peoples and Koch, 1979). Increased phloem loading, transport rate and unloading of sugars by potassium could also account for the increased fruit sugar levels, although it is uncertain whether this is a direct effect (enhanced phloem unloading in fruits) or an indirect effect (enhanced sucrose synthesis in source leaves) (Doman and Geiger, 1979; Peel and Rogers, 1982). Similar results were recorded by Sulladmath and Singh (1972), Singh *et al.* (1981), Singh and Singh (1981), Awang and Atherton (1995), and Liu *et al.* (2007).

Acidity (%): Data in Table 4 showed that the acidity decreased with the applicaton of potassium sulphate spray and reflective mulch . Significantly lowest acidity (0.21%) was found in treatment T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch) whereas the highest acidity (0.30%) was recorded under treatment T_1 (control). The acidity decreased with the increased concentration of potassium sulphate as well as width of reflective mulch. This may be due to conversion of organic acids into sugars and effect of potassium on enzymatic activity of cells (Barden and Thompson, 1962) and precipitation of tartaric acid as potassium bitartarate which is insoluble, thus decreasing acid levels in fruits. These results are in agreement with the results obtained by Naiema (2003), Neilson and Neilson (2006) and Anjum *et al.* (2008).

Table 4. Effect of fruit bagging, reflective mulch and foliar potassium spray on total soluble solids (TSS), acidity and TSS: Acid ratio of apple cv. Fuji Zehn Aztec

Treatments	TSS (%)	Acidity (%)	TSS:Acid ratio
T_1	15.50	0.30	51.66
T_2	16.17	0.28	57.71
T_3	15.53	0.29	53.55
T4	17.00	0.27	62.96
T_5	16.47	0.27	60.96
T_6	17.33	0.26	66.65
T_7	17.63	0.25	70.53
T_8	17.61	0.24	73.33
T_9	17.60	0.24	73.33
T_{10}	18.80	0.21	89.52
T_{11}	18.23	0.22	82.86
C.D ($p< 0.05$)	0.67	0.04	2.76

TSS/acid ratio: It is evident from data that application of fruit bagging, reflective mulch and potassium spray alone or in combination had significant influence on TSS/Acid ratio of fruit (Table 4). Maximum sweetness index of 89.52 was recorded in treatment T_{10} (0.75% potassium sulphate spray + 100 cm wide Polyethylene reflective mulch). The minimum sweetness index 51.66 was found in treatment T_1 (control). The increased TSS/acid acid ratio is because the treatment T_{10} recorded the maximum total soluble solids and lowest acidity. These results are in agreement with the findings of Anjum *et al.* (2008), Mosa *et al.* (2015), Yadav *et al.* (2014) who reported that the foliar application of potassium increases the total soluble solids and simultaneously decreases acidity in different experiments. Also Layne *et al.* (2002) reported that the reflective film resulted in the increase of soluble solids concentration in Gala apples.

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