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RESEARCH PAPER

Application of *Moringa oleifera* leaf extract improves quality and yield of peach (*Prunus persica*)

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Key Message: This study evaluates the influence of foliar use of moringa leaf extract on the quality and yield of peach. It concludes that moringa leaf extract at low concentration effectively improved the quality attribute and resultant yield of peach.

Abstract: Use of plant growth promoters has become very effective in commercial agriculture. Moringa leaf extract (MLE) being a source of cytokinin (zeatin) with growth enhancing properties has played a vital role for enhancing yield potential and fruit quality in various crops. The research trial was envisaged under peculiar climatic conditions of Soon Valley, Khushab, Punjab, Pakistan during 2018. Research trial was executed on twenty plants of peach cv. Early Grand with uniform age and stature to determine the response of MLE spray on fruit quality and resultant yield. Different concentrations of MLE (0, 2, 4 and 6%) were applied during the fruit setting. Plants sprayed with 2% aqueous solution of MLE exhibited maximum fruit diameter (7.8 cm), pulp weight (167.77 g), fruit weight (174.7 g) and yield per tree (80.40 kg) along with significant reduction in fruit drop (25.20%). However, stone weight was noted as a non-significant entity. Biochemically significant effects were noted for the same treatment regarding TSS (13.69 $^{\circ}$Brix), acidity (0.26%), vitamin C (6.02 mg/100g), non-reducing sugars (4.42%), reducing sugars (1.70%) and total sugars (6.02%). Keeping in view aforementioned results it is concluded that in order to improve the quality and yield attributes of peach foliar application of 2% MLE is a pragmatic approach.

Keywords: Aqueous solution, Fruit drop, Fruit quality, Moringa leaf extract, Peach, Yield attributes

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Introduction

Peach (*Prunus persica*) is the "Queen" of fruit crops. Globally, China is the leading peach producer and occupies a significant position with a share of approximately 54% while Italy and Spain enjoy the second and third position respectively. Globally during 2018 total area under peaches and nectarines was 1.71 million hectares and production was 24.45 million metric tonnes (Food and Agriculture Organization [FAO], 2018). During 2017-18, peach was grown in Pakistan on 36.90 thousand acres with total annual production of 73.90 thousand tons (Agriculture Marketing Information Service [AMIS], 2017). Peach fruit has delicious taste, attractive colour, peculiar aroma and vitamins (C and A), potassium and fiber. It contains more than 80% water and an optimum sized peach fruit possesses 7% fiber which is an everyday need for humans (Habib, 2015). In Pakistan's scenario, peach is a conventional fruit crop of Khyber Pakhtunkhwa due to its favourable agro-climatic conditions; however some low chilling cultivars (Early Grand and Florida King) have been successfully grown in plain areas of Punjab province in Pakistan. Per hectare yield of peach is too low owing to numerous constraints such as Pakistani soils particularly in plain areas of Punjab are deficient in zinc, boron and iron that affects the quality and yield. Likewise development of the abscission layer which consequently leads to pre harvest drop of fruit is also a key concern for the peach growers (Balal et al., 2011; Razi et al., 2011). Hence to overcome these problems, farming communities apply micronutrients exogenously either through foliar spray on plants or through soil. Pertaining to nutritional related characters, response of growth regulators is of significant importance for the horticulture industry specifically in controlling fruit drop (Modise et al., 2009; Nawaz et al., 2011; Ashraf et al., 2012).

Fundamentally there are five core groups of plant growth regulators in use including gibberellins, auxins, cytokinins, ethylene and abscisic acid (Davies, 2010). From a commercial point of view, in plants exogenous application of antioxidants and cytokinins are expensive to improve growth and developmental mechanisms. So, it's a prerequisite to identify economical and natural sources of plant growth regulators, nutrients and antioxidants. According to a report, zeatin riboside and cytokinins from extract of seaweed improved the heat tolerance in creeping bentgrass (Zhang & Ervin, 2008). Moringa leaves are integral source of phytohormones like zeatin (cytokinin) and auxin along with minerals (Zn, Fe, Ca and K), phenolic and ascorbate as growth enhancing compounds. It can perform as a naturally occurring bio-stimulant for growth of plants and play a decisive role in enhancing the drought tolerance in plants grown under saline conditions (Howladar, 2014; Abd El-Mageed et al., 2017). According to an estimate, moringa leaves gathered from different countries showed zeatine concentration in the range of 5-200 µg/g in leaf samples (Davies, 2010; Basra et al., 2011; Mona, 2013).

Presence of phytohormones, antioxidants and nutrients in its leaves makes it a potent natural source of plant growth promoters (Yasmeen, 2011). Earlier studies pertaining to the effect of MLE on quality attributes has also been reported by Makkar and Becker (1996) in black gram (*Vigna mungo*) and maize (*Zea mays*). Sivakumar and Ponnusami, (2011) found that P, N and K contents were improved in *Solanum nigrum* by the application of MLE along with FYM. 6% MLE enhanced the color, vitamin C, firmness, soluble solid content, fruit set, fruit weight, yield and anthocyanin in ‘Holly wood’ plum (Thanna et al., 2017). Zinc and potassium along with MLE improved fruit yield, quality and nutrients status in Kinnow leaves (Nasir et al., 2016). Application of MLE in pear depicted improvement in yield, fruit size and weight (Sheren & El-Amary, 2015). MLE also alleviates cadmium and salinity related effects of stress in beans by enhancing its antioxidant ability (Howladar, 2014). A critical analysis of research studies proved that use of MLE is effective for fruit senescence delay, robust growth and improvement of quantitative and quality attributes in wheat, peas and tomato (Azra, 2011). PGRs (GA_3 20-40 ppm and NAA 25-50 ppm) improved quality and yield characters in apple (Osama et al., 2015). Glycine betaine (GB) has been found to be fruitful in improving enzymatic activities pertaining to metabolism of sugar, phenolic compounds and soluble sugar under stress conditions in peach (Wang et al., 2019). In view aforementioned facts, it was hypothesized that spray of MLE intends to produce better quality fruits and improves yield. However, no work has been reported about the function of MLE for improving yield and quality of peach fruit that warrants further investigation. In the light of aforementioned facts, the proposed study was designed to determine the response of MLE regarding physical and biochemical quality and yield attributes of peach under climatic conditions of Soon Valley district Khushab, Pakistan.

Materials and Methods

This study was executed during 2018 on twenty plants of “Early Grand” Peach (*Prunus persica*). Eight years old healthy plants of uniform size and vigor were selected with a planting distance of 4.5×4.5 meters, propagated on local almond rootstock with an open vase system. To prepare MLE, 100 g powder of air-dried *Moringa oleifera* leaves was soaked in 1 liter of H_2O for twenty four hours and then filtered out; it was diluted with H_2O for various concentrations, T1,T2, T3 and T4 (Control, 2, 4 and 6%), respectively for exogenous application to the experimental units. In all these treatments Tween-20 (0.01%) as a surfactant was incorporated. Chemical examination of dried moringa powder is shown in Table 1. Peaches can be grown successfully in an area with 200–1000 chilling hours. Soon valley (32^0 34' 8.00" N, 72^0 09' 11.02" E) is located at 700-800 m above sea level with 350 to 500 annual chilling hours and annual mean precipitation of 400-500 mm (Abbas et al., 2016). The climate is conducive for commercial peach production of a low chill peach variety ‘Early Grand’ as meteorological data regarding chilling hours, annual rainfall, average minimum and average maximum temperature shown in Fig. 1 and Fig. 2, respectively during the experimental period 2018.

Table 1 Chemical examination of 100 g *Moringa oleifera* leaf powder

Chemical component	Values
Fiber (g)	19.2
Calcium (mg)	2.003
Magnesium (mg)	368
Phosphorous (mg)	204
Potassium (mg)	1.32
Copper (mg)	0.6
Iron (mg)	28.2
Sulphur (mg)	870
Vitamin C (Ascorbic acid) (mg)	17.3
Protein (g)	27.1
Carbohydrate (g)	38.2

Soil analysis

For high quality peach production sandy loam soil with good drainage potential is the basic criteria for commercialization of ‘Early Grand’ peach. Soil samples were collected from three different depth levels (0-15 cm, 16-30 cm and 31-45 cm) and each sample contained 200 g soil. These soil samples were analyzed from Soil Analysis Laboratory, Jauharabad, District Khushab and their physico-chemical features are presented in Table 2.

Physical parameters

Fruit diameter (cm)

Fruit diameter is of prime importance to access the quantitative standard of a single fruit. Randomly 10 fruits were taken and their diameter was determined with the help of digital vernier caliper and mean fruit diameter was taken.

Fruit weight (g)

Single fruit weight is the baseline to proceed towards the final plant yield calculation. The weight of ten representative fruits was measured by using electronic weighing balance and single fruit weight was noted and expressed as average fruit weight in gram (g).

Table 2 Physiochemical features of soil samples collected from experimental peach orchard

Soil characteristics	Depth		
	0-15 cm	16-30 cm	31-45 cm
Texture	Loam	Loam	Loam
pH	8.0	8.1	8.5
EC	1.67	1.44	1.62
Organic matter (%)	1.2	0.59	0.43
Available phosphorus (mg/kg)	7.9	5.05	4.42
Available potassium (mg/kg)	181.41	158	1.52
Saturation (%)	41	41	41
Zinc (mg/kg)	1.57	1.32	1.1
Iron (mg/kg)	3.8	2.9	3.2
Copper (mg/kg)	3.8	2.23	1.98
Boron (mg/kg)	0.43	0.31	0.2

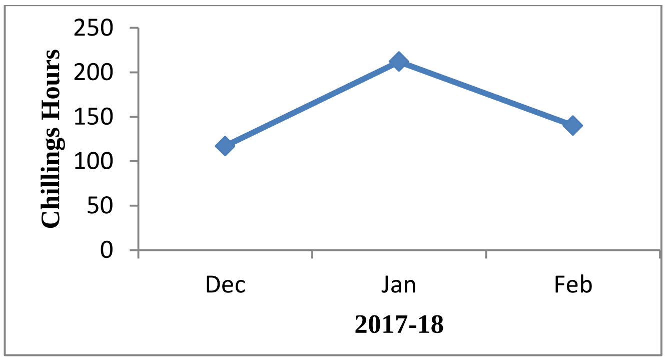

Fig. 1 Chilling hours (0-10 ^{o}C) of Soon Valley, district Khushab from December 2017 to February, 2018

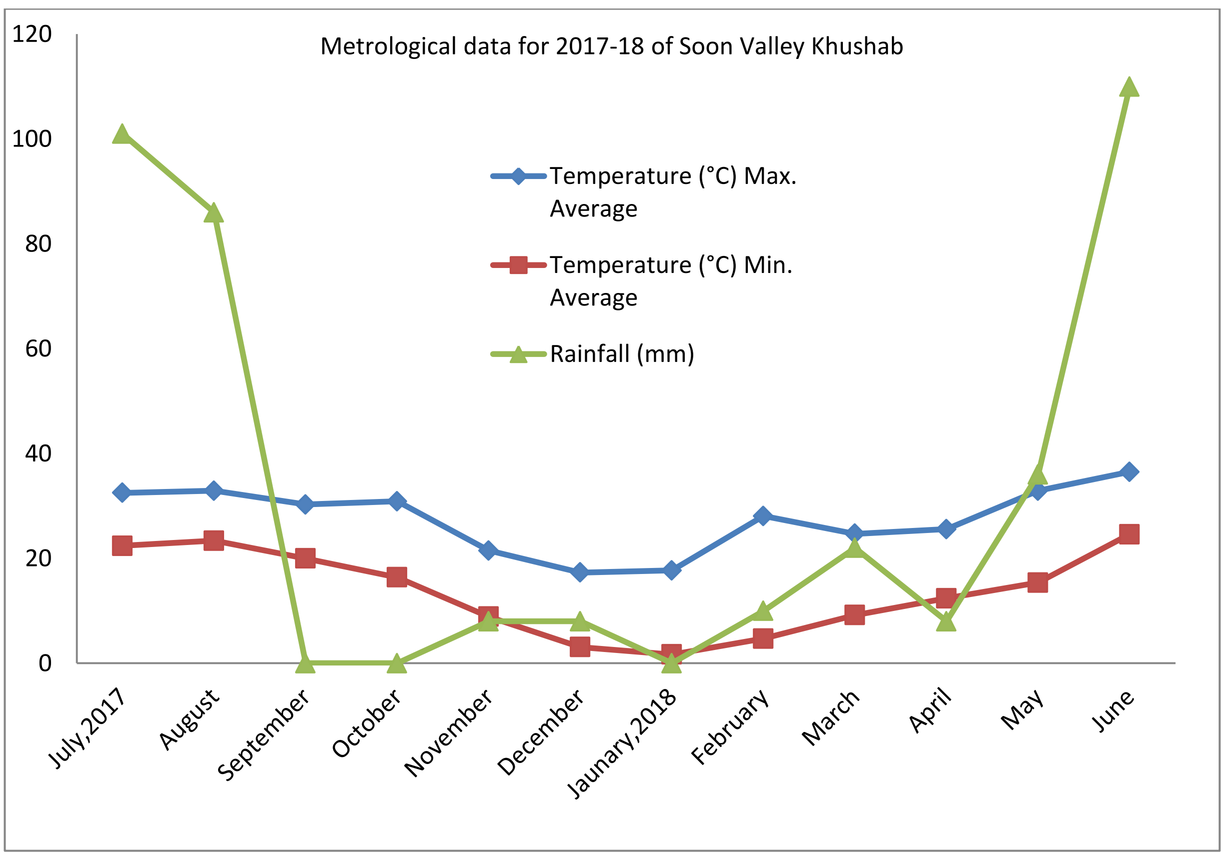

Fig. 2 Metrological data for 2017-18 of Soon Valley Khushab, Pakistan

Pulp weight (g)

Electronic weighing balance was used to obtain the average pulp weight (g) of 10 fruits.

Stone weight (g)

Fruit pulp and stone are the basic components of the fruit. Stone weight (g) was determined by taking the average weight of 10 fruit stones with the help of electronic weighing balance.

Pulp/stone ratio

It was determined by dividing weight of pulp with the concerning stone weight.

Fruit drop (%)

According to research study methodology fruit drop percentage was accessed by finding the difference of basic fruit set and mature fruit harvested after MLE application counting the marketable fruits retained on the tree by tagging the four experimental branches on all sides of the tree.

$$\text{Fruit drop } (\%) = \frac{\text{Number of fruit at final harvest}}{\text{Total number of initial fruit set}} \times 100$$

Yield (kg)

Quantitative character of yield for the experimental units was calculated by harvesting a sample of 10 ripened fruits to assess the average fruit weight with the help of digital balance. It helped to find the yield (kg) per plant as the average weight of fruit was multiplied with the total number of fruits on each tree which were counted at the harvesting time.

Biochemical parameters

TSS (°Brix)

TSS was determined with the help of digital refractometer (ATAGO, RS-5000, Japan). 10 fruits of peach were taken as a sample and their juice was extracted. A drop of juice was put on the refractometer's prism, TSS was measured and its value was expressed in ^{0}Brix.

Acidity (%)

For acidity percentage, 10ml of extracted juice was titrated against 0.1N NaOH. Along with it 2-3 drops of phenolphthalein as an indicator were added until the achievement of pink coloured end point. Following formula was used to determine acidity (%)

$$\text{Acidity } (\%) = \frac{0.1\text{N NaOH } \times 0.0064}{\text{ml of juice used}} \times 100$$

TSS/acidity ratio

This entity in biochemical analysis was estimated in all samples by dividing the TSS (^{0}Brix) with the concerned acidity (%) value.

Vitamin C (mg/100g)

Procedure described by Ruck (1961) was followed to determine vitamin C contents present in investigated peach fruit samples. 10 ml juice was poured in a volumetric flask of 100 ml capacity. After this, oxalic acid solution (0.4%) was added in it to make the volume up to the mark. Prepared aliquot (5 ml) was titrated against 2, 6-dichlorophenol indophenol dye till the appearance of light pink end point, which lasted for a period of 15 seconds and vitamin C was estimated by:

$$\text{Vitamin C (mg/100ml)} = \frac{1 \times \text{R1} \times \text{V} \times 100}{\text{R} \times \text{W} \times \text{V1}}$$

Where

R_1 = ml dye used in titration of aliquot

R = ml dye used in titration of 1 ml of standard ascorbic acid solution prepared by adding 1 ml of 0.1% ascorbic acid + 1.5 ml of 0.4% oxalic acid

V_1 = ml of juice used in titration

V = Volume of aliquot made by addition of 0.4% oxalic acid

W = ml of aliquot used for titration

Sugars (%)

Sugars percentage was calculated by method as stated by (Hortwitz, 1960). A 10 ml of juice sample was transferred in a volumetric flask (250 ml) and 100 ml distilled water was added, then 25% lead acetate (25 ml) and 20% potassium oxalate (10 ml) were added. The resultant volume was formed up to the mark by addition of distilled H_2O and then filtered. This filtrate was utilized in calculation of reducing, non-reducing and total sugars.

Total sugars (%)

To estimate total sugars percentage, aliquot (25 ml) was taken in a volumetric flask (100 ml) by the addition of distilled H_2O (20 ml) and concentrated HCl (5 ml). This solution was retained overnight so that the hydrolysis process may occur for the conversion of non-reducing into reducing sugars. The next day, 0.1 N NaOH was added in it to neutralize the solution in addition to phenolphthalein as an indicator and then volume was made up to the mark by adding distilled H_2O. This solution was transferred into the burette, it was titrated against 10 ml Fehling solution (5% ml Fehling solution A and 10 ml Fehling solution B each prepared separately) for the estimation of total sugars. By using following formula the total sugars were estimated:

$$\text{Total sugars } (\%) = 25 \times \frac{\text{X}}{\text{Z}}$$

Where
X = Volume (ml) of standard sugar used against 10 ml of Fehling solution
Z = Volume (ml) of sample aliquot titrated against 10 ml of Fehling solution

Reducing sugars (%)

Aforementioned aliquot (50 ml) was taken into a burette and titrated against 10 ml Fehling solution (5 ml Fehling solution A and 10 ml Fehling solution B each prepared separately) by slow heating till brick red end point and then 1% methylene blue (2-3 drops) were included and kept boiling by the addition of filtrate drop wise until brick red colour appeared again. The amount of aliquot consumed was noted and percent reducing sugars were estimated by formula:

$$\text{Reducing sugars (\%)} = 6.25 \times \frac{X}{Y}$$

Where
X = Volume (ml) of standard sugar solution titrated against 10 ml Fehling solution
Y = Volume (ml) of sample aliquot used against 10 ml Fehling solution

Non-reducing sugars (%)

Estimation of non-reducing sugars was made in accordance with the method stated by according by (Hortwitz, 1960) by following the formula:

$$\text{Non reducing sugars (\%)} = 0.95 \times (\text{Total sugar \%} - \text{Reducing sugars\%})$$

Statistical analysis

The research was performed in accordance with randomized complete block design (RCBD). Statistix 8.1 was used to analyze tabulated data. ANOVA was applied to evaluate the significant behavior of data, while in order to determine the difference among treatment means Least Significant Difference (LSD) test ($P \leq 0.05$) was used.

Results

Fruit weight (g)

Pertaining to fruit weight was found significant in 'Early Grand' peach among all the treatments of MLE application. Foliar spray of MLE on peach trees significantly improved fruit weight (Table 3) compared with control. Plants sprayed with 2% MLE at the fruit set stage showed maximum average fruit weight (174.7 g) which were followed by 6% and 4% MLE (155.09 g and 147.06 g, respectively). However, minimum average fruit weight fruit 113.4 g was observed in untreated fruits.

Stone weight (g)

Statistically non-significant results were observed when treatment means of MLE were compared. However comparison of means of plants in control showed significant behavior with treated plant means. Data demonstrated that application of 4% MLE as foliar spray showed maximum stone weight 7.42 g, while lowest 5.22 g by 0% MLE (Table 3), while in remaining treatment 6.93g and 7.13 g stone weight was observed in 2% and 6% MLE application.

Pulp/stone ratio

The data presented in Table 3 depicted a significant variation among means of all treatments. Fruit samples collected from plants treated by 2% MLE demonstrated maximum (24.67) Pulp: stone ratio followed by those fruits treated with 6% and 4% MLE while in the untreated plants a minimum ratio (20.83) was noticed.

Yield per tree (kg)

Yield is a core feature in fruit plants because overall income is dependent on it. As a matter of fact, decrease in fruit drop percentage leads to increase in yield. Application of different doses of MLE showed significant improvement in yield of 'Early Grand' peach. In our experiment, trees where 2% MLE was applied depicted maximum yield (80.40 kg/tree) followed by 4% and 6% MLE application(60.20 and 62.20 kg/tree) respectively (Table 3). However, the minimum yield was shown in those trees which remained untreated.

Fruit diameter (cm)

Data regarding average fruit diameter of peaches shows significant results by the foliar use of MLE compared with control (Fig. 3). Trees sprayed with MLE showed significant rise in fruit diameter irrespective of concentration of MLE applied. Harvested fruit from trees sprayed with 2% MLE depicted a maximum increase in diameter of 7.8cm followed by 6% and 4% that are 7.24 cm and 6.71 cm respectively while the lowest results regarding fruit diameter was obtained in untreated fruits having fruit size 5.64 cm only.

Pulp weight (g)

Results demonstrated significant improvement in pulp weight of fruit (Fig 4) that are treated with MLE. Maximum pulp weight (167.77 g) was observed in 2% MLE while minimum pulp weight (108.13 g) was observed for untreated plants. However, as the concentration of MLE surged to 4%, a reduction in pulp weight (139.64 g) was noticed compared with 2% MLE. Similarly when the MLE concentration was enhanced to 6% a gradual increase in pulp weight (147.78 g) was also observed.

Table 3 Foliar response of *Moringa oleifera* leaf extract on fruit weight, stone weight and yield in peach

Treatments	Fruit weight (g)	Stone weight (g)	Pulp: stone ratio	Yield (kg)
0% MLE	113.4[c]	5.22[b]	20.83[a]	52..20[c]
2% MLE	174.7[a]	6.93[a]	24.67[b]	80.40[a]
4% MLE	147.06[ab]	7.42[a]	19.21[a]	60.60[bc]
6% MLE	155.09[c]	7.13[a]	20.78[ab]	62.20[b]

Values sharing same letter in a column are not significant at $P \leq 0.05$.

Fruit drop percentage

Development of the abscission layer which leads to fruit drop is the fundamental concern for growers. In our studies, data regarding fruit drop percentage showed significant difference by all trees treated with different concentrations of MLE compared with untreated trees (Fig. 5). The lowest drop of fruit (25.20 %) was obtained in those trees treated with foliar spray of 2% moringa leaf aqueous extract followed by T3 (4% MLE) and T4 (6% MLE) respectively. Meanwhile, the maximum drop of fruit (55.56%) was present in those trees which remained untreated (0% MLE application).

TSS (°Brix)

Treatment means comparison of TSS (°Brix) showed significant effect when compared in the reported trial. Maximum TSS was noted in 2% MLE which was 13.69 °Brix followed by 4% and 6% MLE application (12.23 and 12.02 °Brix. A minimum TSS was detected in untreated fruits (0% MLE) which was 10.14 °Brix. It is evident from the results that when MLE concentration was increased up to 6% a decrease in TSS was observed (Table 4).

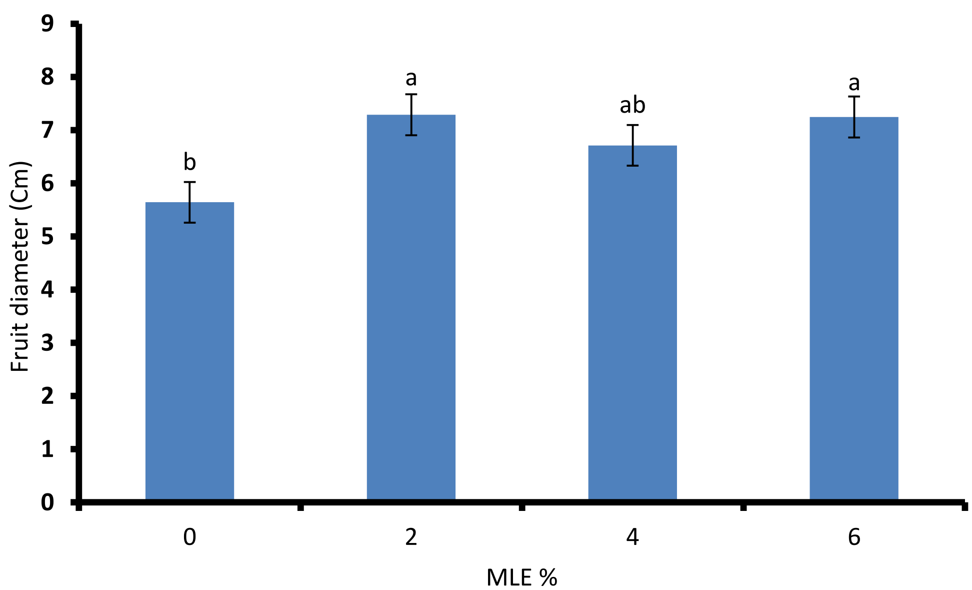

Fig. 3 Foliar response of MLE on fruit diameter (cm) of peach

Acidity (%)

Amount of acidity present in ‘Early Grand’ peach fruit is a chief concern and normally fruit which possesses low acidity contains good taste, high TSS and high market value. Pertaining to the acidity in peach, there was a significant relationship among all treatment means. Untreated fruits depicted maximum acidity level (0.43%) and while the remaining consequently 0.26% in 2% MLE, 0.34% in 4% MLE and 0.36% in 6% MLE (Table 4).

TSS/acidity ratio

Results regarding TSS/Acidity ratio presented in Table 4 depicted a significant dissimilarity among all the treatments. A maximum TSS: acidity ratio (29.63) was observed in plants where 6% MLE was applied. In same way plants which were not treated with MLE showed (18.04). As the concentration of applied MLE increased, this ratio was also increased.

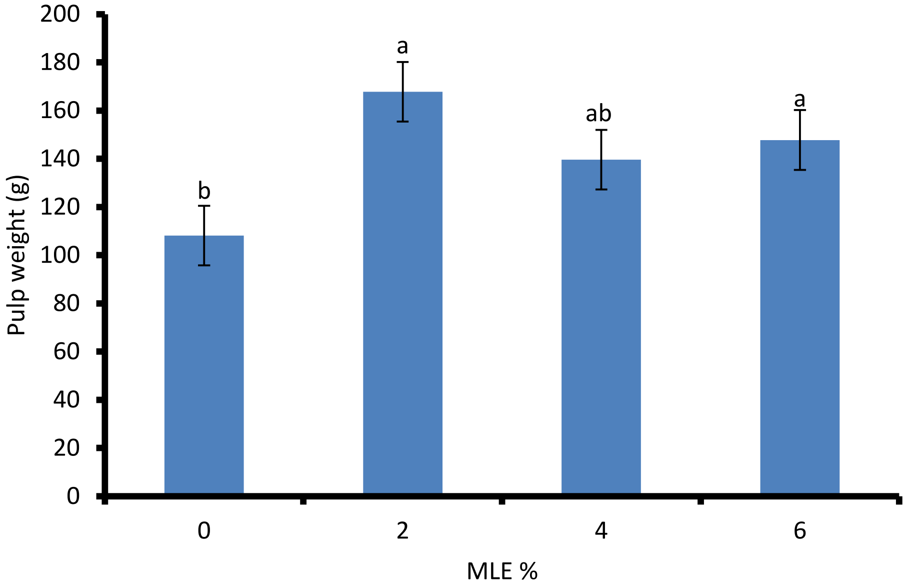

Fig. 4 Foliar response of MLE on pulp weight (g) of peach

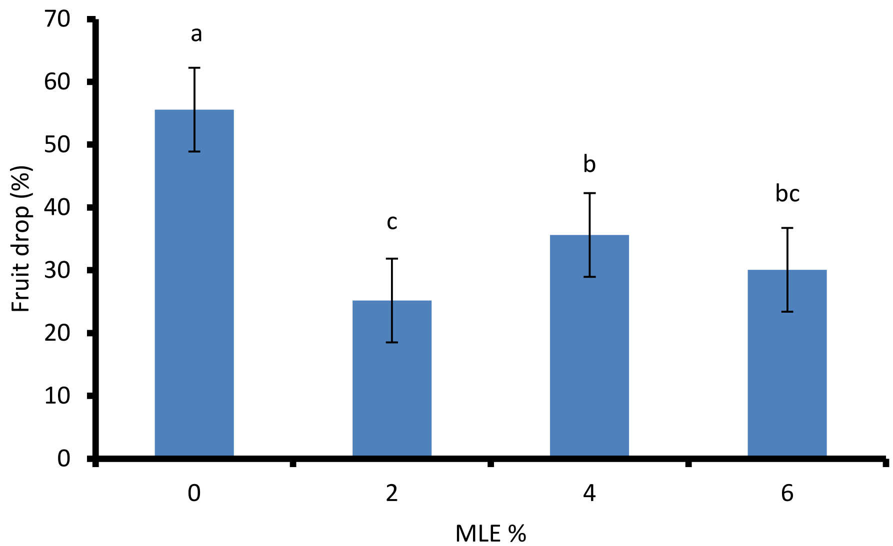

Fig. 5 Foliar response of MLE on fruit drop percentage of peach

Vitamin C (mg/100g)

Results pertaining to the outcome of MLE on ascorbic acid or vitamin C were found statistically significant. All treatment revealed that there was significant influence of MLE spray on vitamin C contents of peach fruit. 2% MLE possessed highest amount of Vitamin C (6.02 mg/100g) followed by 5.25 mg/100g in 4% MLE and 5.20 mg/100g in 6% MLE. Plants where no MLE application was depicted had the lowest quantity of Vitamin C (4.71 mg/100g).

Reducing sugars (%)

Data given in Table 4 depicted that MLE significantly affected the quantity of reducing sugars in peach. The highest quantity of reducing sugars (1.70%) was observed in 2% MLE which differed significantly from all treatment means followed by T4

(6% MLE) and T3 (4% MLE) which were 1.61% and 1.60% respectively. However the minimum quantity of reducing sugars (1.58%) was shown by the untreated plant (0% MLE).

Non-reducing sugars (%)

As far as the non-reducing sugars (%) are concerned, treatments comparison showed a significant difference of means with untreated plants which showed the lowest percentage of non-reducing sugars (3.79%). All the remaining MLE treatment means were found statistically non-significant regarding their impact. Highest level of non-reducing sugars (%) was noted in 2% MLE which was 4.42% (Table 4).

Total sugars (%)

Data regarding total sugar level in peach was increased significantly on using MLE. Maximum quantity of total sugars (6.02%) was noted in those fruits treated with 2% MLE while the lowest level (5.37%) was present in control (untreated fruits) (Table 4). Upon increasing the concentration of MLE a decrease in the total sugars content was noticed (6.01% in 4% MLE application and 5.86% for 6% MLE).

Table 4 Foliar response of *Moringa oleifera* leaf extract on TSS, acidity, reducing sugars, non-reducing sugars and total sugars in peach

Treatments	TSS (^{o}Brix)	Acidity (%)	TSS: acidity ratio	Vitamin C (mg/100g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
0% MLE	10.14^c	0.43^a	18.04^c	4.71^b	1.58^{ab}	3.79^b	5.37^b
2% MLE	13.69^a	0.26^c	24.53^b	6.02^a	1.70^a	4.42^a	6.02^a
4% MLE	12.23^b	0.34^b	26.67^{ab}	5.25^{ab}	1.60^a	4.31^a	6.01^a
6% MLE	12.02^b	0.36^b	29.63^a	5.20^b	1.61^a	4.25^a	5.86^a

Means within a column followed by different letters are significant at $P \leq 0.05$.

Discussion

Exogenous use of plant growth regulators has become an important practice in modern agriculture but owing to the higher costs involved; it is not affordable for farmers. In this study MLE was used as a source of nutrients and phytohormones such as zeatin (cytokinin) and auxin. Fruit size and weight are those parameters that are considered important for market fetching (Nawaz et al., 2008). Our results depicted that pulp weight in addition to fruit size and fruit weight was notably improved in those trees that were sprayed with 2% MLE. Such kind of spike may be due to the fact that foliar execution during fruit set raised the nutritional elements in the plants. Peach plants deficient in Fe produced small size fruit which are commercially unacceptable (Dhotra et al., 2018) whereas fertilization with Fe enhanced the quality and yield characteristics in many crops (Bakshi et al., 2013). MLE being a rich source of zeatin (cytokinin) as well as Ca, K, Zn and Fe are involved in transformation of photoassimilates and expansion of cells (Yasmeen, 2011). Increase in fruit and pulp weight of peach fruit was because of potassium and zinc presence in the MLE. In case of zinc, it is peculiar in its property of being a precursor of tryptophan which ultimately plays a pivotal role in the synthesis of indole-3-acetic acid which is essential for fruit development and maturation (Zekri & Obreza, 2009). Potassium element is significant in translocation as well as formation of carbohydrates from plant shoots to storage organs (fruit) (Ramezani & Shekafandeh, 2011). Furthermore, substances such as cytokinins have a role in cell division and cell expansion, which leads towards fruit quality features in the form of fruit size and weight. Our findings are in consonance to Nasir et al. (2016); Sheren and El-Amary, (2015) who found that aqueous spray of moringa improved fruit weight and size of Kinnow (mandarin) and pear cultivar “Le Conte”, respectively.

Fruit drop and yield are interdependent factors in all crop species and they are one of the most important features which ultimately contribute towards the economic returns of the growers. MLE application reduced fruit drop percentage compared with untreated plants. This reduction in fruit drop may be due to the reason that MLE contains a reasonable amount of zeatin and auxins which are responsible for production of different hormones. These hormones control the internal mechanism of abscission layer development in ovaries (Talon & Zeevaart, 1992). Our findings are in agreement with those of Saleem et al. (2008), who found that foliar use of GA_3 and low biuret urea reduced fruit drop in Blood Red. Enhancement in yield of peaches also results on account of nutritional and hormonal properties of MLE which makes it concrete growth enhancer which directly or indirectly increases the fruit growth and development leading to more number of fruits per tree (Swietlik, 1999; Abdalla, 2013; Emongor, 2015). Moreover, response of MLE on yield and fruit drop in Kinnow mandarin by Nasir et al. (2016) also validated the synergistic impact in this regard.

As a matter of fact, the amount of sugar contents increases as the fruit goes towards maturity. Biochemical parameters such as TSS, vitamin C, total sugars in addition to non-reducing and reducing sugars were notably influenced by the foliar spray of MLE. This increase may be due to presence of high levels of starch and sugar in MLE along with zinc and potassium (Foidl et al., 2001). Potassium is directly responsible for translocation of carbohydrates from source (leaves) to sink (fruits) (Zekri & Obreza, 2009). Zn activates many enzymes, that are involved in photosynthesis leading to production of high levels of carbohydrates (Alloway, 2004). Development in total sugar in peaches might be due to the reason that MLE contains zeatin that is responsible for sugars translocation from leaves to the fruits (Foidl et al., 2001). Similar results have been reported earlier by Rady & Mohamed (2015) who concluded that MLE application in *Phaseolus vulgaris* improved free proline, ascorbic acid, total soluble sugar and total carotenoids. Moringa leaf extract also contains ascorbate, so its foliar application might initiate the production of ascorbate into plants. Similarly zinc and potassium were responsible for sugar metabolism which is directly involved in vitamin C synthesis (Nouman et al., 2012).

Conclusion

MLE contains cytokinins and auxins and is cheaper than synthetic growth regulators. It acts as a growth promoter when apply at lower concentrations. In this study it was proved that 2% MLE foliar application improved physical parameters such as fruit diameter, weight, pulp weight, yield and biochemical variables including vitamin C, TSS, reducing, non-reducing and total sugars. Hence, it may be concluded that MLE (2%) as foliar spray at fruit set stage can be used to develop better fruit qualities and yield in peach. Moreover, this study will be a milestone for those farmers who want to improve their yield and cannot afford to buy the synthetic plant growth regulators.

Author Contribution Statement: Hafiz Wasif Javaad planned and executed the research trial and collected data. Allah Bakhsh wrote the manuscript. Fiaz Hussain contributed in the analysis of data. Attiq Akhtar and Muhammad Kashif Raza provided guide line; helped in literature citation and proof reading.

Conflict of Interest: The authors declare that they have no conflict of interest.

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