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Foliar application of plant extracts and salicylic acid affects the growth and yield of tomato

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Abstract

The average yield per acre of tomato in Pakistan is very low as compared to the yield of neighboring countries like India and china. One of the basic reason behind this lag is improper use of chemical fertilizers. This experiment was designed to investigate the influence of different plant extracts (control, moringa 6%, neem 10% and garlic 4%) and salicylic acid (Control, 2, 4 and 6mM) as a foliar spray on the growth and yield of tomato (Cv. Rio Grande) at the University of Agriculture Peshawar-Pakistan during 2018. The design of the experiment was Randomized Complete Block Design (RCBD) with split plot arrangement. Results in case of plant extracts, the foliar application of moringa 6% gave maximum number of branches plant^{-1} (9.82), number of flower clusters plant^{-1} (9.58), number of fruit plant^{-1} (26.33), fruit length (6.67cm), fruit diameter (4.94 cm), highest yield plant^{-1} (1.83 kg) and total yield (40.22 tons ha^{-1}) with minimum days to fruiting (32.50). Whereas salicylic acid concentration also effected all the attributes as compared to other levels. Maximum number of branches plant^{-1} (9.59), number of flower clusters plant^{-1} (9.17), number of fruit plant^{-1} (22.08), fruit length (6.80 cm), fruit diameter (4.88 cm), yield plant^{-1} (1.66 kg), and total yield (37.05 tons ha^{-1}) with minimum days to fruiting (30.42) were recorded with foliar application of salicylic acid. It is concluded that moringa leaf extract (6%) showed best response as compared to other treatments while salicylic acid also enhanced the growth and yield of tomato.

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Introduction

Tomato (*Lycopersicon esculentum*) belongs to the family solanaceae. It is one of the most important vegetable crops grown by home gardens, market Gardeners and truck farmers. Due to its use and importance, it is cultivated throughout the world; in Pakistan, it is cultivated over an area of 60.7 thousand hectares with the production of 570.6 thousand tons (MINNFSR, 2014-2015).

The production of Pakistan is negligible as compare to other world due to poor production system like the use of low yielding varieties, improper use of fertilizer, disease infestation and insect pest attack. Due to all these issues the growers faces losses due to low yield of the crop (Kader, 1992). Foliar feeding of vegetable plants can effectively supplement soil fertilization.

It has been found that elements in foliar application are at same level or even more influential compared to soil application.

It was suggested that foliar feeding could be applied successfully to compensate shortage of those elements. Salicylic acid (SA) is an endogenous plant growth factor of phenolic nature that possesses an aromatic ring with a hydroxyl group or its hormone plays a vital role in plant growth, ion uptake and transport (Hayat *et al.,* 2010). SA treatments were generally effective on vegetative growth, photosynthetic ability and thereby helping in effective flower formation and fruit development and ultimately enhance productivity of the crops (Solamani *et al*., 2001). Foliar SA application increase plant growth, early yield and total yield of tomato (Yildirim and Dursun, 2008).

Flowering is another important parameter that is directly related to yield and productivity of plants. SA has been reported to induce flowering in a number of plants. Different plant species including ornamental plant *Sinningia speciosa* flowered much earlier as compared to the untreated control, when they received an exogenous foliar spray of SA (Martin-Max *et al*., 2005).

In cucumber and tomato, the fruit yield enhanced significantly, when the plants were sprayed with lower concentrations of SA (Larque-Saavedra and Martin-Mex, 2007).

Moringa, Neem and Garlic leaf extract was sprayed onto leaves of tomato, melon and maize, sorghum, coffee, tea, onions, bell pepper, soya beans, chili and was shown to increase yields of these crops (Fuglie, 2000).

Due to high cost and skill labor in application of inorganic fertilizations and land pollution, harmful nature linked with use of inorganic fertilizer and contribution to climate change that has adverse effect on soil ecosystem, there is a need to examine the alternative sources for plant supplements. Such plant extracts can be promoted for multipurpose that may develop better, safer and cheaper way of increasing the yield of stable vegetable crops for healthy nourishment (Hussein and Abbaro, 1997).

The objective of the current study is to test the effect of Moringa, Neem and Garlic leaf extract with SA to increase the growth and yield characteristics of tomato.

Materials and methods

Experimental site

An experiment to study "Influence of foliar application of different plant extracts and salicylic acid on the growth and yield of tomato" was conducted at Horticulture Research Farm and Post-harvest Laboratory, The University of Agriculture Peshawar during 2018.

Design of Experiment

The research work was conducted in Randomized Complete Block Design (RCBD) with two factorial split plot arrangement. Salicylic acid concentrations along with control were allotted to main plot with four levels (0, 2, 4, and 6mM) while, different plant extracts along with control were allotted to sub plot

with four levels (0, moringa 6%, neem 10% and garlic 4%), having three replications. Salicylic acid and different plant extracts was applied in liquid form as foliar spray to the tomato plants.

Treatments

The total numbers of treatments were 48. The detail of the factors is given as under.

Factor A (Plant extracts %)	Factor B (Salicylic Acid Levels mM)
E_0 = Control	S_0 = 0
E_1 = Moringa (6%)	S_1 = 2
E_2 = Neem (10%)	S_2 = 4
E_3 = Garlic (4%)	S_3 =6

Plant Extracts preparation

Leaf samples of Moringa and Neem were collected from Horticulture Research Farm, Malakandhair and Garlic cloves were collected from local market and brought to the laboratory.

All the samples were washed thoroughly with tape water by putting it in net basket. Then these samples were mixed with water in such a way that samples: water (1: 5) and then were ground with small grinder.

The grinded sample was filtered through masculine cloth to remove the impurities. The filtered solution was taken as standard solution. From the standard solution, the recommended solutions were prepared for each sample i.e. Moringa (6%), Neem (10%) and Garlic (4%) as described by Price (2007).

Nursery Raising and Cultural practices

The seeds (Cv. Rio Grande) were sown in the last week of January. The field was prepared one week before transplantation of the crop. All the stone, stub, root or any other material which may result in barrier to the crop were removed. N-P-K was applied as a basal dose at 112-80-40 kg ha^{-1} respectively. Tomato seedlings were transplanted when they reached 2-4 leaves stage and were transplanted early in morning.

Stage of foliar application

The crop was sprayed fifteen (15) days after transplantation.

Studied attributes

Number of branches $plant^{-1}$: From the selected plants the number of branches $plant^{-1}$ were counted and their average was taken.

Days to fruiting: The average was calculated by counting the days from the date of transplanting to its fruiting in all treatments of each replication.

Number of flower clusters $plant^{-1}$: From the selected plants the number of flower clusters $plant^{-1}$ were counted and their average was taken.

Number of fruits $plant^{-1}$: The total number of fruits $plant^{-1}$ was counted in randomly selected plants from each treatment at every picking and their average was taken.

Fruit length (cm): The fruit length of the selected fruits was measured with the help of digital vernier caliper and their mean was taken.

Fruit diameter (cm): The fruit diameter of the selected fruits was measured with the help of digital vernier caliper and their mean was taken.

Fruit yield $plant^{-1}$ (kg): The fruit yield $plant^{-1}$ was found out by measuring the weight of fruits from start till to the last picking from selected plants in each treatment.

Total yield (tons ha^{-1}): The total productivity was recorded by the following formulae:

$$Yield\ tons\ ha^{-1} = \frac{Yield\ per\ sub\ plot\ (kg)}{Area\ of\ sub\ plot\ (m^2)\ X1000} X\ 10000(m^2)$$

Statistical analysis

The data collected were analyzed through statistical software "Statistix 8.1" for calculating analysis of variance and the means were compared at 1% or 5% level of probability by using least significant difference LSD (Jan *et al.* 2009).

Results

Plant vegetative and reproductive growth

The data regarding number of branches, flowers cluster^{-1}, fruits plant^{-1}, and days to fruiting (table 1) showed significant differences among plant extracts and SA concentrations.

Maximum number of branches (9.82) were obtained with MLE, followed by NLE and GE while the minimum branches (6.19) were recorded for control. In case of SA Maximum number of branches (9.59) were obtained with SA at the rate of 6 mM, followed by 2 mM and 4 mM while the minimum branches (5.77) were noted for control. Less days to fruiting (32.50) were obtained using MLE followed by GE and NE while more days to fruiting (37.93) were recorded in control.

Early fruiting (30.42 days) were recorded by SA at the rate of 6 mM, while late fruiting (40.33 days) were noted for SA control plot. Maximum number of fruits plant^{-1} (26.33) were recorded for MLE followed by NE and GE while minimum fruits plant^{-1} (15.33) were obtained from control plot (table 1). However 6 mM SA gave maximum fruits plant^{-1} (22.08) while control plot gave minimum number of fruits plant^{-1}(16.33).

Table 1. Influence of different plant extracts and salicylic acid on number of branches, days to fruiting, number of flower clusters and number of fruit plant^{-1} of tomato.

Treatments	Characters			
Plant extracts (%)	Number of branches plant^{-1}	Days to fruiting	Number of Flower clusters plant^{-1}	Number of fruit plant^{-1}
Control	6.19C	37.92A	6.08C	15.33C
MLE (6%)	9.82A	32.50C	9.58A	26.33A
NE (10%)	8.41B	35.08B	7.42B	19.25B
GE (4%)	6.27C	35.92B	6.50BC	15.75C
LSD at 1%	1.00	1.93	0.92	1.99
Salicylic acid (mM)				
Control	5.77c	40.33a	5.75c	16.33c
2	7.58b	35.58b	7.17bc	18.92bc
4	7.74b	35.08b	7.50b	19.33b
6	9.59a	30.42c	9.17a	22.08a
LSD at 5%	1.75	4.60	1.59	2.72

Values followed by different letters at same group are significantly different Using LSD test.

Fruit physical parameters

Maximum fruit Length (6.67 cm) was recorded in plants sprayed with foliar MLE followed by NE and GE and minimum fruit length (5.33 cm) was given by Check plot (control). Fruit length was maximum (6.8 cm) with 6 mM of SA while it was minimum (5.27 cm) in case of control (table 2).

The fruit diameter was maximum (4.94 cm) with foliar application of MLE followed by NE and GE while minimum (4.27 cm) with control. Maximum fruit diameter was recorded with SA application at the rate of 6 mM, while minimum fruit diameter was obtained in control plot (table 2).

Yield

Highest yield ha^{-1} (40.22 tons ha^{-1}) was obtained with MLE followed by NE and GE while lowest yield ha^{-1} (28.58 tons ha^{-1}) was recorded in check plot (control). In case of SA maximum yield (37.05 tons ha^{-1}) was recorded with concentration of 6 mM while lowest yield (28.08 tons ha^{-1}) was obtained from control (table 2).

Discussion

Number of primary branches plant^{-1}

Moringa Leaf extract (MLE) increased number of branches. These results are in line with the findings of Mandal (2004), who reported MLE positively

enhanced plant growth attributes of wheat. He also stated that with increasing MLE concentration the growth parameters such as branches plant^{-1} were increased in arithmetic order. Number of branches was also affected by SA.

These results are also in agreement with the findings of El-Yazeid (2011), who stated that the number of branches and leaves of sweet pepper were statistically influenced by exogenous spray of SA as compared to the control. This might be due to presence of zeatin (act like cytokinin that works in cell division and cell elongation) and micronutrients, ascorbic acid and phenolic compounds. SA has a role in increasing photosynthesis rate and stimulates the synthesis of certain plant growth promoting hormones such as Cytokinin and Auxin, which increase cell elongation and cell division leading to more vegetative growth and increase the number of branching (Gharib, 2007).

Table 2. Influence of different plant extracts and salicylic acid on fruit length, fruit diameter, yield plant^{-1} and total yield.

Treatments	Characters			
Plant extracts (%)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Total yield (tons ha^{-1})
Control	5.33C	4.27C	1.04C	28.58C
MLE (6%)	6.67A	4.94A	1.83A	40.22A
NE (10%)	5.99B	4.56B	1.48B	32.03B
GE (4%)	5.96B	4.53BC	1.53C	29.48BC
LSD at 1%	0.60	0.27	0.17	3.22
Salicylic acid (mM)				
Control	5.27c	4.33c	1.13c	28.08c
2	5.85bc	4.50bc	1.31bc	32.33b
4	6.03b	4.59b	1.40b	32.85b
6	6.80a	4.88a	1.66a	37.05a
LSD at 5%	0.75	0.26	0.25	4.18

Values followed by different letters at same group are significantly different Using LSD test.

The number of days to fruiting decreases with foliar application of MLE. Our finding are supported by Nasir *et al.* (2016), who claimed that *kinnow mandarin* treated with MLE produced early fruiting. It increases nutrient absorption and nutrients supply that encourage more synthesis of assimilates and thus produce early flowering and fruiting. Fuglie (2000) stated that MLE contain phosphorous that promoted the development of root and increased the uptake of nutrients through roots that ultimately increased flower production leading to early bearing of fruits. Days to fruiting was significantly affected by SA. SA reduced the days to fruiting as compared to control. These results are in line with the findings of Mady (2014), who observed early fruiting and fruit yield percentage in squash by foliar application of SA. It play an important role in mitigating the hazardous effect of environmental stress that delay the fruit set and results in late maturity of the fruit. Salicylic acid counter act these stress and enable the fruit to mature without effected by these stresses (Korkmaz *et al.*, 2007; Yildrim *et al.*, 2008). Solamani *et al.* (2001) stated that SA improved photosynthetic ability of plants which may increase assimilate supply and can help in early flower formation, fruit and seed development. Foliar application of SA also boosted flowering and pod formation in soybean (Kumar *et al.* 1999).

Number of flower cluster plant^{-1} was found maximum with application of MLE as compared with NE and GE. These results are supported by the findings of

Basra *et al.* (2011), who stated that MLE along with other plant growth regulators (PGRs) increase the number of flowers in tomato. The MLE contain macro and micronutrients that are taken by plants in appropriate quantity, hence increase the number of flowers. Yasmeen *et al.*, (2011) stated that in cherry tomato number of floral branches increased that might be due to the presence of cytokinin and translocation of photo assimilates which resulted more number of flower clusters plant^{-1}. SA significantly affected number of flower cluster plant^{-1}.The probable reason for more number of flower cluster plant^{-1} may be the assimilation of more carbohydrates by SA application. These results are in agreement with the finding of Maddy (2014), who stated that number of flower clusters plant^{-1} increased with increase in carbohydrate assimilation and the increase of carbohydrate might be due to the application of SA, which triggers the movement and translocation of nitrites in the internal plant tissues and enhances synthesis of chlorophyll to increase the photosynthesis mechanism that may lead to more carbohydrates production. SA plays a vital role in ions uptake, plant growth and flower initiation (Hayat and Ahmad, 2007). Similar results were stated by Raskin *et al.* (1987) who reported that SA acts as endogenous growth regulator of flowering and other florigenic effects.

MLE was found to positively influence the number of fruits plant^{-1}.It might be due to presence of zeatin, along with minerals such as (calcium, magnesium, potassium, phosphorus and iron), phenolics, vitamins such as A, B1, B2, B3, C and E, sugar and several hormones which regulate the mechanism of fruit production and fruit set (Talon and Zeevart, 1992). Hafez and El-Metwally (2007) also claimed that MLE contain nutrients (potassium and zinc) which enhanced the uptake of nutrients and photosynthetic activity in leaves therefore, increase the number of fruit and fruit set occurs. Sivakumar and Ponnusami (2011) also claimed that foliar spray of MLE with soil application of farm yard manure (FYM) increased the N, P, and K content of *Solanum nigrum*. SA also improved number of fruits plant^{-1} as compared with control. Vazirimehr and Regi (2014) also proved the same effect that there is a direct relation among flowering, yield and fruit productivity. The probable reason for increase in number of fruit plant^{-1} is related with the increase in number of flower clusters plant^{-1}. Foliar application of SA might inhibited the synthesis of ethylene, which in turn reduced fruitlet drop and there by increased fruit plant^{-1}. Findings of this research is in line with the work of Ngullie *et al.*, (2014). They found that fruit set in mango was improved with the use of SA.

Fruit length was also improved by MLE as compared to GE and NE and control. This increase may be due to the fact that MLE contain high level of zeatin which is natural cytokinin in plants, responsible for cell division and cell elongation of fruit cell walls leading to an increase in the fruit length (Jyotsna and Srivastava, 1998). Furthermore, the increased in fruit length might be due to the excessive level of potassium and zinc in MLE. Fruit quality is increased through potassium by promoting the translocation of carbohydrates from source to sink (Ramezani and Shekafandeh, 2011). Moreover, zinc is precursor of tryptophan which helps in the formation of auxin that promotes fruit growth and development (Zekri and Obreza, 2009).SA also affected fruit length. These results are supported byEl-Yazeid (2011) as he stated that different sprayed treatment of SA enhanced morphological characters of sweet pepper such as length, diameter and size of fruits. SA promotes the synthesis of auxin and cytokinin which is responsible for the cell enlargement and cell division of fruit cell walls leading to an increase in the fruit length. Similarly, Tayeb (2005) and Blokhina (2003) stated that SA enhanced the biochemical and physiological processes in plants, which enhanced the nutrients uptake in plants, increased cell division, cell elongation and cell differentiation and enhanced the protein synthesis, sink/source regulation and enzymatic activities leading to an increased fruit length.

Result of this study shows significant improvement in fruit diameter due to MLE. The increase in fruit

diameter might be due to the high content of cytokinin in MLE which plays good role in enhancing cell division and expansion which results in increased fruit diameter (Sheren *et al.,* 2015). As MLE is a good source of ascorbic acid, the auxinic action of ascorbic acid along with its linkage in cell wall metabolism and cell expansion leads to big fruits (Samirnoff, 1996). The recent study also are in line with Thanaa *et al.* (2017), who concluded that MLE had significantly affected the fruit diameter of plum fruit. SA also promoted fruit diameter as compared to control.SA acts as a growth regulating hormone which can enhance the physiological performance of the plant such as photosynthesis and increases the transfer of assimilates from source to sink. So the increase in fruit diameter in case of SA might be due to an increase in photosynthetic activity and the supply of more assimilates to the developing fruits which results in increased fruit diameter. These results are supported by the findings of Hubbard *et al.*, (1989) and Marcelis (1993) who stated that the fruit cell size increases with the higher level of assimilate and steady supply of carbohydrate which leads to increased fruit diameter. Such increment in fruit parameters might be attributed to the fact that SA increases the vegetative growth, nutrient uptake and photosynthetic pigment which indirectly increase the fruit diameter. Our results are supported by El-Yazeid (2011) as they found that the different sprayed treatments increased physical characters (fruit diameter, fruit size, fruit length) of sweet pepper fruits.

The present study confirms that yield of tomato plant^{-1} was positively increased by applying MLE, It might be due to the fact that moringa leaves contain high zeatin content which is most common form of naturally occurring cytokinin in plants which play a vital role in cell division and elongation that promotes the growth and development of plant. The MLE contain macro and micro nutrients (such as calcium, magnesium, iron, phosphorus, potassium, and sodium) that are taken by plants in appropriate quantity, hence increase yield plant^{-1}. In addition to calcium and potassium which play vital role in crop growth and development via osmoregulation, enzyme stimulation, photosynthesis and many other physiological processes (Hasegawa *et al.*, 2000; Epstein and Bloom, 2005). Fruit yield of tomato significantly increased with each increment of SA concentration. The probable reason for increase in fruit yield may be bigger fruits, fruit weight and number of fruit per plant. Results are in conformity with the investigations of Elwan and Hamahmy (2009) who observed positive effects of SA on fruit yield of cucumber. Tomato plants treated with SA gave higher fruit yield compared to non-treated plants due to an increase in number of branches plant^{-1} (Javaheri *et al.*, 2012). The increase in fruit yield by SA application may be due to a significant increase in vegetative growth parameters, minerals, photosynthetic pigments and some bio-constituents (EL- Yazeid, 2011).

Total yield ha^{-1} was significantly maximum in case of MLE as compared with control. Similar results were observed by Fuglie (2000) who stated that MLE improve growth of young plants, increase number of roots, support plants, increase resistance to diseases and pests, produce more and superior fruits and generally increase yield by 20 to 30%. These findings are also in accordance with work of Jason (2013) who reported that MLE contains zeatin which has been reported to increase yields by 25 to 30% for nearly any crop. Furthermore, Azra (2011) claimed that foliar spray of MLE at the rate of 3.5% on wheat, peas and tomato increased vegetative and reproductive growth. Yield tons ha^{-1} was also affected by SA.Findings of this study are supported by Kazemi (2014) who confirmed that application of SA significantly increased the total yield and quality of tomato. Foliar application of SA considerably improved the total yield (tons ha^{-1}) in squash (Al-Rubaye and Abdatia 2016). SA is an endogenous signal molecule which play an important role in regulating many physiological processes in plants, such as stomata conductance, inhibition of ethylene biosynthesis, promoting photosynthetic rate and also enhances the enzymatic activities of crops and membrane permeability to water uptake, leading to

increase the fruit size and yield of the crop (Blokhina *et al.*, 2007).The increase in total yield (tons ha^{-1}) was mainly due to the role of plant growth regulator in increasing the fruit set and can be explained that auxin are responsible for fruit set and possibly SA application might have increased the endogenous level of auxin that result in enhancing fruit set and ultimately increased the total yield.

Conclusion

Moringa (6%) enhanced different growth and yield attributes of tomato significantly, foliar application of leaf extract was found to have superior results as compared with neem and garlic extract. Also salicylic acid showed good results in improving growth and yield of tomato.

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