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# The Response of Three Sorghum Cultivars to Different Nutritional Treatments as a New Application for Sustainable Agriculture (NASA)

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**ABSTRACT: To study the response of three sorghum cultivars to different nutritional treatments in sustainable agriculture, this experiment was conducted in 2013 at the plant production center of Tehran Municipal, District 5. The experiment was conducted in split plot in the form of a randomized complete block design with three replications and two factors: cultivar in three levels including Speedfeed ($V_1$), Payam ($V_2$) and Sepideh ($V_3$), and nutritional treatments in eight levels including 300 kg/ha urea ($N_1$), 100 kg/ha urea + 2 t/ha animal manure + foliar application of 0.5% salicylic acid ($N_2$), 100 kg/ha urea + 4 t/ha animal manure + salicylic acid ($N_3$), 100 kg/ha urea + 6 t/ha animal manure + salicylic acid ($N_4$), 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid ($N_5$), 100 kg/ha urea + 4 t/ha vermicompost + salicylic acid ($N_6$), 100 kg/ha urea + 6 t/ha vermicompost + salicylic acid ($N_7$), 300 kg/ha urea + salicylic acid ($N_8$). Analysis of variance indicated the significant effect of cultivar, nutrition and the interaction of the two factors on all measured traits. Mean comparison of cultivars showed that fresh weight was the highest in Speedfeed cultivar (73.59 g/plant) and the lowest in Sepideh cultivar (25.55 g/plant). Among the nutritional treatments, fresh weight was the highest in 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid (86.28 g/plant) and the lowest in 300 kg/ha urea + salicylic acid (35.61 g/plant).**

**Keywords**: *Sorghum bicolor*, manure, vermicompost, salicylic acid.

## INTRODUCTION

Increased world population requires the boost of agricultural production. Sorghum (*Sorghum bicolor*) is a crop plant which is mainly used as forage crop for animals and livestock. Sorghum is an annual member of Poaceae family; a $C_4$ plant which is located in the fifth rank after wheat, rice, maize and barley (Khodabandeh, 1995). Nutrient management is one of the most important agronomic practices of improving sorghum growth and yield. Chemical fertilizers and especially nitrogenous fertilizers are the most commonly used sources of nutrients for this purpose (Sharma, 2003).

Application of chemical fertilizers to agricultural fields in Iran was first started in 1940s, when the ministry of agriculture imported 11 tons of different types of chemical fertilizers. At first, there was a balance in using various types of fertilizers; however, little by little the proportion of nitrogenous and phosphorus fertilizers increased noticeably. Even in recent years, farmers are more interested in N and P fertilizers; other macro/micronutrients and organic sources of nutrients are somewhat neglected. This situation is resulted in the environmental pollution and the associated health issues. Nitrogen, as one of the factors studied in this experiment, is the most important yield limiting nutrient in nearly all agricultural fields all over the world. Nitrogen is the main component of many compounds in plants body such as enzymes, protein, nucleic acids, amino acids and chlorophyll (Fageria 2009; Hassegawa *et al.,* 2008; Uhardss and Andrade, 1995; Wiedenhoeft, 2006). Reed et al. (1988) tested the effect of different levels of nitrogen fertilizer on maize yield and yield component and observed that the number ears, the number of grains and grain yield increased when higher doses of nitrogen were applied. Uhardss and Andrade (1995) also reported that N deficiency resulted in the reduction of the number of grains and grain yield. They attributed this reduction to the failure of flowers fertilization and development.

In addition to chemical fertilizers, biological and organic sources of nutrients may also improve soil fertility and plant nutrition. These methods are a new application for sustainable agriculture (NASA). Among these organic sources, vermicompost and animal manure were studied in this experiment. Vermicompost is resulted from the activity of worms on organic compounds such as dead plant materials. In recent years, there have been increased interests in using vermicompost and animal manure because of high costs and health issues of chemical fertilizers (Adediran *et al.,* 2004; Gendi and Sirakumar, 2010). Vermicompost and other organic sources of nutrients such as animal manure have high nutrient and water holding capacity and make a wide range of nutrients available to plants such as N, P, K etc.; increasing growth and yield of crop plants and limiting the environmental pollution (Tahami Zarandi *et al.,* 2010).

Fathi *et al.* (2012) conducted experiments to test the response of clary sage (*Salvia sclarea*) to vermicompost and found that application of vermicompost significantly affected shoot yield and essential oil yield. Tahami Zarandi *et al.* (2010) also reported that application of vermicompost increased plant height, leaf yield and shoot yield of basil (*Ocimum basilicum* L.).

The last factor studied in this experiment was salicylic acid. Salicylic acid is an endogenous growth regulator which was first extracted in 1838. It is a phenolics compound which presents in nature. Salicylic acid is a hormone like substance which participates in the regulation of physiological processes of plants. It affects plant growth, flowers production, ions uptake and stomata movement (Abdel-Ati et al., 2000; Kang and Wang, 2003). Popova *et al.* (1997) reported that salicylic acid promoted cell elongation and division. Sadak *et al.* (2013) tested the effect of salicylic acid on soybean and reported that it increased seed yield, number of seeds and pods and improved biochemical constituents such as protein, carbohydrate, oil, flavonoid and phenolic contents.

Regarding the importance of integrated nutrient management and the complexities of this subject, the objective of this experiment was to find the best nutritional treatment for sorghum by integrating the chemical fertilizers, vermicompost, animal manure and salicylic acid.

## MATERIALS AND METHODS

This experiment was conducted in 2013 at the plant production center of Tehran Municipal, District 5 (51° 28' E, 35° 72' N, 1270 m above the sea level). The mean annual maximum and minimum air temperature at the site was 21.36°C and 12.02°C, respectively. Total annual precipitation based on 30 year statistics was 263.9 mm. The soil at the test site was sandy loam (clay, 6%; silt, 13%; sand, 81%) with the pH of 7.53 and EC of 6.24 ds/m. Other soil properties are listed in Table 1.

**Table 1: Physico-chemical properties of the test site soil.**

| TNV (%) | OC (%) | Total N (%) | $P_{ava}$ (mg/kg) | $K_{ava}$ (mg/kg) | Fe (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Mn (mg/kg) | B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| 6.85 | 1.07 | 0.10 | 36.66 | 933 | 3.31 | 5.37 | 0.37 | 4.02 | 1.11 |

The experiment was conducted in split plot in the form of a randomized complete block design with three replications and two factors:

**Sorghum cultivar as the main plot (V)**: in three levels as follow:

$V_1$: Speedfeed (forage cultivar)
$V_2$: Payam (grain cultivar)
$V_3$: Sepideh (grain cultivar)

**Nutritional treatments as the sub plot (N)**: in eight levels based on urea, organic fertilizers and salicylic acid, as follow:

$N_1$: 300 kg/ha urea
$N_2$: 100 kg/ha urea + 2 t/ha animal manure + foliar application of 0.5% salicylic acid
$N_3$: 100 kg/ha urea + 4 t/ha animal manure + foliar application of 0.5% salicylic acid
$N_4$: 100 kg/ha urea + 6 t/ha animal manure + foliar application of 0.5% salicylic acid
$N_5$: 100 kg/ha urea + 2 t/ha vermicompost + foliar application of 0.5% salicylic acid
$N_6$: 100 kg/ha urea + 4 t/ha vermicompost + foliar application of 0.5% salicylic acid
$N_7$: 100 kg/ha urea + 6 t/ha vermicompost + foliar application of 0.5% salicylic acid
$N_8$: 300 kg/ha urea + foliar application of 0.5% salicylic acid

In May 2013, the field was prepared by moldboard plow and leveler. Prior to seeding, vermicompost and animal manure were applied to the plots. Seeds were planted on May 2, 2013, 4 cm below the soil surface. Planting pattern was a square form with 15 cm interval from each side. Irrigation was conducted regularly during the growth period. According to the results of soil analysis, 300 kg/ha urea was added to soil; 50% at the planting time and 50% after the first harvest as top dressing. Weeds were controlled manually and no herbicide was used. Salicylic acid was sprayed to plants at eight leaves stage.

The harvest was conducted 90 days after planting, when plants received 1915 GDD. For sampling, 10 plants were harvested from each plot. The following traits were measured: plant height, fresh weight, dry leaf weight, leaf area and the number of leaves. After data collection, data were analyzed using SAS and means were compared according to the Duncan's multiple range test at $P \leq 0.05$.

## RESULTS AND DISCUSSION

*A. Plant height*

Analysis of variance indicated the significant effect of cultivar and nutritional treatments and the interaction of the two factors on plant height (Table 2). Mean comparison of the three cultivars (Table 3) showed that plant height was the highest Sepideh cultivar (101.76 cm) and the lowest in Payam cultivar (89.86 cm). Among the nutritional treatments, plant height was the highest (116.78 cm) in 100 kg/ha urea + 2 t/ha animal manure + salicylic acid treatment and the lowest (80.96 cm) in 300 kg/ha urea + salicylic acid treatment (Table 4).

**Table 2: Analysis of variance of the effect of treatments on the measured traits.**

| SOV | df | Mean Squares (MS) | | | | |
|---|---|---|---|---|---|---|
| | | Plant height | Fresh weight | Dry leaf weight | Leaf area | The number of leaves |
| Replication | 2 | * | Ns | Ns | Ns | Ns |
| Cultivar (V) | 2 | ** | ** | ** | ** | ** |
| Error | 4 | 284.15 | 178.22 | 0.58 | 1976255133.9 | 2.03 |
| Nutrition (N) | 7 | ** | ** | ** | * | * |
| V × N | 14 | * | ** | * | ** | ** |
| Error | 42 | 167.60 | 215.44 | 1.16 | 910641870.15 | 1.79 |
| CV (%) | - | 13.71 | 26.33 | 24.77 | 53.39 | 20.47 |

ns, nonsignificant; *, significant at $P \leq 0.05$; **, significant at $P \leq 0.01$.

Studying the interaction of the two factors (Table 5) showed that the highest plant height was achieved in Sepideh × 100 kg/ha urea + 2 t/ha animal manure + salicylic acid (124.0 cm) and the lowest plant height was achieved in Payam × 100 kg/ha urea + 6 t/ha vermicompost + salicylic acid (59.33 cm).

*B. Fresh weight*

Analysis of variance showed that fresh weight was significantly affected by cultivar, nutritional treatments and the interaction of the two factors (Table 2). Mean comparison of the cultivars (Table 3) showed that Speedfeed had the highest fresh weight (73.59 g/plant) and Sepideh had the lowest fresh weight (25.55 g/plant). Among the nutritional treatments (Table 4), fresh weight was the highest in 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid (86.28 g/plant) and the lowest in 300 kg/ha urea + salicylic acid (35.61 g/plant). Among the interactions (Table 5), fresh weight was the highest (169.50 g/plant) in Payam × 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid and the lowest (8.47 g/plant) in Speed feed × 300 kg/ha urea + salicylic acid.

**Table 3: The variation of traits among the three cultivars.**

| Cultivars | Plant height (cm) | Fresh weight (g/plant) | Dry leaf weight (g/plant) | Leaf area ($cm^2$) | The number of leaves |
|---|---|---|---|---|---|
| $V_1$ | 91.58a | 73.59a | 2.30c | 166971a | 7.46a |
| $V_2$ | 89.86a | 68.12a | 6.18b | 1178b | 6.13b |
| $V_3$ | 101.76a | 25.55b | 7.01a | 1581b | 6.00b |

Means in a column followed by the same letter are not significantly different at $P \leq 0.05$.

$V_1$, Speedfeed

$V_2$, Payam

$V_3$, Sepideh

**Table 4: The effect of nutritional treatments on the measured traits.**

| Nutritional treatments | Plant height (cm) | Fresh weight (g/plant) | Dry leaf weight (g/plant) | Leaf area ($cm^2$) | The number of leaves |
|---|---|---|---|---|---|
| $N_1$ | 92.17bc | 49.00cd | 4.09c | 53043a-c | 5.56b |
| $N_2$ | 116.78a | 48.03cd | 4.24c | 53682a-c | 6.67ab |
| $N_3$ | 100.89b | 58.48bc | 5.28bc | 46370bc | 7.67a |
| $N_4$ | 104.67ab | 65.99b | 6.27ab | 46863a-c | 6.89ab |
| $N_5$ | 84.22c | 86.28a | 7.11a | 35981c | 6.33ab |
| $N_6$ | 92.67bc | 50.96bc | 4.89c | 83868a | 6.11b |
| $N_7$ | 82.85c | 51.67bc | 5.19bc | 76699ab | 7.00ab |
| $N_8$ | 80.96c | 35.61d | 4.23c | 37627c | 6.00b |

Means in a column followed by the same letter are not significantly different at $P \leq 0.05$.

$N_1$, 300 kg/ha urea

$N_2$, 100 kg/ha urea + 2 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_3$, 100 kg/ha urea + 4 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_4$, 100 kg/ha urea + 6 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_5$, 100 kg/ha urea + 2 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_6$, 100 kg/ha urea + 4 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_7$, 100 kg/ha urea + 6 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_8$, 300 kg/ha urea + foliar application of 0.5% salicylic acid

*C. Dry leaf weight*

Results indicated that cultivar, nutritional treatments and the interaction of the two factors had significant effect on dry leaf weight (Table 2). Studying the tested cultivars (Table 3) showed that the highest dry leaf weight was related to Sepideh cultivar (7.01 g/plant) and the lowest dry leaf weight was related to Speed feed cultivar (2.30 g/plant).

Mean comparison of the nutritional treatments (Table 4) showed that dry leaf weight was the highest (7.11 g/plant) in 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid and the lowest (4.09 g/plant) in 300 kg/ha urea. Among the interactions of the two factors (Table 5), the highest dry leaf weight (12.30 g/plant) was achieved in Payam × 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid and the lowest dry leaf weight (1.37 g/plant) was achieved in Speed feed × 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid.

*D. Leaf area*

Analysis of variance showed the significant effect of cultivar, nutritional treatments and the interaction of the two factors on leaf area (Table 2). Mean comparison of the cultivars (Table 3) showed that Speedfeed had the highest leaf area (166971 $cm^2$) and Payam had the lowest leaf area (1178 $cm^2$). Among the nutritional treatments (Table 4), leaf area was the highest (83868 $cm^2$) in 100 kg/ha urea + 4 t/ha vermicompost + salicylic acid and the lowest (35981 $cm^2$) in 100 kg/ha urea + 2 t/ha vermicompost + salicylic acid. Studying the interaction of cultivar × nutritional treatments (Table 5) showed that leaf area was the highest (249264 $cm^2$) in Speedfeed × 100 kg/ha urea + 4 t/ha vermicompost + salicylic acid and the lowest (668 $cm^2$) in Payam × 300 kg/ha urea + salicylic acid.

**Table 5: The effect of interaction of cultivar × nutritional treatments on the measured traits.**

| Treatments | Plant height (cm) | Fresh weight (g/plant) | Dry leaf weight (g/plant) | Leaf area ($cm^2$) | The number of leaves |
|---|---|---|---|---|---|
| $V_1N_1$ | 85.67c-e | 17.38j-l | 2.39h-j | 157140cd | 7.67a-d |
| $V_1N_2$ | 112.67ab | 21.56i-l | 1.94ij | 158989cd | 8.33ab |
| $V_1N_3$ | 96.33bc | 25.97i-l | 2.50h-j | 135774d | 6.67a-e |
| $V_1N_4$ | 114.67ab | 42.63f-j | 2.80h-j | 190677bc | 7.67a-d |
| $V_1N_5$ | 66.33d-f | 13.01kl | 1.37j | 104571d | 7.00a-d |
| $V_1N_6$ | 82.00c-f | 39.30g-k | 2.91h-j | 249264a | 8.00a-d |
| $V_1N_7$ | 92.33bc | 36.07h-l | 3.60hj | 227283ab | 7.67a-d |
| $V_1N_8$ | 82.67c-f | 8.47L | 1.87ij | 110632d | 6.67a-d |
| $V_2N_1$ | 89.58b-d | 68.12c-f | 6.18c-f | 1178e | 6.00b-e |
| $V_2N_2$ | 113.67ab | 55.30c-h | 4.23e-i | 1092e | 5.33c-f |
| $V_2N_3$ | 105.00a-c | 53.67h-l | 6.60c-g | 1215e | 9.00a |
| $V_2N_4$ | 100.00a-c | 72.13b-e | 6.52c-e | 1296e | 5.67c-e |
| $V_2N_5$ | 91.00bc | 169.50a | 12.30a | 1838e | 5.00d-f |
| $V_2N_6$ | 96.67bc | 56.07c-h | 4.82d-g | 904e | 4.33ef |
| $V_2N_7$ | 59.33f | 45.37e-i | 5.97c-g | 1234e | 7.33a-d |
| $V_2N_8$ | 63.33ef | 24.77i-l | 3.82e-i | 668e | 5.33c-f |
| $V_3N_1$ | 101.00a-c | 61.50c-h | 3.71g-j | 810e | 3.00f |
| $V_3N_2$ | 124.00a | 67.23c-g | 6.54c-e | 966e | 6.033b-e |
| $V_3N_3$ | 101.33a-c | 95.80b | 7.7bc | 2122e | 7.33a-d |
| $V_3N_4$ | 99.33a-c | 83.20bc | 9.49b | 2618e | 7.33a-d |
| $V_3N_5$ | 95.33bc | 76.33b-d | 7.66bc | 1535e | 7.00a-d |
| $V_3N_6$ | 99.33a-c | 57.50c-h | 6.93cd | 1436e | 6.00b-e |
| $V_3N_7$ | 96.88bc | 73.59b-e | 7.00cd | 1581e | 6.00b-e |
| $V_3N_8$ | 96.88bc | 73.59b-e | 7.00cd | 1581e | 6.00b-e |

Means in a column followed by the same letter are not significantly different at P≤0.05.

$V_1$, Speedfeed

$V_2$, Payam

$V_3$, Sepideh

$N_1$, 300 kg/ha urea

$N_2$, 100 kg/ha urea + 2 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_3$, 100 kg/ha urea + 4 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_4$, 100 kg/ha urea + 6 t/ha animal manure + foliar application of 0.5% salicylic acid

$N_5$, 100 kg/ha urea + 2 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_6$, 100 kg/ha urea + 4 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_7$, 100 kg/ha urea + 6 t/ha vermicompost + foliar application of 0.5% salicylic acid

$N_8$, 300 kg/ha urea + foliar application of 0.5% salicylic acid

*E. The number of leaves*

Results of this experiment indicated that cultivar, nutritional treatment and the interaction of the two factors had significant effect on the number of leaves (Table 2). Among the cultivars (Table 3), Speedfeed had the highest number of leaves (7.46) and Sepideh had the lowest number of leaves (6.0). Studying the mean comparison of the nutritional treatments (Table 4) showed that the highest number of leaves was achieved in 100 kg/ha urea + 4 t/ha animal manure + salicylic acid (7.67) and the lowest number of leaves was achieved in 300 kg/ha urea (5.56). Moreover, results showed that among the interactions (Table 5), the highest number of leaves was achieved in Payam × 100 kg/ha urea + 4 t/ha animal manure + salicylic acid (9.0) and the lowest number of leaves was achieved in Sepideh × 300 kg/ha urea (3.0).

Results of this experiment showed the significant effect of different sources of nutrients on sorghum yield and yield components. Briefly, treatments that contained chemical nitrogen, vermicompost and salicylic acid were more effective than the treatments without vermicompost or without salicylic acid.

Nitrogen, as the most important yield limiting macronutrient, is the most commonly used nutrient in the form chemical fertilizer in agricultural fields. Nitrogen plays structural role many compounds in plants body such as enzymes, protein, nucleic acids, amino acids, chlorophyll and cell wall and is involved in many physiological and biochemical processes in plants body (Fageria 2009; Hassegawa *et al.,* 2008; Uhardss and Andrade, 1995; Wiedenhoeft, 2006). Ardakani and Mafakheri (2011) tested the effect of 0, 50, 100 and 150 kg/ha nitrogen fertilizer on wheat yield and yield components and found a significant effect on the measured traits. They reported that application of 150 kg N/ha increased plant height by 18.2%, grain yield by 63%, the number of panicles by 24.3% and 1000 grain weight by 8.6% compared with the control (0 kg N/ha). Uhardss and Andrade (1995) observed that N deficiency reduced the number of grains and grain yield; they attributed this reduction to the failure of flowers fertilization and development. Njuguna *et al.* (2010) found that N application increased the number of tillers, panicles and grain yield in wheat. They observed that the highest N rate (46 kg/ha) resulted in the highest grain yield (1176.7 kg/ha) compared with the control (0 kg N/ha) which resulted in the lowest grain yield (1022.9 kg/ha). Reed *et al.* (1988) tested the effect of different levels of nitrogen fertilizer on maize yield and yield component and observed that the number ears, the number of grains and grain yield increased when higher doses of nitrogen were applied.

Results of this experiment also showed that vermicompost and animal manure were effective on the measured traits. Vermicompost is the side product worm's activity on organic materials such as dead plant materials. High costs and health issues of chemical fertilizers have attracted the interests of researchers and farmers to these organic sources of nutrients (Adediran *et al.,* 2004; Gendi and Sirakumar, 2010). Vermicompost and animal manure have high nutrient and water holding capacity and make a wide range of nutrients available to plants such as N, P, K etc., release phytohormones, improve soil physico-chemical properties and promote soil biological activity; increasing growth and yield of crop plants and limiting the environmental pollution (Gunadi *et al.,* 2002; Tahami Zarandi *et al.,* 2010). Fathi *et al.* (2012) conducted experiments to test the effect of vermicompost on clary sage (*Salvia sclarea*) and found that application of vermicompost significantly affected shoot yield and essential oil yield. Shishehbor et al. (2013) reported that application of vermicompost increased grain weight and biologic yield and also increased the efficiency of microorganism's inoculation. Tahami Zarandi *et al.* (2010) also reported that application of vermicompost increased plant height, leaf yield and shoot yield of basil (*Ocimum basilicum* L.).

Regarding the effect of animal manure on plants growth and yield, Ardakani and Mafakheri (2011) conducted experiments to test the response of wheat to animal manure and reported that application of animal manure improved wheat stem diameter by 8.4% and grain yield by 9.1%. Ojeniyi *et al.* (2007) also observed that animal manure application improved leaf N and K content, plant height, the number of branches, leaf area, the number and weight of fruits of tomato plants. Animal manure affects soil physico-chemical properties and biological activity. It also increases soil organic matter content which in turn balances soil pH, CEC and temperature, stabilizes soil aggregates and reduces erosion, increases aeration, enhances soil water-holding and buffering capacity, provides food and energy for soil microorganisms and creates a suitable soil environment for plant growth. Clearly, animal manure also adds nutrients to soil (Fageria, 2009; Mujiyati and Supriyadi, 2009; Schoenau, 2006).

The last factor studied in this experiment was salicylic acid which had improving effect on the measured traits. Salicylic acid is an endogenous growth regulator which was first extracted in 1838. It is a phenolics compound which presents in nature. Salicylic acid is a hormone like substance which participates in the regulation of physiological processes of plants. It affects plant growth, flowers production, ions uptake and stomata movement. It increases plants resistance to pathogens. (Abdel-Ati *et al.,* 2000; Kang and Wang, 2003; Popova *et al.,* 1997). Sadak *et al.* (2013) tested the effect of salicylic acid on soybean and reported that it increased seed yield, number of seeds and pods and improved biochemical constituents such as protein, carbohydrate, oil, flavonoid and phenolic contents. Javaheri *et al.* (2012) also studied the response of tomato plants to salicylic acid and found that salicylic acid increased tomato yield so that tomato plants treated with salicylic acid had higher fruit yield (3059.5 g per bush) compared with the non-treated plants (2220 g per bush).

They also found that the treatment improved the quality of fruits and increased the amount of vitamin C, lycopene, fruit skin diameter and rate of pressure tolerance of fruits. In another experiment on strawberry plants, Jamali *et al.* (2011) observed that salicylic application increased root and shoot fresh weight, the number of inflorescences and the number of fruits.

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