Journal of Horticultural Science and Technology 2(1): 5-9 (2019)
ISSN (Print) 2617-3220
http://www.pshsciences.org

Original Research

Role of Foliar Application of Salicylic Acid and Cultivars in Chilli (*Capsicum frutescens* L.) Production in Arid Region of Bahawalpur

Muhammad Nafees[a]*, Rashid Hussain[a], Ishtiaq Ahmad[a], Muhammad Ahsan[a], Muhammad Naveed Aslam[b], Maqshoof Ahmad[c] and Aamir Manzoor[d]

[a]Department of Horticultural Sciences, University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur, 63100, Pakistan

[b]Department of Plant Pathology, University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur, 63100, Pakistan

[c]Department of Soil Science University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur, 63100, Pakistan

[d]Directorate of Farm Management, The Islamia University of Bahawalpur, 63100, Pakistan.

ABSTRACT

A field experiment was carried out to screen the best foliar concentration of salicylic acid (SA) out of 25, 50, 75 and 100 mg L^{-1} for its effect on various growth and yield parameters like number of leaves, plant height, number of fruits $plant^{-1}$, fruit dimensions, leaf chlorophyll content and yield $plant^{-1}$ in three chilli cultivars. The selected chilli cultivars included were Sky-Land-II, Sky-Land and 1130. The experiment was conducted in field area of the Department of Horticultural Sciences, The Islamia University of Bahawalpur, Pakistan during 2017. Results indicated that different levels of SA significantly increased plant growth and yield parameters, but the level of SA @ 75 mg L^{-1} highly improved the studied parameters in selected cultivars. Moreover, foliar spray of SA significantly increased growth in selected cultivars; however, Sky-Land-II performed better in response to different concentrations of SA. In conclusion, foliar spraying of 75 mg L^{-1} SA could be recommended to chilli growers under arid region of Bahawalpur for growing cultivar Sky-Land-II.

Keywords: *Chilli cultivars, foliar spray, plant growth, chlorophyll content, fruit yield*

Article History: *Received 25 December 2018; Revised 12 February 2019; Accepted 15 March 2019; Published 31 March 2019.*

INTRODUCTION

Chilli pepper (*Capsicum frutescens* L.) belongs to Solanaceae family. Chilli crop in Pakistan is produced year round. It is important not only for farm income but also for the nutritional value. It is a superb source of natural colors and various antioxidant (Howard et al., 2000). It is a warm-season and chilling-sensitive tropical crop, cannot tolerate extended period of temperature below 10 °C without serious metabolic disruptions (Decoteau, 2000). A wide range of antioxidants, vitamins, carotenoids, capsaicinoids and phenolic compounds are present in its fruit. Chilli fruits occupy an important place in human diet and are consumed as fresh in salads, and in cooked meals (Maria et al., 2010). This crop is object of much attention for its carotenoids, antioxidants, ascorbic acids and vitamin E, due to possible links in the treatment of certain type of cardiovascular diseases, cancer and delay in ageing process (Simonne et al., 2007). Hot peppers have high content of alkaloid capsaicin, responsible for pungency or heat (Udoh et al., 2005).

Effect of drought, salinity and high temperature are main environmental barrier affecting chilli production worldwide (Ziaf et al., 2009; Farooq et al., 2009; Ashraf and Harris, 2004). Bot et al. (2000) estimated up to 45% world agricultural land subjected to drought which causes various negative physiological effects in plants like reduction in leaf enlargement, leaf water potential, and stomatal conductance (Jafar et al., 2004; Adejare and Umebese, 2007). The decrease in chlorophyll content under drought condition is considered as an oxidative stress and may be the result of chlorophyll degradation (Anjum, 2011) in vegetables. High temperature has been shown to reduce the number of flowers and fruit set in Solanaceous vegetables (Erickson and Markhart, 2002; Russo, 2003). However, this sensitivity varies according to the type of pepper (hot or sweet) and, within the same cultivar (Tarchoun et al., 2003). Soil salinity is the most common problem in various arid and semi-arid regions of the world, significantly affect physiological processes in plant. It causes reduction in leaf surface area, dry weight, chlorophyll content, stomatal conductance and photosynthesis (Saeed et al., 2016). Sweet pepper (*Capsicum annuum* L.) is the most widely grown vegetable all over the world; it is susceptible and cannot survive under high soil salinity levels.

* Corresponding author.
E-mail: muhammad.nafees@iub.edu.pk (M. Nafees)

A naturally occurring plant hormone, salicylic acid (SA) acts as an important signaling molecule to tolerate various abiotic stresses. It plays a vital role in plant growth, ion uptake and transport. Enzymatic activities were increased by the application of SA, showing synergetic effect with auxins and gibberellins (Zaghlool et al., 2006). The exogenous application of SA was reported to have an effect on a wide range of physiological processes including increase in cold germination tolerance in pepper and cucumber (Kang and Saltveit, 2002). Moreover, Horvath et al., (2007) reported that the application of SA could provide protection against low and high temperature and thus improve chilli production in arid region (Abd El-Al, 2009). Foliar spray of salicylic acid increased the fresh and dry weight in plant, pod setting and total proteins in leaves and fruits of dry bean (Sanaa et al., 2001). In general, adding SA significantly relieved the harsh effects of drought on okra germination and growth parameters and it seems that SA is able to enhance the tolerant ability of the plant to drought stress (Baghizadeh and Hajmohammadrezaei, 2011). However, Magda, et al. (2013) reported that effect of different concentration of SA was significant on growth, yield and photosynthetic pigments in arid and drought regions. It was therefore planned to assess different concentrations of SA on plant growth and fruit production in chilli under arid region of Bahawalpur to avoid excessive application of SA for reduction in cost of production without compromising the yield and fruit quality.

MATERIALS AND METHODS

A field experiment was carried out in experimental area of Department of Horticultural Sciences University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Pakistan during spring season 2017 to investigate the response of three cultivars of hot pepper namely Sky-Land-II, Sky-Land and 1130 to foliar spray of SA with five concentrations (0, 25, 50, 75 and 100 mg L^{-1}). Pepper seedlings (40 days old), collected from Choudhry Abdul Slam Farm, Dahnoot (Lodhran), Pakistan were transplanted on both sides of raised beds (15 cm) prepared 75 cm apart keeping plant to plant distance of 60 cm in sandy loam soil. Seedling beds were fertilized with DAP at the time of field preparation and Urea was applied in two splits with irrigation water using recommended doses. Five levels of salicylic acid (SA) solution were sprayed till every leaf of plant was washed on 50, 70 and 90 days after seedling transplantation. Following parameters were recorded; plant height (cm), number of leaves $plant^{-1}$, number of flowers $plant^{-1}$, number of fruits set $plant^{-1}$, fruit weight, fruit length, fruit diameter, yield $plant^{-1}$ and leaf chlorophyll content. Plant height was measured with a meter rod. Numbers of leaves, number of flowers and number of fruit set $plant^{-1}$ were counted for three seedlings and average was recorded for each replication. Fruit weight was measured using digital weighing balance. Fruit length and diameter were measured using meter rod and Vernier caliper, respectively. Chlorophyll content were measured by using SPAD Chlorophyll meter.

Statistical Analysis

There were two factors; chilli cultivars and SA concentrations (0, 25, 50, 75 and 100 mg L^{-1}). Randomized Complete Block Design (RCBD) was used for lay out of the experiment. Recorded data were statistically analyzed through software Statistix 8.1 and the mean values of various treatments were compared using Duncan's multiple range (DMR) test at 5% level of probability.

RESULTS AND DISCUSSION

Analysis of Variance for Response of Chilli Cultivars to SA Spray

Analysis of variance of recorded data showed highly significant effect of chilli cultivars and SA concentrations on plant height, number of leaves $plant^{-1}$, number of fruit set $plant^{-1}$, fruit weight, chlorophyll content in leaves and yield $plant^{-1}$. Moreover, significant effect of SA was recorded for fruit length. However, interactive effect of SA and chilli cultivars was found non-significant regarding plant height, number of fruit set $plant^{-1}$ and fruit diameter. Interactive effects of cultivars and SA on number of leaves, fruit length, fruit weight, chlorophyll content and yield $plant^{-1}$ were highly significant (P <0.01) and for fruit length it was significant (P <0.05) as shown in Table 1.

Table 1: Significance levels of plant growth and yield attributes of chilli cultivars in response to SA spray.

Sr. No.	Parameter	Source of variance	Significance level
1	Plant height (cm)	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	NS
2	Number of leaves $plant^{-1}$	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	**
3	Chlorophyll content (SPAD)	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	**
4	Number of fruit set $plant^{-1}$	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	NS
5	Fruit length (mm)	Chilli cultivars (A)	**
		SA spray (B)	*
		A × B	*
6	Fruit diameter (mm)	Chilli cultivars (A)	**
		SA spray (B)	NS
		A × B	NS
7	Fruit weight (g)	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	**
8	Yield $plant^{-1}$ (g)	Chilli cultivars (A)	**
		SA spray (B)	**
		A × B	**

NS = non-significant; * = significant (P <0.05) and ** = highly significant (P <0.01)

Exogenous application of SA reduced the impact of various abiotic stresses like high temperature in arid regions; thus, improved plant height, number of leaves $plant^{1}$, chlorophyll content, and fruit quality and yield as compared to control (Table 2). Our results are in line with Zaghlool et al. (2006) who stated that plant growth and yield related parameters were increased by application of SA. Moreover, Horvath et al. (2007) reported that application of SA could provide protection against

Table 2: Effect of SA on plant growth and yield attributes.

Treatments (SA conc.)	Plant height (cm)	Number of leaves plant^{-1}	Chlorophyll content (SPAD)	Fruit set plant^{-1}	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Yield plant^{-1} (g)
Control	33.77cd	62.88c	22.85c	7.11c	50.66b	6.26b	6.14c	12.37c
25 mg L^{-1}	35.22bc	62.88c	31.66b	10.77ab	53.33ab	6.45ab	6.90bc	19.02a
50 mg L^{-1}	31.44d	68.88b	37.11a	8.77bc	50.77b	6.27b	6.51bc	15.11b
75 mg L^{-1}	38.77a	74.88a	40.00a	12.22a	55.22a	6.94a	8.03a	20.28a
100 mg L^{-1}	37.22ab	73.77ab	32.88b	10.33ab	51.66b	6.36ab	7.57ab	19.36a
S.E.	±1.16	±2.92	±1.82	±1.15	±1.40	±0.31	±0.36	±1.22

Table 3: Effect of cultivars on plant growth and yield attributes.

Chili Cultivars	Plant height (cm)	Number of leaves plant^{-1}	Chlorophyll content (SPAD)	Fruit set plant^{-1}	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Yield plant^{-1} (g)
Sky-Land-II	41.06a	103.2a	43.91a	13.26a	56.26a	7.11a	8.80a	31.22a
Sky-Land	32.60b	43.20c	30.33b	6.33c	50.86b	6.13b	5.70c	8.86c
1130	32.20b	59.60b	24.46c	9.33b	49.86c	6.08b	7.01b	11.60b
S.E.	0.9	2.26	1.41	0.89	1.08	0.24	0.28	0.94

low and high temperature and thus improved chilli production in arid region (Abd et al., 2009). In another study, foliar spray of SA increased plant fresh and dry weights and hence increase pod setting in pea (Sanaa et al., 2001).

Individual Effect of SA Concentrations

Significant effect of applied concentrations of SA was recorded on different plant growth and yield attributes as shown in Table 2. Significantly greater plant height (38.77 cm) was recorded in plants sprayed with 75 mg L^{-1} SA which was at par with the plants treated with 100 mg L^{-1} SA, however, the minimum plant height (31.44 cm) was recorded in plants sprayed with 50 mg L^{-1} SA. Significantly high number of leaves plant^{-1} (74.88) was recorded in response to 75 mg L^{-1} SA which was at par with 100 mg L^{-1} SA; however, the least number of leaves were recorded in control and with 25 mg L^{-1} spray of SA. Significant effect of different concentrations of SA was recorded on chlorophyll content in leaves with the highest content (40.00 SPAD value) recorded in plants sprayed with 75 mg L^{-1} SA, which was statistically at par 50 mg L^{-1}. However, the least chlorophyll content was recorded in leaves of the plants sprayed with 0 mg L^{-1} SA.

Number of fruits per plant were significantly affected by the application of SA. Significantly higher number of fruits (12.22) was recorded with 75 mg L^{-1} SA spray, which was statistically similar with 100 and 25 mg L^{-1} spray of SA. The least number of fruit set (7.11) was noted in plants sprayed with only distilled water (0 mg L^{-1} SA). Individual fruit length was significantly affected by different concentrations of SA with the highest fruit length (55.22 mm) recorded with 75 mg L^{-1} SA spray, which was statistically at par with 25 mg L^{-1} SA. However, the least fruit length (50.66 mm) was recorded in control plants. Significantly greater fruit diameter (6.94 mm) was recorded in plants sprayed with 75 mg L^{-1} SA, which was statistically similar with spray of 100 and 25 mg L^{-1} SA. The least diameter was recorded in control plants and in those sprayed with 50 mg L^{-1} SA. Fruit weight was significantly affected by foliar spray of SA with the highest fruit weight (8.03 g) recorded in plants sprayed with 75 mg L^{-1} SA which was at par with 100 mg L^{-1} SA. However, the least fruit weight (6.14 g) was recorded in control plants sprayed with distilled water. There was significant effect of SA concentrations on yield plant^{-1} with the highest yield (20.28 g) in plants sprayed with 75 mg L^{-1} SA which was at par with 100 and 25 mg L^{-1} SA. However, the least yield plant^{-1} (12.37 g) was recorded in control plants sprayed with distilled water.

All applied concentrations of SA showed significant impact on various growth and yield parameters of chilli crop grown in arid region of Bahawalpur. Results are in accordance with Magda et al. (2013) who reported that impact of different concentrations of SA was significant on growth, yield and photosynthetic pigment content in barley. Moreover, Shafeek et al. (2014) reported that foliar spray of high level of SA significantly increased growth, yield and pod quality in bean plants. Exogenous application of SA improved vegetative growth and yield attributes in vegetables (Shokr et al., 2014) because SA provides resistance against various biotic and abiotic stresses in plants (Yuan and Lin, 2008).

Individual Effect of Cultivars

There was significant difference among selected chilli cultivars regarding plant height and number of leaves with more plant height and leaves (41.06 cm and 103.2) in Sky-Land-II followed by 1130 and Sky-Land. Significantly high chlorophyll content (43.91 SPAD value) was recorded in Sky-Land-II followed by Sky-Land and 1130 (Table 3).

Fruit set plant^{-1}, fruit length, fruit diameter, fruit weight and yield plant^{-1} were significantly higher (13.26, 56.26 mm, 7.11 mm, 8.80 g and 31.22 g, respectively) in Sky-Land-II as shown in Table 3. Significantly least fruit set plant^{-1}, fruit weight and yield plant^{-1} (6.33, 5.70 g and 8.86 g, respectively) were recorded in Sky-Land. However, statistically, the least fruit length (49.86 mm) was recorded in chilli cultivar 1130 as shown in Table 3.

Significant variation was recorded in selected chilli cultivars with comparatively better performance of Sky-Land-II regarding growth and yield characters. Similar results were published by Zhigila et al. (2014) who recorded variation among different chilli cultivars for 33 morphological characters. Chilli cultivars had great variability in its various plant and fruit characters like

Table 4: Interactive effect of SA and cultivars on plant growth and yield attributes.

	Control (0 mg L^{-1} SA)			25 mg L^{-1} SA			50 mg L^{-1} SA			75 mg L^{-1} SA			100 mg L^{-1} SA			
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3	SE
PH	41.3abc	31.3fg	28.6g	39.6bcd	34.3ef	31.6fg	37.3cde	28.3g	28.6g	44.3a	35.3ef	36.6de	42.6a	33.6ef	35.3ef	±2.0
NL	101.0a	42.6d	45.0d	103.3a	42.0d	43.3d	103.3a	41.6d	61.6c	105.0a	45.0d	74.6b	103.3a	44.6d	73.3b	±5.0
CC	19.9e	30.6c	18.0e	41.3b	31.0c	22.7de	50.3a	30.6c	30.3c	56.3a	32.0c	31.6c	51.6a	27.3cd	19.6e	±3.1
NF	11.6abcd	3.3h	6.3gh	14.3ab	7.3efgh	10.7bcdef	12.0abcd	5.7gh	8.7cdef	15.6a	8.3defg	12.7abc	12.7abc	7.0fgh	11.3bcde	±1.9
FL	56.6abc	51.0de	44.3f	58.3ab	51.0de	50.6de	49.6de	50.6de	52.4cde	60.0a	52.0cde	53.6bcd	56.6abc	49.6de	48.6ef	±2.4
FD	7.0abc	6.2bcde	5.6de	7.3a	6.5abcde	5.5de	6.5abcd	6.0cde	5.9cde	7.5a	6.5abcde	6.8abc	7.2ab	5.4e	6.5abcde	±0.5
FW	8.2bc	6.5def	5.8efg	8.8b	4.8g	7.0cde	6.1ef	5.7fg	7.7bcd	10.5a	5.7efg	7.7bcd	10.2a	5.7efg	6.7def	±0.6
PY	19.8c	7.3f	9.9def	35.1a	9.2ef	12.7de	27.0a	9.2ef	9.0ef	37.5a	9.3ef	13.9d	36.6a	9.1ef	12.3d	±2.1

PH = Plant height (cm), NL = Number of leaves, CC = Chlorophyll content, NF = Number of fruits set per plant, FL = Fruit length, FD = Fruit diameter, FW = Fruit weight and PY = Plant yield. V_1 = Sky-Land-II, V_2 = Sky-Land, V_3 = 1130.

form, size, colour and position of flowers and fruits (Moscone et al., 2007). Fresh fruit weight of various genotypes of *Capsicum frutescens* L. ranged from 0.23 g to 4.04 g (Jarrett et al., 2007), which is lower than our selected cultivars like Sky-Land-II.

Interactive Effect of SA Concentrations and Chilli Cultivars

Significant interaction between cultivars and SA concentrations was recorded for plant height with the highest value (44.3 cm) recorded in Sky-Land-II sprayed with 75 mg L^{-1} SA, which was at par with Sky-Land-II treated with 100 mg L^{-1} SA and sprayed with 0 mg L^{-1} SA (control). However, the least plant height was recorded in the cultivar 1130 sprayed with 0 mg L^{-1} SA and in Sky-Land sprayed with 50 and 25 mg L^{-1} SA as shown in Table 4. Number of leaves $plant^{-1}$ were significantly higher (105.0) in Sky-Land-II sprayed with 75 mg L^{-1} which was at par with Sky-Land-II sprayed with 100, 50, 25 and 0 mg L^{-1} SA, followed by the cultivar 1130 sprayed with 75 and 100 mg L^{-1} SA. However, the least number of leaves (41.6) were counted in Sky-Land sprayed with 50 mg L^{-1} SA. Significant differences in leaf chlorophyll content of different cultivars sprayed with different concentrations of SA were recorded. The highest chlorophyll content (56.3 SPAD value) was recorded in Sky-Land-II sprayed with 75 mg L^{-1} SA which was at par with Sky-Land-II receiving 100 mg L^{-1} SA. However, the least chlorophyll content (18.0 SPAD value) was recorded in the cultivar 1130 treated with 0 mg L^{-1} SA (control) as shown in Table 4.

Significant interactive effect of cultivars and SA concentrations was recorded for number of fruit set $plant^{-1}$ with the highest value (15.6) recorded in Sky-Land-II and followed by the cultivars 1130 and Sky-Land-II sprayed with 75 and 100 mg L^{-1} SA, respectively. However, the least number of fruit set $plant^{-1}$ (3.3) were recorded in Sky-Land receiving 0 mg L^{-1} SA. Significantly greater fruit length (60.0 mm) was recorded in Sky-Land-II that received 75 mg L^{-1} SA, which was at par with Sky-Land-II sprayed with 25 mg L^{-1} SA and distilled water. Significantly least fruit length (44.3 cm) was recorded in the cultivar 1130 sprayed no SA which was at par with the same cultivar sprayed with 100 mg L^{-1} SA (Table 4). Significantly greater fruit diameter (7.5 mm) was recorded in Sky-Land-II received 75 mg L^{-1} of SA which was statistically similar with Sky-Land-II treated with 25 mg L^{-1} SA and Sky-Land-II received 100 mg L^{-1} SA. However, the least fruit diameter (5.4 mm) was recorded in Sky-Land received 100 mg L^{-1} SA. Fruit weight was significantly high (10.5 g) in Sky-Land-II sprayed with 75 mg L^{-1} SA, which was at par with 100 mg L^{-1} in the same cultivar. However, the least fruit weight (4.8 g) was recorded in Sky-Land sprayed with 25 mg L^{-1} SA, which was at par with the same cultivar received 50 mg L^{-1} SA and also with some others. Significant interaction effect of chilli cultivars and SA concentrations was also recorded for fruit yield $plant^{-1}$ with the highest fruit yield (37.5 g) measured in Sky-Land-II treated with 75 mg L^{-1} SA which was at par with Sky-Land-II sprayed with 100, 50 and 25 mg L^{-1} SA. However, the least yield $plant^{-1}$ (7.3 g) was recorded in Sky-Land sprayed with distilled water.

Significant impact of SA concentrations and chilli cultivars for plant height, fruit dimension and fruit weight in our selected cultivars was in line with the finding of Chartzoulakis and Klapaki (2000), who stated that greenhouse hybrid pepper responded differently for plant height, fruit length, fruit weight and yield $plant^{-1}$. Moreover, Aliu et al. (2017) stated that different pepper genotypes of Kosovo showed highly significant differences for various morphological traits like plant height, fruit dimension and fruit weight as proved in our studied cultivars. Bozokalfa et al. (2009) proved phenotypic variation in pepper cultivars in response to various cultural practices in Turkey.

CONCLUSION

Life zone for capsicum species is 7 to 29 °C with an annual precipitation of 0.3 to 4.6 meters, however, average summer temperature and rainfall in arid region of Bahawalpur is ≥ 38 °C and ≤ 0.2 meters, respectively; thus it is recommended to spray 75 mg L^{-1} SA on chilli cultivar (Sky-Land-II) after 50, 70 and 90 days of seedlings transplantation for better plant and fruit growth and high yield. Other cultivars are needed to be introduced in this region through screening and standardizing the production technology against various salinity and drought stresses.

REFERENCES

Aliu, S., Rusinovci, I., Fetahu, S., Kaciu, S. and Zeka, D. 2017. Assessment of morphological variability and chemical composition of some local pepper (*Capsicum annuum* L.) populations on the area of Kosovo. *Acta Agriculturae Slovenica*, 109: 205-213.

Abd El-Al, S.F. 2009. Effect of urea and some organic acids on plant growth, fruit yield and its quality of sweet pepper (*Capsicum annuum* L.). *Research Journal of Agriculture and Biological Sciences*. 5: 372-379.

Adejare, F.B. and Umebese, C.E. 2007. Stomatal resistance to low water potential at different growth stages affects plant biomass in *Glycine max* L. *American Journal of Agricultural and Biological Sciences*, 3: 136-141.

Anjum, S.A. 2011. Morphological, physiological and biochemical responses of plants to drought stress. *African Journal of Agricultural Research*, 6: 2026-2032.

Ashraf, M. and Harris, P.J. 2004. Potential biochemical indicators of salinity tolerance in plants. *Plant Sci*ence, 166: 3-16.

Baghizadeh, A. and Hajmohammadrezaei, M. 2011. Effect of drought stress and its interaction with ascorbate and salicylic acid on okra (*Hibiscus esculents* L.) germination and seedling growth. *Journal of Stress Physiology and Biochemistry*, 7: 55- 65.

Bozokalfa K., Esiyok, D. and Turhan, K. 2009. Patterns of phenotypic variation in a germplasm collection of pepper (*Capsicum annuum* L.) from Turkey. *Spanish Journal of Agricultural Research*, 1: 83-95.

Bot, A.J., Nachtergaele, F.O. and Young, A. 2000. Land Resource Potential and Constraints at Regional and Country Levels. World Soil Resources Reports 90. Land and Water Development Division, Food and Agricultural Organization of the United Nations, Rome.

Chartzoulakis, K. and Klapaki, G. 2000. Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. *Scientia Horticulturae*, 86: 247-260.

Decoteau, D.R. 2000. Vegetable Crops, Pearson Publishers, pp. 392-398.

Erickson, E.R. and Markhart, A.F. 2002. Flower developmental stage and organ sensitivity of bell pepper (*Capsicum annuum* L.) to elevated temperature. *Plant Cell and Environment*, 25: 123-130.

Farooq, M., Wahid, A., Kobayashi, N., Fujita, D. and Basra, S.M.A. 2009. Plant drought stress: effects, mechanisms and management. *Agronomy for Sustainable Development*, 29: 185-212.

Horvath, E., Szalai, G. and Janda, T. 2007. Induction of abiotic stress tolerance by salicylic acid signaling. *Journal of Plant Growth Regulation*, 26: 290-300.

Howard, L.R., Talcott, S.T., Brenes, C.S. and Villalon, B. 2000. Changes in phytochemical and antioxidant activity of selected pepper cultivars (*Capsicum spp*.) as influenced by maturity. *Journal of Agricultural and Food Chemistry*, 48: 1713-1720.

Jafar, M.S., Nourmohammadi, G. and Meleki, A. 2004. Effect of water deficit on seedling, plantlets and compatible solutes of forage sorghum cv. Speed field. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia.

Jarrett, R.L., Baldwin, E., Perkins, B., Bushway, R. and Guthrie, K. 2007. Diversity of fruit quality characteristics in *Capsicum frutescens*. *Horticultural Science*, 42: 16-19.

Kang, H.M. and Saltveit, M.E. 2002. Chilling tolerance of maize, cucumber and rice seedling leaves and roots are differentially affected by salicylic acid. *Plant Physiology*, 115: 571-576.

Maria, S., Zapata, P.J., Castillo, S., Guillen, F. and Martinez, R.D. 2010. Antioxidant and nutritive constituents during sweet pepper development and ripening are enhanced by nitrophenolate treatments. *Food Chemistry*, 118: 4970-503.

Moscone, E.A., Scaldaferro, M.A., Grabiele, M., Cecchini, N.M., Garcia, Y.S., Jarret, R., Davina, J.R., Ducasse, D.A., Barboza, G.E. and Ehrendorfer, F. 2007. The evolution of the chili pepper (*Capsicum - Solanaceae*): a cytogenetic perspective. *Acta Horticulturae*, 745: 137-169.

Magda, A.F., Shalaby, M.A., Ahmed, M.S.A., Abdallah, E. and El-Housini, A. 2013. Physiological role of salicylic acid in improving growth and productivity of barley (*Hordeum vulgare* L.) under sandy soil conditions. *Middle East Journal of Agriculture Research*, 2: 68-75.

Russo, V.M. 2003. Planting date and plant density affect yield of pungent and non-pungent Jalapeno peppers. *Horticultural Science*, 38: 520-523.

Saeed, H.M., Anjum, M.A. and Mirza, J.I. 2016. Glycinebetaine induced modulations in biochemical and gas exchange characteristics of okra under saline regimes. *Pakistan Journal of Botany*, 46: 2205-2210.

Sanaa, A.M., Ibrahim, S.I. and Eldeen, H.A. 2001. The effect of naphthalene acetic acid (NAA), salicylic acid on growth, fruit setting, yield and some correlated components in dry bean. *Annals of Agricultural Sciences*, 46: 451 463.

Shafeek, M.R., Helmy, Y.I. Ahmed, A.A. and Magda, A.F. 2014. Productivity of Snap Bean plants by spraying of some antioxidant's materials under sandy soil conditions in plastic house. *Middle East Journal of Agriculture Research*, 3: 100-105.

Shokr, M.M.B., Elsaid, M., Elsaid, E. and Shafeek, M.R. 2014. Effect of some stimulative substances as foliar applications on snap bean (*Phaseolus vulgaris* L.) productivity under milder thermo-stress of local summer season. *Middle East Journal of Applied Sciences,* 4: 175-180.

Simonne, A.H., Simonne, E.H., Eitenmiller, R.R., Mills, H.A. and Green, N.R. 2007. Ascorbic acid and provitamin A contents in unusually colored bell peppers (*Capsicum annuum* L.). *Journal of Food Composition and Analysis*, 10: 299-311.

Tarchoun, N., Bodson M. and Mougou, A. 2003. Effects of low night temperature on flowering, fruit set and parthenocarpic ability of hot and sweet pepper varieties, (*Capsicum annuum* L.). *Journal of the Korean Society for Horticultural Science*, 44: 271-276.

Udoh, D.J., Ndon, B.A., Asuquo, P.E. and Ndaeyo, N.U. 2005. Crop Production Techniques for the Tropics. Concept Publications (Press Division), Lagos, Nigeria, pp. 464.

Yuan, S. and Lin, H.H. 2008. Role of salicylic acid in plant abiotic stress. *Zeitschrift für Naturforschung*, 63c: 313-320.

Zaghlool, A.M., Mostafa, M.A. and Shehata, S.A.M. 2006. Physiological studies on the effect of kinetin and salicylic acid on growth and yield of wheat plant. *Annals of Agricultural Science*, 51: 41-55.

Zhigila, D.A., AbdulRahaman, A.A, Kolawole, O.S. and Oladele, F.A. 2014. Fruit morphology as taxonomic features in five varieties of *Capsicum annuum* L. Solanaceae. *Journal of Botany*, 2014 (Article ID 540868): 1-6.

Ziaf, K., Amjad, M., Pervez, M.A., Iqbal, Q., Rajwana, I.A. and Ayyub, M. 2009. Evaluation of different growth and physiological traits as indices of salt tolerance in hot pepper (*Capsicum annuum* L.). *Pakistan Journal of Botany*, 41: 1797-1809.