The Pharma Innovation Journal 2021; 10(10): 701-705

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 701-705

www.thepharmajournal.com
Received: 18-08-2021
Accepted: 30-09-2021

Pallavi Soni
M.Sc. Scholar, Department of Horticulture, Vegetable Science, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Dr. Reena Nair
Assistant Professor, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Dr. Surabhi Jain
Scientist (Statistic), PC unit, AICRP on Sesame and Niger, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Dr. RK Sahu
Assistant Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Pallavi Soni
M.Sc. Scholar, Department of Horticulture, Vegetable Science, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Salicylic acid induced drought tolerance and yield stability under water deficit stress condition in pea (*Pisum sativum* L. var. Kashi Nandni)

Pallavi Soni, Dr. Reena Nair, Dr. Surabhi Jain and Dr. RK Sahu

Abstract
Pea (*Pisum sativum* L.) is an important legume crop and consumed all over the world, especially in the developing country because it is a good source of protein. Salicylic acid (SA) is a naturally existing phenolic compound that regulates a large variety of physiological and biochemical processes in plants. This experiment was, therefore, conducted to determine the effects of exogenous application of SA on the yield and its attributes of pea under two different water stress condition, during 2019-20 at Vegetable Research Centre, Department of Horticulture, JNKVV, Jabalpur (M.P.).
The experiment was performed in a split plot design and replicated thrice. Water stress condition i.e. irrigated and water deficit stress conditions were assigned to main plots and five doses of SA (0, 0.25, 0.50, 0.75 and 1 mM) were allocated to sub plots. Water stress reduced number of pods plant^{-1}, seed weight (g), pod length (cm), pod width (cm), pod yield plant^{-1} (g), and pod yield hectare^{-1} (q ha^{-1}) of pea. Results signifies that the exogenous application of SA (especially 0.5 mM) improved all measured traits under both irrigated and water deficit stress conditions except in number of seeds per pod. SA plays a vital role in mitigating drought stress. Recent studies have demonstrated the major role of SA in modulating plant responses to abiotic stresses such as water stress on yield and its component. Hence, SA could be used as a potential growth regulator, for improving pea yield and drought tolerance under water deficit stress conditions.

Keywords: Salicylic acid, pea, yield attributes, water deficit stress, irrigated

Introduction
Pea (*Pisum sativum* L.) belongs to family Fabaceae and is a popular legume vegetable crop for local consumption as well as export across the world. This plant is diploid in nature (2n=14) (Hancock, 2004) [8]. Pea is essential source of protein in human diets. The crop gives higher yield and ensures maximum profits in market, especially when cultivated for tender green pods. As a result, it takes prominent place among other legumes. Garden pea is harvested before the seed is mature for the fresh market (Pavek, 2012) [19]. Total pea production in India was 5,415.52 t, of which Uttar Pradesh shares (46.37%) followed by Madhya Pradesh (17.76%), Punjab (7.28%) and Jharkhand (6.41%), (National Horticulture Board, 2017-18). Pea grows tremendously on fertile, lightly textured, well drained soils (Hartmann *et al*., 1988; Elzebroek and Wind, 2008) [9, 7]. Peas are highly susceptible to salinity and acidity in the soil. For better growth of pea a pH range of 5.5 to 7.0 is optimal (Hartmann *et al*., 1988) [9]. It's can be also used as various purpose like rotational crop and forage crops.
Water stress is one of the most usual environmental stresses that affects growth and development of plants (Sadras and Milroy, 1996; Bray, 1997) [22, 4]. Drought is a persistent limitation to agricultural production system in several developing countries and it's a cause of losses of agricultural production and productivity in developed ones (Ceccarelli and Grando, 1996) [5]. Drought stress is a severe issue which can be arise by reduction of water content or leaf water potential, low turgor pressure, closure of stomata, and decrease in cell enlargement and growth. Water stress mostly retard cell enlargement more than cell division (Morgan, 1994) [17]. It inhibits plant growth and yield by affecting various physiological processes such as photosynthesis, respiration, translocation, ion uptake, nutrient metabolisms, biosynthesis of proteins, carbohydrates and growth promoters (Bray, 1997) [4]. However, water stress always pumps up the production of compatible solutes like proline content in pea and it's an effective aid against drought tolerance (Alexieva *et al.*, 2001) [2]. Under severe water stress condition, cell elongation may reduce due to breakdown of water surge from the xylem to the surrounding extending cells (Nonami, 1998) [18].

Salicylic acid (SA) is a phenolic endogenous growth regulator that also acts as a signalling molecule in plants, governing physiological processes including plant growth, photosynthesis, and other metabolic processes (Popova *et al*., 1997; Hayat *et al*., 2010) [20, 12]. The exogenous application of SA helps for enhancement in resistance against different biotic and abiotic stress. There are several effective ways for exogenous application of SA either foliar spray or seed soaking method but it's entirely depends over plant species. The low concentration of SA shows fruitful effects in abiotic stress tolerance of plants while, the high concentration shows harmful effects (Hasanuzzaman *et al*., 2017) [10]. Thus, to have the best effect on various plant species, both the concentration and application method of SA are crucial. However, the efficacy of SA in stress tolerance depends on the type of species and experimental condition like the concentration of the SA applied the type of stress and the intensity and duration of stress (Hasanuzzaman *et al*., 2017) [10]. Therefore, the aim of this present work was to study the Effect of different doses of Salicylic acid on the yield and its attributes on pea plant under water deficit stress as well as irrigated condition.

Materials and Methods

Plant Material

Seeds of *Pisum sativum* L. var. Kashi Nandni were collected from Office of Director Farms, Collage of Agriculture, JNKVV, Jabalpur. Seeds were treated with *Trichoderma* and were sown at a spacing of 30 × 10 cm and 2.5 cm depth during 1st week of November 2019-20. At the same time plots were fertilized with recommended doses of NPK.

Experimental condition

This experiment was conducted during the year of 2019-20 at Vegetable Research Centre, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The soil of the experimental field was medium black with good drainage, uniform texture and medium NPK status. With three replications, the experiment was set up in a split plot design. Each replication has two main plots and a wide distance has been maintained between main plots. Water stress condition *i.e.* water deficit stress condition and irrigated condition was allotted in main plot and five doses of SA (0.00 mM, 0.25 mM, 0.50 mM, 0.75 mM and 1.00 mM) was allotted as subplot. Water deficit stress and irrigated (no water stress) condition defines the level of water stress.

SA Application

SA was initially dissolved in absolute ethanol and then added drop wise to the water (ethanol/water, 1/1000, v/v) (Stevens *et al*., 2006) [25]. Exogenous application of SA was scheduled at 10 days before flowering and 10 days after flowering.

Irrigation treatments

Experimental field were irrigated immediately just after the sowing, and subsequent irrigations were given to the irrigated plots. In the case of irrigated condition frequent irrigation has given within 10 days interval. However, in water deficit stress condition only one irrigation immediately after sowing was given, thereafter no subsequent irrigation was provided. Flowering and pod formation periods are the critical stages in pea and in main plot of water deficit stress condition during this critical period stress was measured with the help of tensiometer. Water stress during flowering and subsequent pod-filling stage severely limits yield.

Sampling Method

Five plants from each plot were assigned for sampling. Numbers of pods were removed from tagged five plants in each plot at picking and then counting of these collected pods was made for each plot. Total number of seeds was counted from ten randomly selected pods from each plot, at peak fruiting stage. The length of pod was measured in cm from joint to calyx to the apex for ten randomly selected pods from each plot. The width of pod was measured with the help of Vernier calliper in cm. The weight of ten pods was recorded separately after sun drying with the help of weighing balance. The yield of pod of the tagged plants was recorded at each picking and the average yield of the pods per plant was calculated in gram. Total yield of pods (g) per plant were converted into quintal per hectare.

Statically Analysis

Least Significant Difference (LSD) test at 5% level of probability was applied to compare the means of the levels of the statistically significant factors and their interactions. Statistical analysis was performed using OPSTAT statistical software; $p< 0.05$ and $p< 0.01$ were considered statistically significant and highly significant, respectively.

Results

Analysis of variance indicated that the number of pods plant^{-1}, pod weight (g), pod length (cm), pod width (cm), pod yield plant^{-1} (g) and pod yield hectare^{-1} (q ha^{-1}) were significantly influenced by exogenous application of SA as depicted in (Table 1). The yield response is presented in (Table 2) for both water deficit stress and irrigated condition of pea. Water stress condition significantly decreased number of pods plant^{-1}, pod weight (g), pod length (cm), pod width (cm), pod yield plant^{-1} (g) and pod yield hectare^{-1} (q ha^{-1}) as compared to irrigated condition (Table 2). Studies have revealed that water deficit stress is the major limiting abiotic factor in crop production. It reduces the growth and development of plants by affecting various physiological and biochemical processes (Fig 1). Plants treated with SA (0.25mM, 0.50mM, 0.75mM and 1.00mM) shows the significant increase in all the characteristics except number of seed pods^{-1} (Table 1). Nevertheless, application of SA at 0.5 mM enhance all the characteristics in water deficit stress condition as well as irrigated condition, as depicted in (Table 2). Best result was obtained with the treatment 0.50 mM SA followed by 0.75 mM and it was significantly superior over other treatments in irrigated as well as water deficit stress condition (Fig 1 & 2).
Interactions were found significant in few characteristics like seed weight, pod yield plant^{-1} and pod yield hectare^{-1}. While 1.00 mM contributed for slightly decline in pod yield and its attributes which is clear from (Fig 1 & 2). Significant difference in pod yield components was recorded due to different concentration of salicylic acid. Foliar application of SA was more significant in irrigated condition as compared to water deficit stress condition (Fig 1 & 2).

Discussion

The useful effect of SA improves the relative water content and efficiency of photosynthesis as well as increases the growth and yield production (Sadeghipour and Aghaei, 2012) [21]. The findings of this investigation have also been supported with the findings of other research workers on

legume and non-leguminous crops. The plant showed a higher performance at the irrigated treatment (no drought stress). It has been reported that plants exposed in water stress exhibited a significant decline in photosynthetic parameters, membrane stability index, leaf water potential, nitrate reductase activity, carbonic anhydrase activity, chlorophyll content and relative water content (Hayat *et al*., 2008) [11]. Similar results were reported by Hegazi and El-Shraiy (2007) [13] where, exogenous application of SA resulted in an increase of yield components (pod number and pod weight). However, there was significant difference among different concentration of salicylic acid. El-Shraiy and Hegazi (2009) [6] observed significant increase in pod parameters (pod length and no. of pods plant^{-1}) by acetyl salicylic acid in pea at harvest comparing with control. Abdelaal (2015) [1] reported that drought stress significantly decreased number of pods plant^{-1}, number of seeds pod^{-1} and seed yield plant^{-1}, whereas application of SA at 1.00 mM increased these parameters in faba bean under drought. So, it was stated clearly that salicylic acid plays a significant role in mitigating the effect of water deficit stress. Thomson *et al*. (2017) [26] studied the application of SA significantly affected seed yield and plant biomass in pea. Similar results were confirmed by (Khademian and Yaghoubian, 2018; Hesami *et al*., 2012) [15, 14]. Khan *et al*. (2010) [16] found that the application of a higher dose of SA had either proved inhibitory or no additional benefit in mungbean plants.

SA is known as natural endogenous signalling molecule that plays a key role in governing and mediating the responses of plants in diverse environmental stresses such as drought (Hayat *et al*., 2010) [12]. The reason of decreasing in yield may be due to drought during the vegetative stage and reproductive development or across terminal stress at the end of the crop life (Serraj *et al.*, 2004) [24]. It is obvious from the data recorded that all the above mentioned traits were significantly decreased with decreasing level of irrigation or in water deficit stress condition. Salicylic acid application is an effective treatment to get rid of water deficit stress condition. These results coincide with those reported by Senaratna *et al*. (2000) [23] who suggested SA induced multiple stress tolerance in bean and tomato plants. Baninasab (2010) [3] also proved that salicylic acid is a common, plant-produced signalling molecule that is responsible for inducing tolerance in a number of biotic and abiotic stresses. SA is able to mitigate the effect of stresses on plants and increase crop productivity through morphological, physiological and biochemical mechanisms. The deleterious effect of drought on number of pods may be due to the reduction of relative water content, total chlorophyll content, and efficiency of photosynthesis, translocation and ion uptake which were decreased under water stress.

Table 1: Analysis of variance for the influences of exogenous application of salicylic acid on pod yield and its components of pea under water deficit stress and irrigated condition

	Mean sum of square							
Source of Variation	**df**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pod weight (g)**	**Pod length (cm)**	**Pod width (cm)**	**Pod yield plant^{-1} (g)**	**Pod yield (q/ha^{-1})**
Replication	2	3.03	2.31	0.035	0.437	0.0185	1.395	0.964
Water stress condition (W)	1	11.99*	5.62	5.95**	0.83	0.01	506.16**	1,558.55**
Error (W)	2	0.35	4.04	0.03	0.59	0.04	1.74	3.44
Level of salicylic acid (S)	4	17.31**	4.28	4.30**	5.31**	0.37**	161.70**	122.25**
Interaction (W× S)	4	0.40	3.59	0.53**	0.10	0.002	9.82*	12.64**
Error (S)	16	0.67	4.73	0.01	0.25	0.01	2.78	0.97

* and **: significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 2: Means of pod yield and its components of pea as influenced by salicylic acid in water deficit stress and irrigated condition

	No of pods plant^{-1}		**No. of seed plant^{-1}**		**Pod weight**		**Pod length**		**Pod width**		**Pod yield plant^{-1}**		**Pod yield hectare^{-1}**	
SA concentration	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**	**Water deficit stress**	**Irrigated**
0.00 mM	9.26^{c}	10.06^{c}	4.34	4.85	4.92^{b}	5.32^{c}	5.91^{c}	6.27^{c}	1.16^{b}	1.18^{c}	59.66^{c}	67.99^{c}	47.39^{c}	57.26^{d}
0.25 mM	10.94^{b}	12.07^{bc}	5.11	5.03	5.29^{b}	6.15^{c}	7.06^{b}	7.05^{bc}	1.37^{b}	1.39^{bc}	64.12^{b}	75.66^{b}	50.75^{b}	65.52^{c}
0.50 mM	13.76^{a}	14.91^{a}	5.47	5.81	6.56 ^{a}	8.12 ^{a}	8.28 ^{a}	8.91 ^{a}	1.74 ^{a}	1.85 ^{a}	72.83 ^{a}	82.54 ^{a}	56.49 ^{a}	72.33 ^{a}
0.75 mM	11.51^{b}	13.67^{ab}	5.05	8.65	5.67^{b}	7.08^{b}	7.56^{b}	8.08^{ab}	1.42^{b}	1.44^{b}	69.66^{a}	76.00^{b}	51.69^{b}	69.37^{b}
1.00 mM	11.65^{b}	12.73^{b}	5.4	5.32	5.58^{c}	5.8^{c}	7.66^{b}	7.83^{ab}	1.19^{b}	1.2^{c}	65.5^{b}	70.66^{c}	49.47^{bc}	63.39^{c}

Different letters in each column indicate significant difference at $p \leq 0.05$. Any two means not sharing a common letter differ significantly from each other at 5% probability.

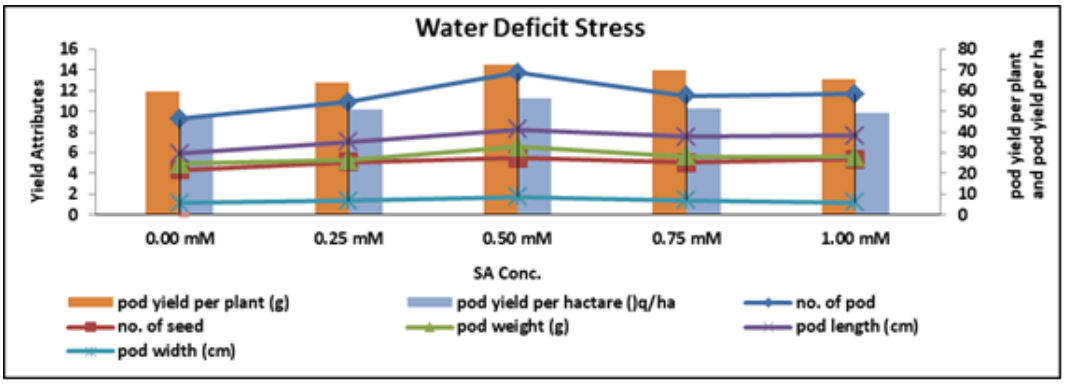

Fig 1: Mean values of pod yield and its attributes of pea under water deficit stress condition

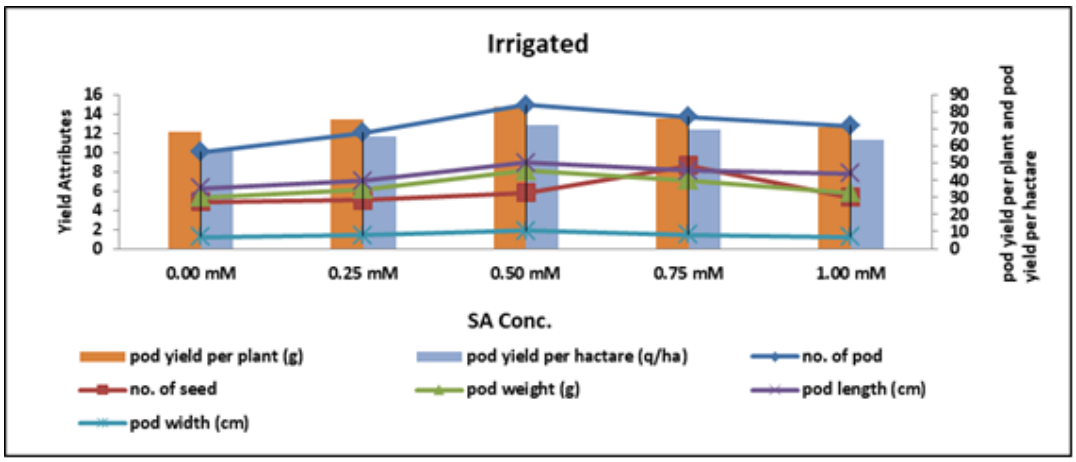

Fig 2: Mean values of pod yield and its attributes of pea under irrigated condition

Conclusion

It could be concluded from the present study that water deficit stress is the major factor which reduces yield and yield attributes in pea. Exogenously application of SA is an effective method for avoiding deleterious effect of water deficit stress or ameliorates drought stress. SA application improved all measured traits not only under irrigated but also under water deficit stressed plants. The effect of 0.5 mM SA was more pronounced and effective as compared to other treatments. Hence, it is suggested that application of SA may help to get rid of the adverse effects of water deficit in pea as well as important tool for mitigating drought stress.

Acknowledgments

The first author acknowledges the financial grant from Department of Horticulture, Collage of Agriculture, JNKVV, Jabalpur, (M.P.) India.

References

1. Abdelaal KH AA. Effect of salicylic acid and abscisic acid on morpho-physiological and anatomical characters of faba bean plants (*Vicia faba* L.) under drought stress. Journal of Plant Production 2015;6(11):1771-1788.
2. Alexieva V, Sergiev I, Mapelli S, Karanov E. The effect of drought and ultraviolet radiation on growth and stress markers in pea and wheat. Plant Cell and Environment 2001;24:1337-1344.
3. Baninasab B. Induction of drought tolerance by salicylic acid in seedlings of cucumber (*Cucumis sativus* L.). Journal of Horticultural Science and Technology 2010;85(3):191-196.
4. Bray EA. Plant responses to water deficit. Trends Plant Science 1997;2:48-54.
5. Ceccarelli S, Grando S. Drought as a challenge for the plant breeder. Plant Growth Regulation 1996;20:149-155.
6. El-Shraiy AM, Hegazi AM. Effect of acetyl salicylic acid, indole-3-buytric acid and gibberellic acid on plant growth and yield of pea (*Pisum sativum* L.). Australian Journal of Basic and Applied Science 2009;3(4):3514-3523.
7. Elzebroek T, Wind K. Guide to cultivated plants, CAB International, Oxfordshire, UK 2008.
8. Hancock JF. Plant evolution and the origin of crop species. 3rd edition, CABI Publishing, Wallingford UK and Cambridge MA 2004.
9. Hartmann HT, Kofranek AM, Rubatzky VE, Flocker WJ. Plant science: Growth, development and utilization of cultivated plants. 2nd edition, Prentice Hall Career and Technology, Englewood Cliffs, NJ 1988.
10. Hasanuzzaman M, Nahar K, Bhuiyan TF, Anee TI, Inafuku M, Oku H, Fujita M. Salicylic Acid: an all-rounder in regulating abiotic stress responses in plants 2017. Available at: http://dx.doi.org/10.5772/intechopen.68213 (Accessed: 23 March 2020)
11. Hayat S, Hasan SA, Fariduddin Q, Ahmad A. Growth of tomato (*Lycopersicum esculentum*) in response to salicylic acid under water stress. Journal of Plant Interactions 2008;3(4):297-304.
12. Hayat Q, Hayat S, Irfan M, Ahmad A. Effect of exogenous salicylic acid under changing environment. Environmental and Experimental Botany 2010;68:14-25.
13. Hegazi AM, El-Shraiy AM. Impact of salicylic acid and paclobutrazol exogenous application on the growth, yield

and nodule formation of common bean. Australian Journal of Basic and Applied Science 2007;1(4):834-840.
14. Hesami S, Nabizadeh E, Rahimi A, Rokhzadi A. Effects of salicylic acid levels and irrigation intervals on growth and yield of coriander (*Coriandrum sativum*) in field conditions. Environmental and Experimental Biology 2012;10:113-116.
15. Khademian R, Yaghoubian I. Growth of chick pea (*Cicer arietinum*) in response to salicylic acid under drought stress. Journal of Biodiversity and Environmental Sciences 2018;12:255-263.
16. Khan NA, Syeed S, Masood A, Nazar R, Iqbal N. Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effects of salinity stress. International Journal of Plant Biology 2010;1:1-8.
17. Morgan JM. Osmoregulation and water stress in higher-plants. Annual Review of Plant Physiology 1984;35:299-319.
18. Nonami H. Plant water relations and control of cell elongation at low water potentials. Journal of Plant Research 1998;111:373-382.
19. Pavek PLS. Plant guide for pea (*Pisum sativum* L.). USDA-Natural Resources Conservation Service, Pullman, WA 2012.
20. Popova L, Pancheva T, Uzunova A. Salicylic acid: properties, biosynthesis and physiological role. Bulgarian Journal of Plant Physiology 1997;23(1-2):85-93.
21. Sadeghipour O, Aghaei P. Response of common bean (*Phaseolus vulgaris* L.) to exogenous application of salicylic acid (SA) under water stress conditions. Advances in Environmental Biology 2012;6(3):1160-1168.
22. Sadras VO, Milroy PS. Soil-water thresholds for the responses of leaf expansion and gas exchange: a review. Field Crops Research 1996;47:253-266.
23. Senaratna T, Touchell D, Bunn E, Dixon K. Acetyl salicylic acid (aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Plant Growth Regulation 2000;30:157-161.
24. Serraj R, Krishnamurthy L, Kashiwagi J, Kumar J, Chandra S, Crouch JH. Variation in root traits of chickpea (*Cicer arietinum* L.) grown under terminal drought. Field Crops Research 2004;88:115-127.
25. Stevens J, Senaratna T, Sivasithamparam K. Salicylic acid induces salinity tolerance in tomato (*Lycopersicon esculentum* cv. Roma): associated changes in gas exchange, water relations and membrane stabilisation. Plant Growth Regulation 2006;49:77-83.
26. Thomson T, Patel GS, Thakar JB, Pandya KS. Effect of foliar application of acetyl salicylic acid and ascorbic acid on protein content, yield and economics of garden pea (*Pisum sativum* L. cv. Bonneville). International Journal of Current Microbiology and Applied Science 2017;6:1987-1990.
27. Vavilov NI. The origin, variation, immunity and breeding of cultivated plants. *Chronica Botonica* 1949;13:1-54.