International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-1; Jan-Feb, 2024
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Influence of Foliar Application of Salicylic Acid on Growth and Yield of Chia (*Salvia hispanica*)

Jashkaran Singh, L. P. Yadava and Raj Nandini Singh

Department of Horticulture, C. B. G. Agriculture PG College, BKT, Lucknow, India

Received: 09 Dec 2023; Received in revised form: 15 Jan 2024; Accepted: 25 Jan 2024; Available online: 05 Feb 2024

***Abstract*— *Chia has become enormous recognition as a super food worldwide, as reflected by a sharp rise in both consumption and cultivation. Salicylic acid (SA), a vital signaling molecule, is essential for plant tolerance responses to biotic and abiotic stress preserving healthy plant growth and enhancing productivity in stress condition. A field investigation of carried out during Rabi season of 2021 and 2022 at experimental field of Horticulture Department, C. B. G. Agriculture PG College, BKT, Lucknow to examine the "Influence of foliar application of salicylic acid on growth and yield of chia (Salvia hispanica L.)". The treatment consisted of five dose of foliar application of salicylic acid (0, 75, 150, 300 and 600 ppm). The experiment was laid out in a design of Randomized Block Design (RBD) and replicated three times. The foliar application of SA resulted in greater plant height, number of branches, fresh weight and dry weight of plant, yield and yield component of chia during the study. Generally the greatest values were registered from 300 ppm foliar application of salicylic acid.*

Keywords*— *Chia, Salvia hispanica, Salicylic Acid, Growth, Yield

I. INTRODUCTION

Chia (*Salvia hispanica* L.), native to southern Mexico and Northern Guatemala (Silva *et al.*, 2016, Artocos, 2018), is an annual herbaceous short day plant belonging to the family Lamiaceae. It grows naturally in tropical and subtropical environments from 400 to 2500 m above mean sea level. Chia seeds were traditionally one of the four basic elements in the diet and also a source of energy in Aztec civilization of Central America and Southern civilization in the pre-Columbian era (Ali *et al.* 2012; Cortes *et al.*, 2017). Chia grows up to 1 m tall with opposite arranged leaves with small flowers (3–4 mm) purple or white in a spike at the end of stem, with small corollas and fused flower parts that contribute to a high self-pollination rate. The seed colour varies from black - grey with black spotted, oval in shape and seeds are found in size ranging from 1 to 2 mm (Yeboah *et al.*, 2014).

Chia seeds are composed of multiple nutritionally important polyunsaturated fatty acids (PUSFA) comprising approximately 25 to 40% oil content, of which 60% and 20% is w-3 alpha linolenic and w-6 alpha linolenic acids, respectively (Ali *et al.*, 2012). Due to the vast health and medicinal properties of Chia seeds, it has been shown to lower the triglycerides (TG) and cholesterol levels, which in turn lowers the risk of cardiovascular related diseases and lowers blood pressure (Ali *et al.*, 2012).

Chia is currently commercially cultivated in Australia Bolivia, Columbia, Guatemala, Mexico, Peru, Ecuador and Argentina (Jamboonsri *et al.*, 2012). Mexico is the largest producing centre ofchia and currently exports seeds to Japan, USA and Europe (Baginsky *et al.*, 2016). The promotion of the consumption and cultivation of chia could be of value due toits unique nutrient composition and its inherited tolerance to drought andother stress factors. It has been deemed to be drought tolerant, although there is lack of research on the physiological and molecular responses of this crop to drought stress. Salicylic acid is perhaps the only compound on the surface of the earthto mediate so diverse function as ranging from curing various human ailmentsto protect the plant various biotic and abiotic stresses and affecting various physiological and biological processes of plants (Popova *et* *al.*, 2012). There is a need to establish a suitable crop that can be deemed to be drought tolerant and is able to withstand such environments outside of the scope of cereals, but also pseudo cereals.

II. MATERIALS AND METHODS

An experiment entitled "Influence of foliar application of salicylic acid on growth and yield of chia (*Salvia hispanica*)" was conducted during the Rabi season of 2021 and 2022 at Horticulture Research Farm, Department of Horticulture, C.B.G. Agriculture PG College, Bakshi Ka Talab, Lucknow, situated at 26°84 N latitude and 80°94 E longitude with an average altitude of 123 meter above mean sea level. The experiment was laid out in randomized block design consisting five levels of Salicylic Acid (control, 75ppm, 150 ppm, 300 ppm and 600ppm) with three replications. The observation on growth parameters *viz.* plant height (cm), number of branches per plant, herb fresh weight (g) and herb dry weight (g) were recorded at 30, 60 and 90 days after sowing. The data on seed weight (g/plant), 100-seed weight (g) and seed yield (kg ha^{-1}) were noted at harvest.

III. RESULTS AND DISCUSSION

1. Vegetative growth characters

1.1 Plant height (cm)

The plant height was increased significantly up to SA 300 ppm at all stages, however, reduced non-significantly with SA 600 ppm. Crop received SA 300 ppm recorded significantly maximum plant height (21.11 cm) at 30 DAS (50.11 cm) at 60 DAS and (81.11cm) at 90 DAS as compared to rest of the treatment. While, minimum plant height (55.03 cm) was noted in plants sprayed with tape water (T_1). Salicylic acid plays key roles in regulation of various physiological and developmental processes of plants. It is a phenolic compound that enables plants to survive under challenging soil and environmental situations (Iqbal *et al.*, 2012). Different concentration of Salicylic acid increases regulation of nutrition and hormone in plants (Shafiee *et al.*, 2010). The growth stimulated by salicylic acid can be associated by mineral nutrition, hormonal profile and photosynthesis. The positive effect on growth of salicylic acid to its positive effect on hormonal balance disturbed by metallic stress have been linked by several authors (Shakirova *et al.*, 2003), they treated wheat with SA and recorded increased ABA content, which regulate to stomata movements (Wilkinson and Davies, 2010) and genes and antioxidant enzymes activity (Bari and Jones, 2009). Shakirova *et al.* (2013) found that salicylic acid influence the endogenous ABA, hormonal intermediary to trigger defense reactions in plants.

The increase in plant height due to salicylic acid is recognized to regulate cell enlargement and cell division during root and shoot development (Shakirova *et al.*, 2003) and also increase the number of internodes (Jaiwal and Bhambie, 1989). According to Martin-Mex *et al.* (2005), SA cause an increase in plant growth with increasing cell division in both stem and root, hence increasing plant height (23%) under greenhouse and field condition. Similar results due to application of salicylic acid were also obtained by Kaur *et al.* (2007) in chickpea, Yildirim *et al.* (2008) in cucumber, Anwar *et al.* (2014) in tuberose, (Kamkari *et al.*, 2016) in onion and (Basit *et al.*, 2018) in marigold. Furthermore, foliar application of lower concentration of SA treatment improved the plant height of *Salvia hispanica* (Fouad *et al.*, 2018).

1.2 Number of branches per plant

The data indicated that different levels of salicylic acid had significantly affected the number of branches during crop growth stages. The highest number of primary branches (9.57) per plant was obtained with SA @ 300ppm, while the lowest (7.79) recorded with control (Table 1). The increase in number of branches per plant may be due to the involvement in enhancing some physiological and biochemical processes of plants such as cell elongation, cell division, cell differentiation, enzymatic activities, protein synthesis and photosynthetic activity (Raskin, 1992). The results are in agreement with Ebtsam *et al.* (2006) in tuberose, Hassanain *et al.* (2006) in chamomile, Jat *et al.* (2007) in African marigold, El-shraiy and Hegazi (2009) in pea, Mohammadzadeh *et al.*(2013) in basil and Al-Rawi *et al.* (2014) in cotton. On the contrary, Fouad *et al.* (2018) found that foliar application of SA treatment did not influence the number of branches in Chia.

1.3-Herb Fresh and dry Weight (g/plant)

All the levels of salicylic acid produced more fresh weight as compared to control (Table 1). The data explicit that maximum herb fresh weight (29.90 g) was observed in treatment of 300 ppm salicylic acid (T_4), followed by T_3 (28.64 g) and T_5 (28.20 g). While, minimum Herb fresh weight (27.50 g) was listed in plants sprayed with tape water (T_1). The herb fresh weight produced per plant appeared to be positively correlated with height and number of primary branches per plant, as the plants in various treatments having more height and number of branches also had more herb fresh weight. These results are in close conformity with the results of (Fouad *et al.*, 2018) in chia. Similar findings were also reported by Anuprita *et al.* (2005) in gerbera, Jat *et al.*

(2007) in African marigold, Singh *et al.* (2012) in gladiolus and Anwar *et al.* (2014) in tuberose. Najafian (2009) reported that spraying salicylic acid at three levels (150, 300, and 450 mMol) on *Thymus vulgaris* L. had a significant effect on the fresh and dry weight of Thyme plant. Spraying at a concentration of 150 mM showed an increase in the dry weight of the plant and foliar application of 300 ppm salicylic acid was found to be superior in promoting herb dry weights (g) plant^{-1} comparing to rest of the treatments which gained (14.34g) dry weight plant^{-1}.

Application of exogenous SA also influenced significant variation in dry weight of the plant. An application of SA significantly increased the dry weight of plant may be due to improved photosynthetic efficiency in plants (Hayat *et al.*, 2007), stabilization of chlorophyll and assimilates translocation from source to sink, which ultimately enhanced dry weight of chia plant (Fouad *et al.*, 2018). Furthermore, salicylic acid acts as defense hormone that could reduce the abiotic stress in leaves which ultimately leads to increase amount of dry matter contents production in marigold flowers (Champa *et al.*, 2015). The positive effects of salicylic acid on fresh and dry weight are corroborated with the results as reported by Gharib (2006) in basil and marjoram, Khandaker *et al.*, (2011) in red amaranth, Abdou and Mohamed (2014) in mint, Miri *et al.* (2015) in thyme, Fouad *et al.* (2018) in Chia.

Table 1. Influence of salicylic acid on plant height (cm), number of branches per plant, herb fresh weight and herb dry weight (g plant^{-1})

Treatments		Plant Height (cm)			Number of branches per plant			Herb fresh weight (g/plant)			Herb dry weights (g/plant)		
		30 DAS	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T_1	SA 0 ppm (Control)	14.84	34.81	2.37	4.13	7.79	7.79	20.48	21.64	27.50	7.57	7.70	11.78
T_2	SA 075 ppm	15.87	45.19	2.59	4.44	7.96	7.96	20.67	22.52	27.88	7.82	7.85	11.87
T_3	SA 150 ppm	17.39	47.39	2.75	4.90	8.30	8.30	20.84	23.50	28.64	7.87	8.50	12.59
T_4	SA 300 ppm	21.11	50.11	3.38	5.89	9.57	9.57	22.84	25.55	29.90	9.00	10.08	14.34
T_5	SA 600 ppm	19.02	49.06	2.45	4.20	7.90	7.90	21.64	24.00	28.20	8.90	8.62	12.63
SE(m)		0.59	0.44	0.59	0.10	0.19	0.25	0.40	0.43	0.35	0.16	0.33	0.29
C. D. at 5%		1.97	1.44	1.98	0.36	0.63	0.83	1.35	1.40	0.81	0.52	1.09	0.95

2. Yield and Yield Components

The different levels of salicylic acid significantly increased the seed weight per plant as compared to control (Table 2). The treatment of SA 300 ppm (T_4) showed significantly highest value of seed weight (4.36 g) and was closely followed by T_5 i.e. SA 600ppm. While the control treatment produced significantly lowest seed weight (3.24 g) as compared to the rest of treatment. The treatment of SA 300 ppm (T_4) was also registered significantly maximum 100-seed weight (4.75 mg) as compared to rest of the treatments.

In the present investigation, highest seed weight per plant and 100- seed weight attributed highest yield per hectare. The highest seed yield ha^{-1} (327.86 kg) was produced by foliar application of 300 ppm SA, while the lowest (285.6 kg/ plant) was with control (Table 2). The salicylic acid affected the physiological and biochemical processes that were led to ameliorate in vegetative growth (Dawood *et al.*, 2012), active assimilation and translocation of photosynthates from source to sink in plant (Hayat and Ahmed, 2007). Results are also in the line of Gharib (2006) in basil, Jat *et al.* (2007) in African marigold, Han *et al.* (2011) in soybean. Al-Rawi *et al.* (2014) concluded that cotton plant (*Gossypium hirsutum* L.) tested with three levels of salicylic acid (50, 100, and 150 mg/l) exhibited highest total cotton yield (3371.9

kg/ha) with150 mg/l SA in relation to other concentrations used.

Table 2. Effect of salicylic acid on seed weight (g/plant), 100 seed weight (g) / seed yield (kg/plant) at different stages of plant growth

Treatment		Seed weight (g/plant)	100-seed weight (g)	Seed yield (kg/ha)
T_1	SA 0 ppm (Control)	3.24	3.94	285.60
T_2	SA 075 ppm	3.56	3.95	291.60
T_3	SA 150 ppm	3.78	4.29	291.46
T_4	SA 300 ppm	4.36	4.75	327.86
T_5	SA 600 ppm	3.97	4.50	296.26
SE(m)		0.14	0.11	1.96
C. D. at 5%		0.47	0.38	6.48

In a study on the response of the Indian mustard (*Brassica juncea* L.) to spraying with two levels of salicylic acid (35 and 70 mg/l), there was a significant increase in all the parameters of the crop (the weight of onemustard, the total yield of the seed, and the seed yield), when spraying the plants @70 mg/l in comparison to @ 35 mg/l and spraying with distilled water only (Dugogi *et al.*, 2012). Abbas and Ibrahim (2014) worked out that the growth regulator SA was sprayed on *Niggella sativa* L. at different levels (50, 100, and 200 mg/l). Spraying of 50 mg/l salicylic acid was the best in increasing growth, yield and oil ratio indices. Al-Mohammadi and Al-Rawi (2016) were also observed that spraying with acetylsalicylic acid with 200 ppm registered the highest fruit numbers of per plant and the total yield kg ha^{-1} as compared to non-treated plants of *Datura sp.*

IV. CONCLUSION

Based on the above findings it can be concluded that the application of salicylic acid @ 300ppm was found to be significantly superior in respect of improving growth, flowering and fruit set, yield attributes and yield of Chia.

REFERENCES

[1] Abbas, J, and Ibrahim, B.A.(2014). Effect of salicylic acid in some vegetative and fruit traits of the black bean. Iraqi Journal of Agricultural Sciences, 45(8):845-853.

[2] Abdou M, Mohamed MAH. (2014). Effect of plant compost, salicylic and ascorbic acids on *Mentha piperita* L. plants. *Bio Agric Hort*., 30: 131- 143.

[3] Ali, N. M., Yeap, S.K., Ho, W.Y., Beh, B.K., Tan, S.W. and Tan, S.G.(2012). Review Article: The promising future of chia (*Salvia hispanica* L.). *J. Biom. Biotechnol.,* 1-9.

[4] Al-Mohammadi AN, Al-Rawi AR. (2016). Effect of planting date, growth promoters, type of organic manure on growth and yield, and active ingredient of *Datura stramonium* L. Tikrit. *Journal for Agricultural Sciences*, 16(2): 26-50.

[5] Al-Rawi ANT, Al-Ani MH, Al-Saad TM (2014). Response of cotton *Gossypium hirsutum* L. for different irrigation periods and salicylic acid. *Anbar Journal of Agricultural Sciences*, 12(2): 283.

[6] Anuprita, H., Jadhav, S. R., Dalal, R. D and Rajeshwari, P. (2005). Effect of micro-nutrients on growth and flower production of gerbera under poly house conditions Adv. Sci., 18(11): 755-758.

[7] Anwar, M., Sahito, H. A, Hassan, L, Abbasi, N. A. and Abro, H. A. (2014). Effect of preharvest treatment of salicylic acid on growth and vase life of tuberose with aroma environment. *J. Agric. Res*., 3(2): 50-57.

[8] Artcos, S. D. (2018). Collaborative collection management solution. Arctos Plants. Retrieved from http://arctos.database.museum/name/Salvia hispanica

[9] Baginsky, C., Arenas, J., Escobar, H., Garrido, M., Valero, N., Tello, D., Pizarro, L., Valenzuela, A., Morales, L. and Silva. H. (2016). "Growth and Yield of Chia (Salvia Hispanica L.) in the Mediterranean and Desert Climates of Chile." Chilean Journal of Agricultural Research 76: 255–64.

[10] Bari R. and Jones J. D. (2009). Role of plant hormones in plant defense responses. *Plant Mol. Biol*., 69: 473–88.

[11] Basit Abdul, Shah Kamran, Rahman M. U., Xing L., Zuo Xiya, Han Mingyu, Alam Noor, Khan Fayaz, Ahmed Imran and Khalid M. A. (2018). Salicylic acid an emerging growth and flower inducing hormone in marigold (*Tagetes sp*. L.). *Pure Appl. Biol.*, 7(4): 1301-1308.

[12] Champa WH, Gill M, Mahajan B & Arora N (2015). Preharvest salicylic acid treatments to improve quality and postharvest life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless. *J Food Sci Tech*., 52: 3607-3616.

[13] Cortes D., Silva H., Baginsky C., Morales L. (2017). Climatic zoning of chia(*Salvia hispanica* L.) in chile using a species distribution model. *Spanish J. Agric Res*., 15: 0302.

[14] Dawood, M.G., Sadak, M. and Hozayen, M. (2012). Physiological role of salicylic acid in improving performance, yield and some biochemical aspects of sunflower plant grown under newly reclaimed sandy soil. Australian Journal of Basic and Applied Sciences, 6: 82-89.

[15] Dugogi E. H., Mahdi N. K., Matroud S. A. K. (2012). Response of Indian mustard (Brassica juncea L.) to the distance of planting and spraying with salicylic acid and their effect on growth, seed yield and hard oil. In: Second Scientific Conference of the Faculty of Agriculture, University of Karbala. pp. 173-181.

[16] Ebtsam, M. M. Abdella, S. S. M. Ahmed, Z. H and El-Mageed, F. M. (2006). Physiological effect of K soil application and Zn foliar spray and their interaction on growth, flowering. bulbs and chemical composition of *Polianthes tuberosa* L. cv. Double *Annals Agric Sci*., 44(3): 1207- 1221.

[17] El-Shraiy, A. M. and Hegazi, A. M. (2009). Effect of Acetylsalicylic acid, IBA and GA, on plant growth and yield of pea (*Pisum sativum*). *Australian J. Basic Applied Sci*., 3: 3514-3523.

[18] Fouad R, Omer E. A., Kandeel A. M., Ibrahim A. K. and Hendawy S. F. (2018). Effect of some irrigation levels and foliar-spray application with some chemical substances on growth and yield of *Salvia hispanica*in Egypt. *Arab Univ. J. Agric. Sci.,* Ain Shams Univ., Cairo Special Issue, 26(2A): 971- 984

[19] Gharib, F. (2006). Effect of salicylic acid on the growth, metabolic activities and oil content of basil and marjoram. *Int. J. Agric. & Bio*., 9(2): 294- 301.

[20] Han, H. X. L., Uren, N. and Tang, C. (2011). Zinc fractions and availability to soyabeans in representative soils of Northeast China. *J. Sofie Sediments*, 11: 596-606.

[21] Hassanain, M. A., Ebtsam, M. M. and Rady, M. M. (2006). Response of growth, flowering, oil Yield and chemical composition of *Matricaria camomilla* L plants to some micro nutrients foliar application. *J. Agric. Sci.,* 5(2): 33-58.

[22] Hayat, S. and Ahmad, A. (2007). The role of salicylates in rhizobium legumes symbiosis and abiotic stresses in higher plants. Salicylic acid. *Plant Hormone Springer*, pp. 151-162.

[23] Iqbal D., Habib U., Abbasi N. A. & Chaudhry A. N. (2012). Improvement in postharvest attributes of zinnia (*Zinnia elegans* cv. benary"s giant) cut- flowers by the application of various growth regulators. *Pak. J. Bot.,* 44: 1091-1094.

[24] Jaiwal, P. K. K. and Bhambie, S. (1989). Effect of growth regulating substances on poding and yield of *Vigna radiata* L. *Acta Botani. Indica.,* 17: 54-80.

[25] Jamboonsri W., Phillips T., Geneve R., Cahill J. and Hildebrand D. (2012). Extending the range of an ancient crop, *Salvia hispanica* L.-a new 3 source. *Genet Resour Crop Evol.,* 59: 171–178.

[26] Jat, R. N., Khandelwal, S. K. and Gupta, K. N. (2007). Effect of foliar application of urea and Zinc sulphate on growth and flowering parameters in African marigold (*Tagetes erecta* Linn). *J. Orn Hort*., 10(4): 271-273.

[27] Kamkari B., Asgharzadeh A. & Azimzadeh M. (2016). Effects of salt stress and salicylic acid on vegetative and reproductive traits of pot marigold. *IIOABJ,* 7(S): 34-41.

[28] Kaur, G. Singh, P. Kaur, J and Sandhu J. S. (2007). Response of abscisic acid and salicylic 591 acid on morphophysiological traits of chickpea cultivars. *Eco. Envi. Con.*, 13(3): 589.

[29] Khandaker L., Masum Akond A. S. M. G., Oba S.(2011). Foliar application of salicylic acid improved the growth, yield and leaf"s bioactive compounds in red amaranth (*Amaranthus tricolor* L.). *Vegetable Crops Res. Bull*., 74: 77-86.

[30] Martin-Mex R, Villanueva-Couoh E, Herrera-Campos T & Larque-Saavedra A (2005). Positive effect of salicylates on the flowering of African violet. *Sci. Hortic*., 103: 499-502.

[31] Miri S M., Ahmadi S and Moradi P. (2015). Influence of Salicylic Acid and Citric Acid on the Growth, Biochemical Characteristics and Essential Oil Content of Thyme (*Thymus vulgaris* L.). *Journal of MedicinalPlants and By-products,* 2: 141-146.

[32] Mohamed, G. F. and Ebteam, M. M. A. (2013). Response of *Calendula officinalis* L. plants to foliar application of Gibberellic acid and mixture of some Micro-nutrients. *J. Applied Sci. Res*., 9(1): 735-742.

[33] Mohammadzadeh, M., Arouce, H., Neamati, S. H. and Shoor, M. (2013). Effect of different levels of Salt stress and Salicylic acid on morphological characteristics of four mass native basils. *Int. J. Agro. Pl. Prod.,* 4(5): 3590-3596.

[34] Najafian S, Khoshkhui M, Tavallali V, Saharkhiz MJ.(2009). Effect of salicylic acid and salinity in thyme (*Thymus vulgaris* L.): Investigation on changes in gas exchange, water relations, and membrane stabilization and biomass accumulation. *Australian Journal of Basic and Applied Sciences*, 3(3): 2620-2626.

[35] Popova, L. P. (2012). Role of jasmonates in plant adaptation to stress. In: P. Ahmad & M.N.V. Prasad (Eds.), Salt stress and functional adaptations in plants. Berlin: Springer, pp. 381-412.

[36] Raskin, I. (1992). Role of salicylic acid in plant Annu. *Rev. Pl physiol. Pl. Mol. . (43):439-463.*

[37] Shafiee M., Taghavi T. & Babalar M. (2010). Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. *Sci Hortic.,* 124: 40-45.

[38] Shakirova F. M., Bezrukova M. V., Maslennikova D. R. (2013). Endogenous ABA as a hormonal intermediate in the salicylic acid induced protection of wheat plants against toxic ions. In: Salicylic Acid. *Springer Dordrecht*: pp. 119–140

[39] Shakirova, F. M., Sakhabutdinova, A R, Bezrukova, M. V and Fathkutdinov,R. A. (2003). Changes in the hormonal status of wheat seedlings induced by salicylic acid and salinity. *Pl. Sci.,* 164: 317-322.

[40] Silva, C., Garcia, V.A.S. and Zanette, C.M. (2016). Chia (*Salvia hispanica* L.) oil extraction using different organic solvents: oil yield, fatty acids profile and technological analysis of defatted meal. *International Food Research J.,*

23(3): 998-1004.

[41] Singh, J. P. Kumar, K. and Katiyar, P. N. (2012). Effect of zinc, iron and copper on yield esters of gladiolus. *Hort. Flora Res. Spect.*, 1(1): 64-68.

[42] Wilkinson S and Davies WJ. (2010). Drought, ozone, ABA and ethylene: new insights from cell to plant to community. *Plant, Cell and Environ.*, 33: 510–25.

[43] Yeboah, S., Danquah, E. O., Lamptey, J. N. L., Mochiah, M. B., Lamptey, S., Oteng-Darko, P., Adama, I., Appiah-Kubi, Z. and Agyeman, K. (2014). Influence of planting methods and density on performance of chia(Salvia hispanica) and its suitability as an oilseed plant. *Agric. Sci.*, 2(4), 14-26.

[44] Yildirim, E. Turan, M. and Guvenc, I. (2008). Effect of foliar salicylic acid applications on growth, chlorophyll and mineral content of Cucumber grown under salt stress. *J. PL. Nutrition*, 31(3): 593-612.