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Assessment of Foliar Application of Bio-stimulants for Better Growth, Yield and Quality in Chilli (*Capsicum annuum* var. *annuum*)

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Abstract

The study was carried out to assess the effect of bio-stimulants on growth, yield and quality of chilli (*Capsicum annuum* var. *annuum*) var. Rudra at Sanjeevini Vatika, Department of Horticulture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka during *kharif* 2023-24. Among bio-stimulants used, significantly better growth, yield and quality attributes such as plant height (76.47 cm and 95.90 cm at 60 and 120 DAT, respectively), number of primary branches per plant (4.86 and 8.50 at 60 and 120 DAT, respectively), stem girth (1.62 cm and 2.61 cm at 60 and 120 DAT, respectively), number of leaves per plant (181.95 and 288.50 at 60 and 90 DAT, respectively), number of green fruits per plant (132.67), fruit length (12.93 cm), green fruit yield per plant (1145.17 g), thousand seed weight (7.49 g), chlorophyll (53.37 mg/100g), TSS (5.74 ^{0}Brix) and ascorbic acid (144.26 mg/100g) were recorded with the foliar application of humic acid at 4ml/l.

Keywords : Bio-stimuants, Green chilli, Dry chilli, Quality, Yield

Chilli (*Capsicum annuum* L.) is an important spice crop, belongs to the family Solanaceae with a chromosome number of 2n = 24. Native to Peru and Mexico, it plays a significant role as a vegetable and spice in everyone's daily lives around the world.

The average yield of green chilli in India is low compared to the USA, Korea and Taiwan. Consequently, there is a lot of scope to increase the yield of green chilli in India. Efforts have been made to enhance vegetable production by developing high-yielding, high-quality and disease-resistant varieties and hybrids, as well as by using improved production and protection technologies. However, there is a gap inorder to meet the requirements of the 1.4 billion population in India. Moreover, excessive use of inorganic fertilizers and pesticides has reduced the quality of the crop.

In the last few decades, several technological innovations have been proposed to enhance the sustainable vegetable production system by reducing the use of agrochemicals, pesticides and fertilizers. In order to fulfil this aim various breeding programme have been introduced, but they are time consuming and species-specific. Therefore, apart from this, a less time-consuming, cost effective and environment friendly agricututal practices are needed. So one of the most innovative and promising solutions for sustainable production involves the use of the Bio-stimulants.

In this context, the use of bio-stimulants, become imperative which do not leave any residual effect in the produce, that safeguards human health. Bio-stimulants are natural compounds that help in promoting plant growth and enhancing nutrient

uptake. They may not only delivering nutrients to the plant but also stimulate plant metabolism such as respiration, photosynthesis, nucleic acid synthesis and ion uptake (Gu *et al*., 2014). Hence, use of bio stimulants is the most important and new tool in increasing crop yield and quality without any harmful effects.

Plant bio-stimulants are referred to as 'any substance or microorganism, when applied to plants, seeds or the rhizosphere with the intention to stimulate natural processes of plants benefiting nutrient use efficiency, tolerance to abiotic stress, regardless of nutrients content or combination of any such substances or microorganisms intended for this use'.

Some bio-stimulants like humic acid, seaweed extracts, fish amino acids, salicyclic acid, chitosan, microbial consortia, *Kappaphycus alvarezii* and Arka microbial consortia etc., have been reported as positively affecting yield and quality parameters.

In consideration of these reports, the use of bio-stimulants at specific concentrations may have positive effect on plants growth, yield and quality. In this context the current field experiment was conducted to study the 'Assessment of foliar application of bio-stimulants for better growth, yield and quality in chilli (*Capsicum annuum* var. *annuum*)'.

Material and Methods

A field experiment was conducted during *kharif* 2022-23 at Sanjeevini Vatika, Department of Horticulture, University of Agricultural Sciences, GKVK, Bengaluru, Karanataka which is situated under the Eastern dry zone (Zone-V) of Karnataka at 12°58' North latitude and 77°35' East longitude with an elevation of 930 meters above mean sea level. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatments included in the study were control (no bio-stimulant application) (T_1), foliar spray of chitosan 5 ml/l (T_2), *Kappaphycus alvarezii* 1.5 ml/l (T_3), Microbial consortia 10 ml/l (T_4), Salicylic acid 0.5 mM (T_5), Humic acid 4 ml/l (T_6), Seaweed extract 2 ml/l (T_7), Fish amino acid 5 ml/l (T_8) and Arka microbial consortia 10 ml/l (T_9) applied to the crop at 15, 30, 45, 60 and 75 days after transplanting.

The field layout and randomization of treatments were made with plot size of 6 x 2 m. The seedlings of chilli variety *Rudra* were transplanted in field at 30 days after sowing at a spacing of 60 × 60 cm. Each treatment plot had 40 plants that were all treated to the same cultural practices throughout the trial. Observation were recorded on plant height, number of primary branches per plant, stem girth, number of leaves per plant, number of green fruits per plant, fruit length, green fruit yield per plant, thousand seed weight, cholorophyll, ascorbic acid and TSS. The statistical analysis was done as per the procedure outlined by (Panse and Sukhtame, 1985).

Results and Discussion

Plant height of chilli was found significantly different among all the treatments as compare to the control. The plants treated with foliar application of humic acid based bio-stimulant recorded significantly maximum plant height (76.47 cm and 95.90 cm at 60 and 120 DAT, respectively) which was *on par* with foliar application of seaweed extract (75.90 cm and 92.37 cm at 60 and 120 DAT, respectively) based bio-stimulant. While, the minimm plant height (59.86 cm and 72.47 cm at 60 and 120 DAT, respectively) was observed in control plants (Table 1). This might be due to the application of influence of humic acid application, which might have increased cell division, cell elongation and provided other nutrient minerals as an energy source for nitrogen fixing bacteria, improving their biological function and finally led to growth induction (Abdel-Mawgaud *et al*., 2007). Similar findings were also reported by Fathima and Dinesh (2013), Saraswathi and Praneetha (2013), Chakravarthy *et al*. (2023) and Singh (2023) in chilli.

The maximum number of primary branches per plant (4.86 and 8.50 at 60 and 120 DAT, respectively) and stem girth (1.62 cm and 2.61 cm at 60 and 120 DAT, respectively) were recorded in plants treated with foliar application of humic acid based bio-stimulant which was *on par* with foliar application of seaweed extract based bio-stimulant. Whereas, minimum

TABLE 1

Effect of bio-stimulants on plant height of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

Treatments	Plant height (cm)	
	60 DAT	120 DAT
T_1 - Untreated	59.86	72.47
T_2 - Foliar application of Chitosan based bio-stimuant	63.97	76.44
T_3 - Foliar application of *Kappaphycus alvarezii* based bio-stimuant	73.50	90.00
T_4 - Foliar application of Microbial consortia based bio-stimuant	67.33	86.29
T_5 - Foliar application of Salicylic acid based bio-stimuant	64.18	84.00
T_6 - Foliar application of Humic acid based bio-stimuant	76.47	95.90
T_7 - Foliar application of Seaweed extract based bio-stimuant	75.90	92.37
T_8 - Foliar application of Fish amino acid based bio-stimuant	68.22	76.36
T_9 - Foliar application of Arka microbial consortia based bio-stimuant	62.93	79.03
Mean	68.04	83.65
S.Em ±	3.68	3.88
C.D @ 5 %	11.05	11.62

Note : DAT- Days after transplantig; Significance @ 5 % level

number of primary branches per plant (3.28 and 6.85 at 60 and 120 DAT, respectively) and stem girth (1.26 cm and 1.99 cm at 60 and 120 DAT, respectively) were recorded in the control plants. Increased primary branches and stem girth was due to use of right concentration of humic acid, which might have increased the efficiency of photosynthesis process, stimulated meristematic activity and enhanced supply of photosynthates, which led to the accumulation of nutrients in the plant and stimulated the plant to increase the number of branches per plants. Humic acids also stimulated the synthesis of cell wall components, contributing to a stronger cell wall structure, which resulted in thicker stems. These results are relation with Sarojnee *et al*. (2009), Fathima & Dinesh (2013) and Chakravarthy *et al*. (2023) in chilli (Table 2).

TABLE 2

Effect of bio-stimuants on number of primary branches per plant and stem girth of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

Treatments		Number of primary branches per plant		Stem girth (cm)	
		60 DAT	120 DAT	60 DAT	120 DAT
T_1 – Untreated	3.28	6.85	1.26	1.99	
T_2 - Foliar application of Chitosan based bio-stimuant	3.79	7.22	1.32	2.35	
T_3 - Foliar application of *Kappaphycus alvarezii* based bio-stimuant	3.96	7.65	1.46	2.50	
T_4 - Foliar application of Microbial consortia based bio-stimuant	3.78	7.41	1.29	2.46	
T_5 - Foliar application of Salicylic acid based bio-stimuant	3.38	6.91	1.27	2.00	
T_6 - Foliar application of Humic acid based bio-stimuant	4.86	8.50	1.62	2.61	
T_7 - Foliar application of Seaweed extract based bio-stimuant	4.40	7.85	1.54	2.54	
T_8 - Foliar application of Fish amino acid based bio-stimuant	3.50	6.99	1.28	2.06	
T_9 - Foliar application of Arka microbial consortia based bio-stimuant	3.68	7.30	1.31	2.20	
Mean	3.25	6.85	1.20	2.27	
S.Em ±	0.30	1.49	0.10	0.17	
C.D @ 5 %	0.90	4.47	0.22	0.50	

Note : DAT- Days after transplanting; Significance @ 5 % level

Treatment with foliar application of humic acid based bio-stimulant produced significantly maximum number of leaves per plant (181.95 and 288.50 at 60 and 90 DAT, respectively) which was followed by foliar application of seaweed extract (168.78 and 279.10 at 60 and 90 DAT, respectively) based bio-stimulant. Wheareas, minimum number of leaves per plant (146.04 and 223.97 at 60 and 90 DAT, respectively) was found in control plants. The increased number of leaves per plant might have been due to the capability of humic acid to stimulate hormonal activities in plants and enhance nutrient uptake. Humic acid improved the physical, chemical, biological and nutritional characteristics of the plants and also increased water-holding capacity, which promoted plant growth and led to a greater number of leaves. Similar results were reported by Fathima & Dinesh (2013), Chakravarthy *et al*. (2023) and Singh *et al*. (2023) in chilli.

The number of green fruits per plant was significantly varied with different bio-stimulant treatments. Foliar application of humic acid based bio-stimulant put forth maximum number of green fruits per plant (132.67) which was followed by foliar application of seaweed extract (125.17) based bio-stimulant and foliar application of *Kappaphycus alvarezii* (123.75) based bio-stimulant. Whereas, minimum number of green fruits per plant (115.07) was found in control plants. This might be due to the effect of humic acid and seaweed extract that increased the number of green fruits was due to presence of natural growth hormones, such as cytokinins and auxins, along with essential micronutrients. These components might have worked synergistically to enhance cell division, promoted fruit set and reduced fruit drop. The cytokinins in seaweed extract helped in delay senescence (aging) of the fruit, keeping them green for a longer period. Additionally, the improved nutrient uptake facilitated by the seaweed extract supported overall plant health, as a result it produced more number of green fruits in chilli. These results are in relation with the findings of Sarojnee *et al*. (2009), Fatima & Dinesh (2013) and Singh *et al*. (2023) in chilli.

The treatment with foliar application of humic acid based bio-stimuant recorded significantly maximum fruit length (12.93 cm), while untreated plants

TABLE 3

Effect of bio-stimuants on number of leaves per plant in chilli (*Capsicum annuum* var. *annuum*) var. Rudra

Treatments	Number of leaves per plant	
	60 DAT	90 DAT
T_1 - Untreated	146.04	223.97
T_2 - Foliar application of Chitosan based bio-stimuant	151.70	254.44
T_3 - Foliar application of *Kappaphycus alvarezii* based bio-stimuant	159.34	271.43
T_4 - Foliar application of Microbial consortia based bio-stimuant	148.63	239.80
T_5 - Foliar application of Salicylic acid based bio-stimuant	146.66	230.60
T_6 - Foliar application of Humic acid based bio-stimuant	181.95	288.50
T_7 - Foliar application of Seaweed extract based bio-stimuant	168.78	279.10
T_8 - Foliar application of Fish amino acid based bio-stimuant	147.81	232.04
T_9 - Foliar application of Arka microbial consortia based bio-stimuant	151.40	250.60
Mean	151.46	248.07
S.Em ±	8.40	15.34
C.D @ 5 %	25.18	46.49

Note: DAT- Days after transplanting; Significance @ 5 % level

TABLE 4

Effect of bio-stimuants on number of green fruits per plant, fruit length and green fruit yield per plant of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

Treatments	Number of green fruits per plant	Fruit length (cm)	Green fruit yield per plant (g)
T_1 - Untreated	115.07	9.98	858.33
T_2 - Foliar application of Chitosan based bio-stimuant	123.21	11.03	964.83
T_3 - Foliar application of *Kappaphycus alvarezii* based bio-stimuant	123.75	11.72	995.44
T_4 - Foliar application of Microbial consortia based bio-stimuant	121.80	11.04	927.33
T_5 - Foliar application of Salicylic acid based bio-stimuant	117.33	11.15	864.93
T_6 - Foliar application of Humic acid based bio-stimuant	132.67	12.93	1145.17
T_7 - Foliar application of Seaweed extract based bio-stimuant	125.17	12.49	1039.04
T_8 - Foliar application of Fish amino acid based bio-stimuant	118.47	10.85	904.34
T_9 - Foliar application of Arka microbial consortia based bio-stimuant	120.16	11.44	915.98
Mean	121.96	11.40	957.27
S.Em ±	2.04	0.44	55.44
C.D @ 5 %	6.13	1.31	166.22

Note: Significance @ 5 % level

recorded minimum fruit length (9.98 cm). This might be due to the effect of humic acid, which promoted root growth and development, leading to better nutrient absorption, encouraging cell elongation and cell division as a result produced larger and longer fruits. These findings are in line with studies of El-Sayed *et al*. (2019) and Shehata *et al*. (2019) in sweet pepper, Jan *et al*. (2020) in chilli and Sharanya *et al*. (2022) in cowhage (Table 4).

The maximum green fruit yield per plant (1145.17 g) was found with foliar application of humic acid based bio-stimulant which was followed by seaweed extract (1039.04 g) based bio-stimuant and *Kappaphycus alvarezii* based bio-stimuant. On the other hand, minimum green fruits yield per plant (858.33 g) was found in control plants. The increased in the fruit yield per plant in response to humic acid was likely due to enhanced plant growth and an expanded plant canopy, which allowed the plant to intercept light more effectively. As a result, there was an increased in the number of leaves and fruits, contributing to a maximum fruit yield per plant. Similar findings were also reported by El-Sayed *et al*. (2019), Ibrahim *et al.* (2019) in sweet pepper, Shehata *et al*. (2019) and Pavani *et al*. (2022) in chilli (Table 4).

The maximum thousand seed weight (7.49 g) of fruits was recorded with the foliar application of humic acid based bio-stimulant. Whereas, minimum thousand seed weight (6.39 g) of fruits was noticed in untreated plants. Humic acid can stimulate the activity of enzymes involved in carbohydrate and protein synthesis. These enzymes help in the accumulation of reserves such as starch and proteins in the seeds. Enhanced enzymatic activity results in larger and heavier seeds. These results are in conformity with the findings of Arthur *et al*. (2022), Singh *et al*. (2023) in chilli, Sharanya *et al*. (2022) in cowhage, Gayathri and Srinivasamurthy (2016) in maize (Fig. 1).

Treatments with bio-stimulants singnificantly elevated the chlrophyll content. The highest chlorophyll content (53.37 mg/100g) was noticed in plants applied with foliar application of humic acid based bio-stimulant, which was followed by foliar application of seaweed exract (50.41 mg/100g) based bio-stimulant. On the other hand, lower chlorophyll

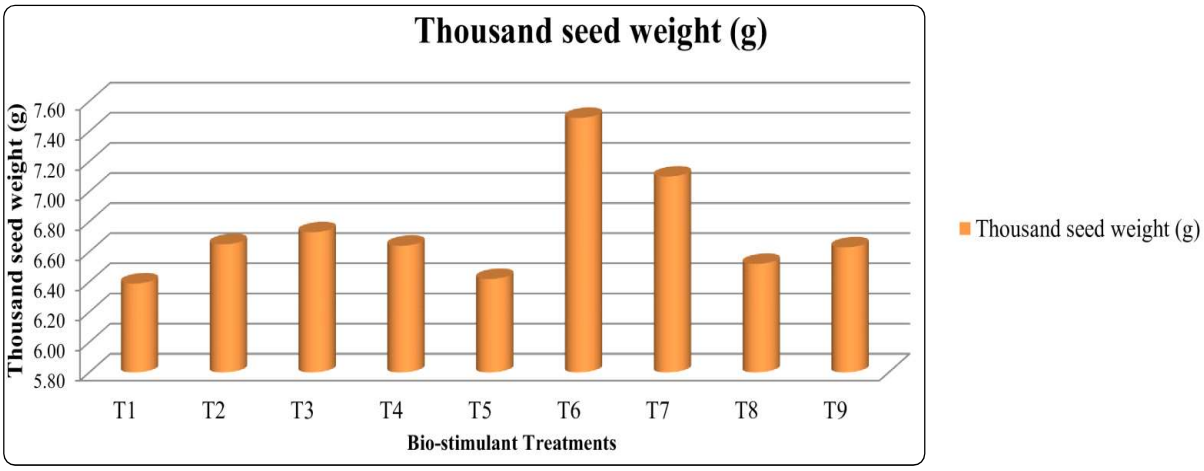

Fig. 1: Effect of bio-stimulants on thousand seed weight of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

content (46.00 mg/100g) was reported in control plants. The increased in total chlorophyll content by the foliar application of humic acid might be due to the acceleration of N and NO_3 uptake, enhancing nitrogen metabolism and synthesis of protein that must have increased chlorophyll content. The results are in line with Kakakurt *et al*. (2009) in pepper, Helay *et al*. (2018) in tomato, Shehata *et al*. (2019) in sweet pepper (Table 5).

The highest TSS (5.74 °Brix) and ascorbic acid (144.26 mg/100g) content were recorded in plants treated with foliar application of humic acid based bio-stimulant and followed by foliar application of seaweed exract based bio-stimulant. Whereas, the lowest TSS (4.99 °Brix) and ascorbic acid (126.09 mg/100g) content were recorded in the control plants (Fig. 2 and Table 5). It might be due to Humic acid that enhanced the availability and uptake of essential

TABLE 5

Effect of bio-stimuants on chlorophyll and ascorbic acid content of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

Treatments	Chlorophyll (mg/100g)	Ascorbic acid(mg/100g)
T_1 - Untreated	46.00	126.09
T_2 - Foliar application of Chitosan based bio-stimuant	48.31	129.70
T_3 - Foliar application of *Kappaphycus alvarezii* based bio-stimuant	49.61	136.55
T_4 - Foliar application of Microbial consortia based bio-stimuant	47.00	128.66
T_5 - Foliar application of Salicylic acid based bio-stimuant	46.11	126.66
T_6 - Foliar application of Humic acid based bio-stimuant	53.37	144.26
T_7 - Foliar application of Seaweed extract based bio-stimuant	50.41	140.77
T_8 - Foliar application of Fish amino acid based bio-stimuant	46.46	127.51
T_9 - Foliar application of Arka microbial consortia based bio-stimuant	46.74	128.00
Mean	48.22	132.02
S.Em ±	0.83	2.26
C.D @ 5 %	2.50	6.78

Note: Significance @ 5 % level

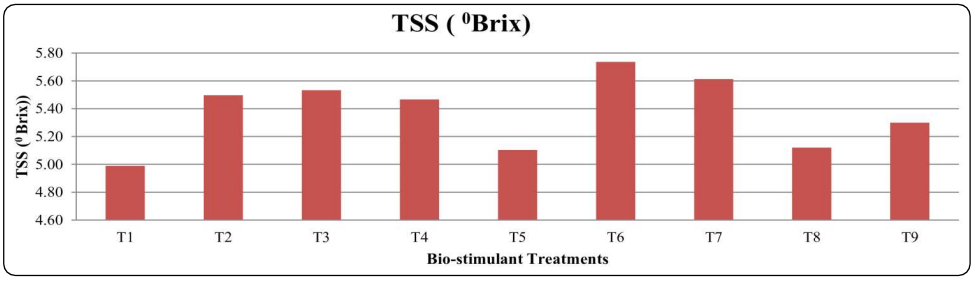

Fig. 2 : Effect of bio-stimulants on TSS content of chilli (*Capsicum annuum* var. *annuum*) var. Rudra

nutrients by plants and also stimulated enzyme activity, memberane permeablity, photosynthesis and maintaing transpiration rate which increased TSS and ascorbic acid content in fruits. Similar results were also reported by Pavani *et al*. (2022), Chakravarthy *et al*. (2023) and Singh *et al.* (2023) in chilli.

From the present experimental results, it can be concluded that foliar application of humic acid at 4 ml/l (T_6) resulted in better plant growth, maximum yield and quality of chilli.

References

Abdel-Mawgoud, A. M. R., Greadly, N. H. M., Helmy, Y. I. and Singer, S. M., 2007, Responses of tomato plants to different rates of humic-based fertilizer and NPK fertilization. *J. Applied Sci. Research*, **3** (2) : 169 - 174.

Anonymous, 2023, Horticulture crop statistics of Karnataka State 2022-23, Department of Horticulture, Karnataka, pp. : 66 - 67.

Arthur, J. D., Li, T. and Bi, G., 2022, Plant growth, yield and quality of containerized heirloom chilli pepper cultivars affected by three types of biostimulants. *Horticulture*, **9** (1) : 12.

Chakravarthy, G. A. and Mohan, K. K., 2023, Effect of bio-stimulants on growth, development and yield of chilli (*Capsicum annuum* L.). *Int. J. Plant and Soil Sci*., **35** (6) : 172 - 176.

El-Sayed, H. A., Shokr, M. M. B. and Elbauome, A., 2019, Response of sweet pepper to irrigation intervals and humic acid application. *J. Plant Production*, **10** (1) : 7 - 16.

Fathima, P. S. and Denesh, G. R., 2013, Influence of humic acid spray on growth and yield of chilli (*Capsicum annuum* L.). *Int. J. Agric. Sci*., **9** (2) : 542 - 546.

Gayathri, B. and Srinivasamurthy, C. A., 2016, Effect of different levels and sources of humic acid extracted from organic wastes on soil properties, growth, yield and nutrient uptake by Maize. *Mysore J. Agric. Sci*., **50** (2) : 463 - 468.

Gu, D., Wang, X. F. and Ding, F. J., 2014, Plant biostimulants: A review on categories, effects and application. *In Proceedings of the Chinese Society of Plant Nutrition and Fertilizer Science, Academic Annual Conference, Harbin, Heilongjiang Province,* China, pp. : 1 - 9.

Helaly, M. N., Arafa, A. A., Heba, M. and Ibrahim, K. H., 2018, Improving the growth and productivity of tomato by some bio-stimulants and micronutrients with or without mulching. *J. Appl. Phytol*., **10** : 15 - 23.

Ibrahim, A., Razzak, H., Alenazi, M., Alsadon, A. and Dewir, Y. H., 2019, Improvement in growth, yield and quality of three red sweet pepper cultivars by foliar application of humic and salicylic acids. *Hort. Technology*, **29** (2) : 170 - 178.

Jan, J. A., Nabi, G., Khan, M., Ahmad, S., Shah, P. S. and Hussain, S., 2020, Foliar application of humic acid improves growth and yield of chilli (*Capsicum annuum* L.) varieties. *Pakistan J. Agricultural Research*, **33** (3) : 461.

Karakurt, Y., Unlu, H. and Padem, H., 2009, The influence of foliar and soil fertilization of humic acid on yield and quality of pepper. *Acta Agric. Scand. Sec. B Soil Plant Sci*., **59** : 233 - 237.

PANSE, V. R. AND SUKHATME, P. N., 1985, Statistical methods for agricultural workers, ZARZ, New Delhi, pp. : 145 - 156.

PAVANI, DESHMUKH, P., WAND, O., SRIKANTH AND YADAV, 2022, Effect of foliar application of humic acid on yield parameters and quality of chilli. *J. Pharmacognosy and Phytochemistry*, **11** (3) : 235 - 239.

SARASWATHI, T. AND PRANEETHA, S., 2013, Effect of bio-stimulants on yield and quality in tomato. *J. Hortl. Sci.,* **8** (1) : 107 - 110.

SAROJNEE, D. Y., NAVINDRA, B. AND CHANDRABOSE, S., 2009, Effect of naturally occurring amino acid stimulants on the growth and yield of hot peppers. *J. Animal and Plant Sci*., **5** (1) : 414 - 424.

SHARANYA, B., GOWDA, A. A. AND SRINIVASAPPA, K. N., 2022, Bio-stimulants for better growth and yield potency in cowhage (*Mucuna pruriens* L.). *Mysore J. Agric. Sci.,* **56** (4) : 399 - 404.

SHEHATA, S. A., SAAD, M. SALEH, M. A. AND ATALA, S. A., 2019, Effect of some bio-stimulants materials on growth, yield, quality and storability of sweet pepper. *Annals of Agric. Sci.,* **57** (1) : 77 - 88.

SINGH, D., SUHAINI, N. AND WESLEY, C. J., 2023, Effect of different bio-stimulants on growth, yield and quality of chilli (*Capsicum annuum* L.) under Prayagraj agro climatic conditions. *Int. J. Envr. and Climate Change*, **13** (9) : 191 - 197.