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Morphological Diversity in certain Turmeric (*Curcuma longa* L.) Cultivars under Salinity Stress

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ABSTRACT: Five robust turmeric germplasms are selected from the Horticulture Research Center, where the climatic conditions were highly humid and the soils were prone to maximum salinity. These cultivars were compared for their morphological parameters under salt stress conditions. These parameters were observed, 140 days after the sowing of the selected turmeric germplasms and 90 days after the salinity treatment. These cultivars, were observed for five prominent morphological characteristics that are important *i.e.*, plant height, longest leaf length, longest leaf width, number of leaves, and number of tillers. These morphological parameters are checked in order to identify the ability of the plants to tolerate the stress conditions and to check the effect of salt stress on the growing turmeric cultivars. The data analysis of the obtained morphological parameters is done by FCRD method, by using R-software along with DMRT observations. These two methods, were accurate and effective in analyzing the morphological data with three treatments and five cultivars. Therefore, Vallabh Sharad and New Selection 1 are observed to be able to cope with high salt conditions and can be recommended as the important cultivars for the farmers in and around Uttar Pradesh.

Keywords: Factorial CRD, Salinity stress, Morphological parameters, DMRT, Tolerant cultivars.

INTRODUCTION

The Zingiberaceae family consists of many species with several useful properties. These species are named important after understanding their medicinal and therapeutic properties. They are used in many industries to make useful products and are well-known in the beauty world (Chakraborty *et al.,* 2019). Out of all the available species in this family, turmeric and ginger are known to play major roles in promoting several health benefits and therapeutic properties (Zhang and Kitts 2021). Compared to ginger, turmeric is used in almost all the dishes and considered to be medicinal which can be taken raw in a powder form or added in the curries (Edwards *et al.,* 2020). Turmeric is commonly known as an herbaceous medicinal plant with anti-cancerous, anti- diabetic properties. Apart from these, this plant helps in the efficient functioning of the immune system and promotes anti-inflammatory properties (Scott *et al.,* 2020). Along with this, curcuminoids present in these plants helps in curing many neurological disorders and cancerous properties. It is observed that, the daily intake of one table spoon of the turmeric powder is advisable for proper functioning of human body.

India is considered as the top most producer and exporter of turmeric powder with high curcuminoid value to many countries like USA, UK, Japan and Russia. The turmeric powder is considered very auspicious and used for many rituals and ceremonies as well (Alizedeh *et al.,* 2019). Also, the turmeric powder adds aroma, taste and spice to the dishes due to which almost all the dishes prepared across the globe uses a pinch of this powder (Cowell *et al.,* 2017). All Indian delicacies need turmeric powder to improve the color and aroma of the dish. India is also known for its diverse turmeric germplasms with maximum benefits some tolerant to biotic stresses, other towards abiotic stresses and certain species tolerant to the changes in the environment (Akter *et al.,* 2019). Almost 40 species are recorded in each area of South East Asia with India being the topmost producer of turmeric whose genetic nature is triploid (2n= 3x= 63) (Verma *et al.,* 2018).

Although there are many advantages with this crop, few disadvantages are noticed with respect to their

resistance against abiotic stresses (Forsyth *et al.,* 2019). Almost all the cultivars of turmeric are resistant to abiotic stresses up to certain level but, few varieties are susceptible with maximum yield losses ((Meng *et al.,* 2018). The important stress observed these days is salinity stress which causes a serious havoc to the growing crops by arresting their growth with many symptoms ultimately leading to the death of these crops under maximum salt concentrations (Wang *et al.,* 2021).

Recent studies revealed that, the salinity stress has maximum influence on the growth and development of the turmeric cultivars especially effecting the morphological parameters which in turn effects the growth and development of the underground rhizomes (Smith *et al.,* 2019). Not many experiments are conducted regarding salinity stress in turmeric cultivars also, not many cultivars are included in the studies so far (White *et al.,* 2019). This can be due to the long-life cycle of the crop and improper adaptability of the turmeric crops to the surrounding environmental conditions. To understand the effect of salinity in the growing turmeric cultivars, five turmeric cultivars belonging to UP are selected and the growth conditions are observed three months after the salinity treatment (Sanidad *et al.,* 2019).

Therefore, our study is aimed to understand the growth of the turmeric cultivars imposed by salinity stress in two treatments *i.e*., 50mM concentration and 100mM concentrations along with their controls for comparison. Different morphological parameters are checked in the plants, three months after the salinity treatment *i.e*., 140 days after sowing and 90 days after salt treatment. The observations are recorded in order to observe the fluctuations in the growth of the turmeric cultivars because, the increase in the foliage aids in the growth of the underground rhizomes which is the major economical part of the turmeric crop.

MATERIAL AND METHODS

Five turmeric cultivars were selected form the Horticulture Research Center, Dept. of Horticulture, SVPUA&T, Meerut. These cultivars were developed and thoroughly checked for their characters in UP, these cultivars include Vallabh Sharad, New Selection 1, Vallabh Priya, Azad and New Selection 2. The experiment was conducted in pot culture which was maintained under lab conditions in the Dept. of Ag. Biotechnology, SVPUA&T, Meerut.

Different growth parameters were examined up to certain growth period of the turmeric cultivars *i.e*., 140 days after sowing and 90 days after the salt treatment. The values observed and recorded were analyzed using FCRD (Factorial Completely randomized Design) method using R-software along with the DMRT (Duncan Multiple Range Test) which was indicated by alphabets to identify the treatments and cultivars that were on-par with each other and that show significant variations among them (Dafaallah *et al.,* 2019).

In this experiment, a total of five cultivars with three replications each including control, 50mM and 100mM concentrations were sown at the same time in pot culture. The salt stress was given to the plant 45 days after sowing and allowed to absorb maximum salt water to impose severe stress conditions. 90 days after the treatment the plants were observed for certain morphological parameters like plant height, longest leaf length, longest leaf width, number of leaves and number of tillers in control, 50mM and 100mM concentrations respectively. All the details and their means were recorded carefully to observe the highest and the least responsive cultivars towards salinity stress conditions. Along with this the mean values, standard deviation, standard error and CV was also determined using the R- software.

Fig. 1. Different turmeric germplasms selected for observing morphological parameters under salt stress conditions (90 days old plants).

RESULTS AND DISCUSSIONS

Different morphological parameters suitable for that particular growth period were recorded carefully in order to observe the maximum tolerant cultivars to the least tolerant cultivar in the selected turmeric germplasms for the experiment.

Table 1: Different Morphological parameters observed under salt stress conditions in turmeric cultivars three months after the treatment.

			THREE MONTHS AFTER SALINITY TREATMENT			
VARIETIES	TREATMENTS	PLANT HEIGHT	LONGEST LEAF LENGTH	LONGEST LEAF WIDTH	NUMBER OF LEAVES	NUMBER OF TILLERS
VALLABH SHARAD	CONTROL	24.5±0.177	12.6±0.274	4.6±0.314	8.0±0.043	5.0±0.094
NEW SELECTION1	CONTROL	23.7±0.321	11.4±0.071	4.1±0.075	6.0±0.121	5.0±0.062
VALLABH PRIYA	CONTROL	16.5±0.156	10.3±0.215	3.2±0.069	5.0±0.028	4.0±0.023
AZAD	CONTROL	14.2±0.200	9.4±0.116	2.8±0.034	4.0±0.050	4.0±0.046
NEW SELECTION2	CONTROL	14.5±0.221	8.5±0.084	2.7±0.030	4.0±0.039	4.0±0.023
VALLABH SHARAD	50MM	22.5±0.077	11.9±0.275	4.3±0.027	7.0±0.010	4.0±0.024
NEW SELECTION1	50MM	19.8±0.883	11.3±0.073	4.2±0.073	7.0±0.118	4.0±0.048
VALLABH PRIYA	50MM	18.9±0.564	8.7±0.086	3.4±0.062	6.0±0.611	3.0±0.037
AZAD	50MM	18.1±0.838	8.5±0.096	3.9±3.14E-16	4.0±0.024	3.0±0.054
NEW SELECTION2	50MM	17.9±0.225	8.2±0.098	3.3±0.019	4.0±0.024	2.0±0.012
VALLABH SHARAD	100MM	22.3±0.248	12.1±0.276	4.6±0.127	7.0±0.042	3.0±0.347
NEW SELECTION1	100MM	20.1±0.561	11.5±0.118	4.4±0.053	7.0±0.073	4.0±0.023
VALLABH PRIYA	100MM	17.8±0.795	7.9±0.100	3.8±0.021	5.0±0.058	3.0±0.040
AZAD	100MM	18.9±0.305	7.8±0.045	3.5±0.035	3.0±0.054	3.0±0.017
NEW SELECTION2	100MM	18.9±0.924	7.6±0.089	3.3±0.037	3.0±0.030	3.0±0.017
GRAND MEAN		19.2±1.76	9.8±1.02	3.7±0.36	5.3±0.93	3.7±0.46
STDEV		2.932	1.736	0.601	1.578	0.789
S.E.		0.749	0.439	0.155	0.413	0.207

All the turmeric cultivars selected for salinity treatment were observed for the changes in their morphological parameters in this stage (three months after salinity treatment) (Fig. 1). Although in previous stages it was observed that Vallabh Sharad gave maximum followed by new Selection1 compared to all the other varieties under salt stress conditions. Therefore, in this stage it was observed that Vallabh Sharad gave maximum plant height compared to other cultivars *i.e.*, 24.5±0.177, 22.5±0.077 and 22.3±0.248 for control, 50mM and 100mM concentrations. Also, New Selction1 gave positive results little lesser than that of Vallabh Sharad *i.e.*, 23.7±0.321, 19.8±0.883 and 20.1±0.561 for control, 50mM and 100mM concentrations respectively. Not only this but for longest leaf length Vallabh Sharda gave maximum growth followed by New Selction1 *i.e.*, 12.6±0.27, 11.9±0.27 and 12.1±27 foe control, 50mM and 100mM respectively for Vallabh Sharad and 11.4±0.07, 11.3±0.07 and 11.5±0.115 for control, 50mM and 100mM treatments for New Selection1. Also, Vallabh Sharad gave maximum growth for longest leaf width *i.e.*, 4.6±0.314, 4.3±0.327 and 4.6±0.127 for control, 50mM and 100mM concentrations followed by 4.1±0.075, 4.2◦±0.073 and 4.4±0.053 for New Selection 1 for same treatments. Not only this the total number of leaves and tillers were maximum for Vallabh Sharad *i.e.*, 8±0.043, 7±0.01 and 7±0.042 for total leaves and 5±0.094, 4±0.024 and 3±0.347 for number of tillers under control, 50mM and 100mM concentrations, followed by New Selection1 *i.e.*, 6±0.121, 7±0.118 and 7±0.073 for total leaves and 5±0.062, 4±0.048 and 4±0.023 for tillers under control, 50mM and 100mM concentrations respectively (Table 1). Therefore, the individual parameters were observed for growth under salt stress conditions in this stage.

Table 2: Mean values observed for plant height.

		Control	50MM	100MM	
		A1	A2	A3	Mean
Vallabh Sharad	**B1**	24.50	22.50	22.30	23.10 a
New Selection 1	**B2**	23.70	19.80	20.10	21.20 b
Vallabh Priya	**B3**	16.60	18.90	17.80	17.77 c
Azad	**B4**	14.20	18.10	18.90	17.07 c
New Selection 2	**B5**	14.50	17.90	18.90	17.10 c
Mean		18.70 b	19.44 a	19.60 a	

	SE(M)	CD 5%	CV
A	0.23	0.67	4.69
B	0.30	0.87	
A X B	0.52	1.50	

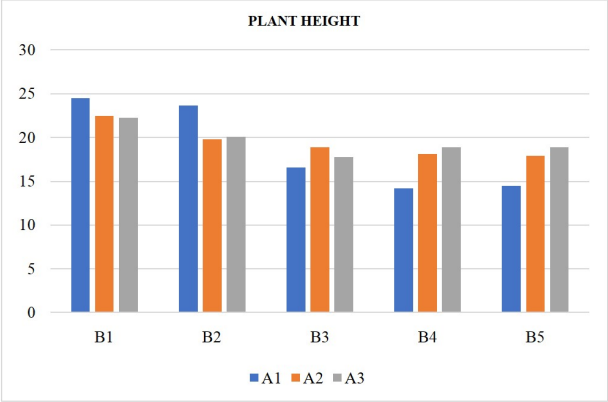

Fig. 2. Observations in plant height 90 days after the treatment.

Plant Height: The maximum plant height was observed in Vallabh Sharad *i.e.*, 24.5, 22.5 and 22.3 for control, 50mM and 100mM followed by New Selection1 *i.e.*, 23.7, 19.8 and 20.10 for control, 50mM and 100mM conditions. Therefore, it was clear that these two cultivars gave maximum increase in their plant height compared to other cultivars even under salt stress condition in this stage (Fig. 2). It was observed that the plant height in Vallabh Sharad and New selection1 increased in comparison to the previous stages by 1 – 1.5 cms each, whereas in other cultivars there is not much increase in the plant height *i.e.*, hardly found to be in millimeters (Mohan *et al.,* 2017). Also, in case of DMRT for the treatments it was observed that the 50mM and 100mM were on-par with each compared to control which was expected to be showing significant variation with these two treatments. Whereas, in case of the cultivars, Vallabh Sharad and New Selection 1 *i.e.*, 23.10 and 21.20 respectively, showed significant variations compared to Vallabh Priya, Azad and New Selection 2 with their mean values 17.77, 17.07 and 17.10 respectively, so referred to be on-par with each other. Along with this the CV value of 4.69 indicates that there is significance in the treatment (Table 2).

Table 3: Mean values observed for longest leaf length.

		CONTROL	50MM	100MM	
		A1	A2	A3	MEAN
VALLABH SHARAD	B1	12.6	11.9	12.1	12.2 a
NEW SELECTION 1	B2	11.4	11.3	11.5	11.4 b
VALLABH PRIYA	B3	10.3	8.7	7.9	9.0 c
AZAD	B4	9.4	8.5	7.8	8.6 d
NEW SELECTION 2	B5	8.5	8.2	7.6	8.1 e
MEAN		10.44 a	9.72 b	9.38 c	

	SE(M)	CD 5%	CV
A	0.07	0.20	2.75
B	0.09	0.26	
A X B	0.16	0.45	

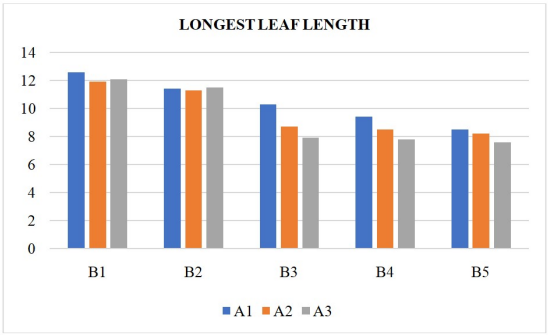

Fig. 3. Observations in longest leaf length 90 days after the treatment.

Longest Leaf length: The longest leaf length was maximum observed in Vallabh Sharad *i.e.*, 12.6, 11.9 and 12.1 respectively in control, 50mM and 100mM which was followed by New Selection1 *i.e.*, 11.4,11.3 and 11.5 for New Selection1 respectively in all the treatments. These two varieties gave maximum longest leaf length compared to previous stages (Fig. 3). Also, rest of the cultivars showed little increase in the longest

leaf length compared to Vallabh Sharad and New Selection1. It was observed that the other cultivars did not increase much in this stage compared to previous stages (Chander *et al.,* 2016).

Also, in case of DMRT the mean values in case of treatments and cultivars were observed to show significant difference with each other and no any related values with each other. In case of treatments, it was observed that all the treatments were significantly different with each other *i.e.*, 10.44, 9.72 and 9.38 for control, 50mM and 100mM even in case of the cultivars significant difference was observed with each other *i.e.*, 12.2, 11.4, 9.0, 8.6 and 8.1 respectively for each of the cultivar (Table 3). Also, the CV value of 2.75 indicates the significance of the treatment.

Table 4: Mean values observed for longest leaf width.

		CONTROL	50MM	100MM	
		A1	A2	A3	MEAN
VALLABH SHARAD	B1	4.60	4.30	4.60	4.50 a
NEW SELECTION 1	B2	4.10	4.20	4.40	4.23 b
VALLABH PRIYA	B3	3.20	3.40	3.80	3.47 c
AZAD	B4	2.80	3.90	3.50	3.40 c
NEW SELECTION 2	B5	2.70	3.30	3.30	3.10 d
MEAN		3.48 b	3.82 a	3.92 a	

	SE(M)	CD 5%	CV
A	0.04	0.13	4.55
B	0.06	0.16	
A X B	0.10	0.28	

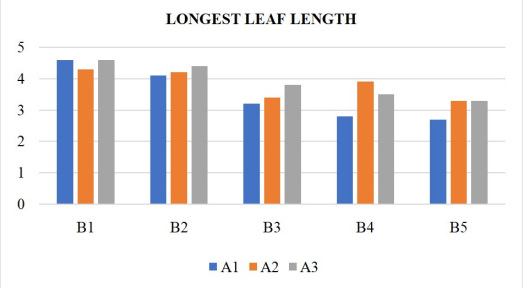

Fig. 4. Observations in longest leaf width 90 days after treatment.

Longest leaf width: The longest leaf width was maximum in case of Vallabh Sharad *i.e.*, 4.60, 4.30 and 4.60 respectively for control, 50mM and 100mM followed by new Selection1 *i.e.*, 4.10, 4.20 and 4.40 respectively for control, 50mM and 100mM (Kadam *et al.,* 2020). The other cultivars were known to show less leaf width compared to these two cultivars (Fig. 4).

In case of DMRT, it was observed that there was significant variation in all the treatments and cultivars as well. In case of treatments 50mM and 100mM i.e., 3.82 and 3.92 were on-par with each other compared to control *i.e.*, 3.48 as it is showing significant variation compared to other treatments. Also, in cultivars Vallabh Priya and Azad were on-par with each other *i.e.*, 3.47 and 3.40 compared to other cultivars which were showing significant variations among them *i.e.*, 4.5, 4.23 and 3.10 for Vallabh Sharad, New Selection 1 and New Selection 2 (Table 4). Also, the CV value of 4.55 indicates that there is significance in the treatment.

Table 5: Mean values for the number of leaves.

		CONTROL	50MM	100MM	
		A1	A2	A3	MEAN
VALLABH SHARAD	B1	8.00	7.00	7.00	7.33 a
NEW SELECTION 1	B2	6.00	7.00	7.00	6.67 b
VALLABH PRIYA	B3	5.00	6.00	5.00	5.33 c
AZAD	B4	4.00	4.00	3.00	3.67 d
NEW SELECTION 2	B5	4.00	4.00	3.00	3.67 d
MEAN		5.40 a	5.60 a	5.00 b	

	SE(M)	CD 5%	CV
A	0.08	0.22	5.55
B	0.10	0.28	
A X B	0.17	0.49	

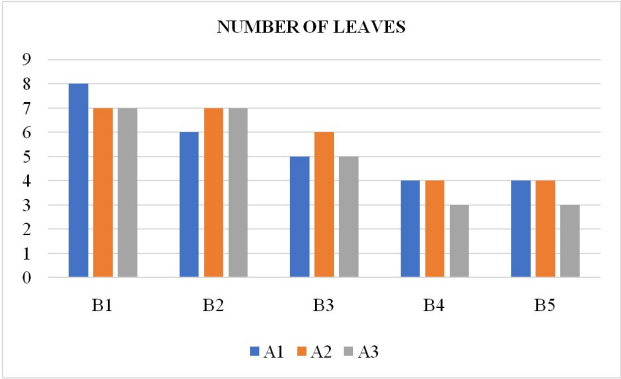

Fig. 5. Observations in number of leaves 90 days after treatment.

Number of leaves: It was observed that the maximum number of leaves were observed in case of Vallabh Sharad *i.e.*, 8, 7 and 7 respectively in all the treatments followed by New Selction1 *i.e.*, 6, 7 and 7 respectively for control, 50mM and 100mM (Kumar *et al.,* 2018). These two cultivars gave maximum number of leaves compared to other cultivars in this stage (Fig. 5).

In case of DMRT, it was observed that control and 50mM *i.e.*, 5.40 and 5.60 respectively were on-par with each other compared to 100mM *i.e.*, 5.0 which was showing significant variation with the other treatments. Also, in case of cultivars Azad and New Slection2 were observed to be on-par with each compared to other cultivars *i.e.*, 3.67 and 3.67 respectively followed by Vallabh Sharad, New Selection 1 and Vallabh Priya *i.e.*, 7.33, 6.67 and 5.33 respectively (Table 5). Also, the CV value of 5.55 indicates maximum significance in the treatment.

Table 6: Mean values for the number of tillers.

		CONTROL	50MM	100MM	
		A1	A2	A3	MEAN
VALLABH SHARAD	B1	5.0	4.0	4.0	4.3 a
NEW SELECTION 1	B2	5.0	4.0	4.0	4.3 a
VALLABH PRIYA	B3	4.0	3.0	3.0	3.3 b
AZAD	B4	4.0	3.0	3.0	3.3 b
NEW SELECTION 2	B5	4.0	2.0	3.0	3.0 c
MEAN		4.4 a	3.2 b	3.4 c	

	SE(M)	CD 5%	CV
A	0.04	0.13	4.68
B	0.06	0.17	
A X B	0.10	0.29	

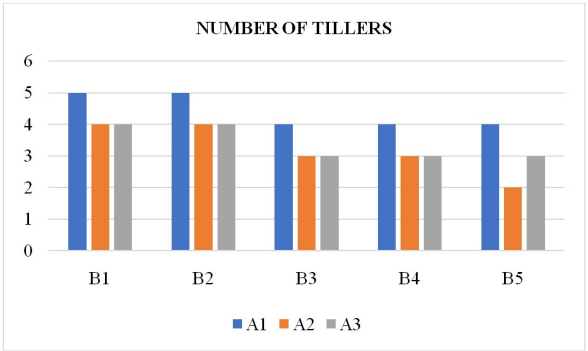

Fig. 6. Observations for the number of tillers 90 days after treatment.

Number of tillers: Cultivars Vallabh Sharad and New Selection1 gave maximum number of tillers in this stage compared to other cultivars with their mean values 5, 4 and 4 respectively for both the cultivars in control, 50mM and 100mM concentrations (Fig. 6) (Mane *et al.,* 2018).

In case of DMRT, all the treatments showed significant variations among them *i.e.*, 4.4, 3.4 and 3.2 respectively for control, 50mM and 100mM concentrations. Also, in case of cultivars, Vallabh Sharad and New Selection1 were on-par with each other with mean values 4.3 and 4.3 respectively, followed by Vallabh Priya and Azad *i.e.*, 3.3 and 3.3 respectively whereas, New Selction2 showed significant variation compared to the other cultivars *i.e.*, 3.0. Along with this, the CV value of 4.68 indicates that the treatment is significant (Table 6).

Therefore, in our study with respect to morphological parameters in this stage suggests that there is significant

reduction of certain parameters like plant height and longest leaf length where control is maximum compared to the treatments but under such conditions, 100mM concentrations gave better results compared to 50mM concentrations for these two parameters in this stage for Vallabh Sharad followed by New Selection 1 compared to other cultivars, with differences in their mean values indicated by using DMRT.

Also, in case of longest leaf width 100mM was observed to show maximum increase compared to controls in each of the cultivar and was recorded maximum in case of Vallabh Sharad followed by New Selection1 in this stage followed by the observations of their means recorded using DMRT.

Finally in this stage, it was observed that the total number of leaves and tillers were maximum in case of controls, and reduced in 50mM and 100mM in all the cultivars but maximum number of leaves and tillers were recorded in Vallabh Sharad and New Selection1. Therefore, our study indicates that Vallabh Sharad followed by New Selection1 gave maximum plant height in controls and treatments.

CONCLUSION

To conclude, the FCRD method using R-software along with DMRT was determined to be a successful and accurate software in analyzing the morphological data against salinity stress on all the five cultivars of turmeric along with the treatments. It was understood that any turmeric plants with maximum height, large leaf area, longest leaf length, maximum number of leaves and tillers indicates healthy growing conditions and were advisable for the cultivation. If these parameters were also achieved even under severe salinity stress conditions which indicates that the crop was able to withstand the stress conditions and promote maximum growth so that the growth of the rhizomes will be affected in a positive way along with the curcumin content should be taken into consideration and the breeding objectives of such cultivars needs to be improved. Therefore, in our study Vallabh Sharad followed by New Selection 1 can be considered as the crops to be cultivated under salt stress conditions as their mean values and their growth patterns were almost similar to their controls in that very particular stage. It was also advisable that this North East Indian region which has maximum genetic diversity and many turmeric cultivars should be considered for maximum experimentation with this regard.

FUTURE SCOPE

The interaction between the soil salinity and the morphological characters of all the five selected cultivars will help in the selection of the suitable and superior cultivars under salt stress conditions so that these superior cultivars identified in our study Vallabh Sharad and New Selection 1 are advisable for cultivation under salt stress conditions to obtain maximum rhizome yield along with maximum curcuminoid content.

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Conflict of interest. None.

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