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Performance of flower and medicinal plants with saline irrigation water through drip system

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Abstract
A field experiment was conducted during *rabi* season of 2017-18 and 2018-19 at Saline Water Scheme, Ag College Farm Campus, Bapatla on sandy loam soil to evaluate the performance of marigold, chrysanthemum and tulasi crops with saline water through drip irrigation system. The experiment was laid out in split plot design with three replications. The crops *viz*, marigold, chrysanthemum and tulasi were considered as main treatments and five salinity levels of irrigation water *viz*, BAW (0.6 dSm^{-1}), 2, 4, 6 and 8 dSm^{-1} were considered as sub treatments. The results revealed that significantly maximum number of flowers 148 and 158.6 in marigold crop, 95 and 96.8 number of flowers in chrysanthemum crop was recorded with BAW (EC 0.6 dSm^{-1}) treatment among the different levels of saline water through drip irrigation, respectively. Increased salinity levels caused yield reduction by % 69.6, 71.8 and 64.2 and 68.1% in marigold and chrysanthemum crops when irrigated with salinity level of 8 dSm^{-1}. In Tulasi crop 9220 and 8645 kg ha^{-1} biomass yield was recorded irrigated with salinity level of 0.6 dSm^{-1}.

Keywords: Salinity, dSm^{-1}, drip irrigation, saline water, medicinal plants

Introduction
Quality of water has become a major concern due to high pressure on water resources from different sectors for a country like India. With the increase in pressure for good quality of water resources, the agriculture sector is one which was pushed to sustain in over-exploited water resource areas due to low cost of land value. In these areas because of overexploitation of freshwater resources, encroachments in recharging points, change in rainfall pattern, and increase in seawater temperature pushing the seawater intrude freshwater aquifers there by water resources quality along the coast is decreasing at an alarming rate. In a country like India, agriculture remains a primary source of employment for nearly half of its working force for sustenance because of which farmers (including tenants) look to reduce the proportion of the fixed cost of production to the lowest possible. Small and marginal farmers are more affected due to changes in the quality of water that generally practices floriculture and medicinal plants. Besides the above, members of the nursery and landscape industries are increasingly turning to recycled, often saline, wastewaters as a valuable alternative to the use of freshwater for irrigation. Limited information is available on the effect of poor quality of water on the growth, yield, and quality of the above plants. Members of the nursery and landscape industries are increasingly turning to recycled, often saline, wastewaters as a valuable alternative to the use of freshwater for irrigation. Little information is available to floral and nursery producers, however, on the usage of the limit of poor quality water on the growth, yield, and quality of many ornamental species. Likewise, landscape designers and gardeners have few guidelines for the selection of plant species suitable for sites where soils are saline or irrigation waters are high in salinity.

Use of marginal quality water becomes necessary in and around urban areas and coastal areas because of which building of salinity on land areas. With the use of semi-saline under groundwater leads to gradual buildup of Na^+ and Cl^- in the root Zone (Sonneveld, 2000).

Salinity is of concern because of its deleterious effect on plant growth, visual injury, flower distortion, reduced stem length, nutritional imbalance, and marketable quality of plant and flower. Plant growth is detrimentally affected by salinity as a result of the disruption of certain physiological processes that lead to reductions in yield and/or quality. Growth, yield, and quality reduction may occur through a decrease in the ability of plants to take up water from the soil solution and the destruction of soil structure (Barrett Lennard, 2003) [2]. In addition, toxicity resulting from an excessive concentration of certain ions, principally Na^+, Ca^{2+}, Mg^{2+},

Cl^-, SO_4^{2-} and HCO_3^- as well as nutritional imbalances (Grattan and Grieve, 1999) [6] may also play important roles in the response of plants in saline environments.

In India, the area under floriculture is (60487 ha). The highest area under floriculture was found in Karnataka (20,780 ha), followed by Tamil Nadu (16,745 ha), West Bengal (13,720 ha), Andhra Pradesh (8,420 ha) (Rachana kolambkar *et al*., 2014) [14]. These states together accounted for 98.64% of the total area in the country. Karnataka alone accounts for nearly 75% of total floriculture exports from the country at 10 million and rose to dominate at 90%. The area under floriculture in Maharashtra during 2010-11 was is 15000 ha, out of which marigold contributes 29% share with an area of 4350 hectares. While the production of floriculture is 64,400 million tones out of which marigold contributes 33,488 million tones which is an account for about (52%).

Most horticultural crops are glycophytes (Greenway and Munns, 1980) [7] and range from salt-sensitive to moderately salt-tolerant. Producers of ornamental species are, therefore, reluctant to use water of poor quality for irrigation because they consider floricultural species to be highly sensitive. However, studies have demonstrated that moderately saline waters can be used to irrigate certain ornamental species without compromising economic value (Friedman *et al*., 2007 and Carter and Grieve, 2008) [4, 3]. Marigold and chrysanthemum are the most important annual ornamental species used in beds or borders of landscape settings and/or as cut flowers (Nau, 1997) [13]. Huang and Cox (1988) [8] rated the tall marigold 'First Lady' as moderately tolerant to salinity; plants grown in peat perlite medium exhibited symptoms of toxicity only when the electrical conductivity (EC) of a NaCl + $CaCl_2$ solution exceeded 7.9 dSm^{-1}. However, little is known about the effect of salinity on marigold performance when the pH of the irrigation waters is also high. The high pH of irrigation water is associated with high concentrations of HCO_3 and CO_3^{2-} and eventually alters plant growth by rendering micronutrients insoluble. Cultivation of medicinal plants on degraded lands or irrigated with poor quality water is more feasible and profitable. These will not only provide better economic returns but also help in ameliorating the saline environment.

Saline water through drip irrigation system maintains high soil matric potential in the root zone thus compensate the decrease of osmotic potential and the constant the high total water potential can be maintained for crop growth as its characteristics of low rate and high frequent irrigations over a long period of time (Kang, 1998) [10]. To mitigate the salinity problem to a certain extent the saline water through drip irrigation is considered an important research subject in this study. In recent years, due to drought and its yield has declined. Drip irrigation delivers water through the use of pressurized pipes that run close to the plants and that can be placed on the soil surface or below ground. This method is highly efficient because only the immediate root zone of each plant is wetted. Drip irrigation is reported to help achieve yield gains of up to 100%, water savings of up to 40-80%. Research efforts have addressed irrigation management in floriculture and medicinal crops with irrigation methods to meet production demands. The present study was designed to compare the growth of three crops in response to irrigation with different levels of saline water through the drip irrigation system.

A field experiment was conducted in Saline Water Scheme, Agricultural College Farm Campus, Bapatla during 2017-18 and 2018-19. The experiment was conducted in split plot design replicated thrice in permanent fixed layout. The main treatments were crops *viz.*, marigold, chrysanthemum and tulasi with irrigated with five salinity levels of 0.6, 2, 4, 6 and 8 dS m^{-1} were taken as a sub treatments. The experimental soil was sandy loam having a pH of 7.6 and EC 0.45 dS m^{-1}, low in available nitrogen (75kg N ha^{-1}) medium in phosphorous (27 kg P_2O_5 ha^{-1}) and high in potassium (320 kg K_2O ha^{-1}). Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and murate of potash, respectively. All other agronomic practices were followed as per recommendation. The data were collected on five randomly selected plants in each plot and the data were subjected for statistical analysis.

Results and Discussion

Fig 1: View of flower/medicinal plants with saline irrigation water through drip system

Growth and yield of marigold crop

Irrigation with saline water negatively affected plant growth and the growth parameters with the increase of salinity levels. Plant height was significantly affected by salinity levels in marigold. The highest plant height of 62.4 and 59.1 cm in marigold crop was observed at a salinity level of 0.6 dS m^{-1} (BAW) and it was on par with 2 and 4 dSm^{-1}, which was significantly superior to the 6 and 8 dSm^{-1} whereas, the lowest plant height of 39.3 and 41.8 cm was observed at the maximum salinity level of 8 dSm^{-1} during 2017 and 2018. Marigold crop growth was decreased by increasing ECiw, probably in response to limited cell expansion resulting from osmotic stress (Munns and Tester, 2008) [12]. The branch number was decreased significantly with each increment in salinity level. The maximum number of branches was observed with BAW (0.6 dSm^{-1}) treatment (13.1 and 12.2) and was found to be on par with 2 and 4 dSm^{-1} and these were significantly superior to the rest of salinity levels. The minimum number of branches was observed at the 8 dSm^{-1} treatment (5.3 and 7.4). From the data, it could be inferred that, as the salinity increased from 0.6 dSm^{-1} to 8 dSm^{-1} the number of branches was decreased. This might be due to the disruption of normal growth and development of plant with an increase in salinity. The salinity decreases drymatter production (Janila *et al*., 1999) [9]. Salinity, which causes reductions in yield, is one of the important abiotic constraints in crop production. Consequently, there is a differential reduction in growth and yield when grown with salt water. The data pertaining to the number of flowers were found to be significantly influenced by salinity levels. The results revealed that the maximum number of flowers 148 and 158.6 in marigold crop were recorded with BAW treatment during 2017 and 2018 respectively. Marigold registered 148 & 158.6 flowers/plant at ECiw of 0.6 and reduced to 69.6 & 71.8% at ECiw of 8.0 with 45.2 & 44.7 flowers/plant during 2017 and 2018. In marigold 50% yields were obtained at water salinity levels of 5.5 dSm^{-1} respectively. The lowest number of flowers was observed at the highest salinity level of 8 dS m^{-1} during the two years of study. The significant and gradual reduction in yield with a progressive increase in soil salinity could be mainly due to the cumulative effect of yield attributing characters. Under salinity stress, plants tend to record low yields because of adverse effects of salinity on such parameters as relative water content, total dry weight, plant height, and number of leaves per plant (Singh and Jain, 1989) [16]. This is because salinity inhibits plant growth by exerting low water potentials, ion toxicity, and ion imbalance. Salinity has been shown to negatively affect yield in *Brassica napus* (Zadeh and Naeini, 2007) [17].

Table 1: Performance of marigold crop at different salinity levels of water

ECiw levels	Plant height (cm)		No. of branches/ plant		No. of flowers/plant		Percent reduction	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
BAW	62.4	59.1	13.1	12.2	148.0	158.6	--	--
2EC	59.6	56.2	11.6	11.1	134.8	133.7	9.5	15.7
4EC	56.7	54.6	9.9	10.4	110.5	117.5	33.8	38.5
6EC	48.5	48.6	6.5	7.8	61.4	69.8	58.8	56.0
8EC	39.3	41.8	5.3	7.4	45.2	44.7	69.6	71.8
S.Em+	2.5	1.9	1.1	0.7	13	14	--	--
CD(0.05)	7.4	5.6	3.2	2.2	38	40	--	--
CV (%)	6.3	7.2	5.3	6.4	7.5	8.2	--	--

Table 2: Threshold irrigation water salinity of Marigold during 2017-18 and 2018-19

Marigold				
Yield Level (%)	2017-18		2018-19	
	No. of Flowers/Plant	ECiw (dSm^{-1})	No. of flowers/plant	ECiw (dSm^{-1})
100	148.0	0.73	158.6	0.38
90	133.2	1.72	142.7	1.41
80	118.4	2.72	126.9	2.43
70	103.6	3.71	111.0	3.46
60	88.8	4.71	95.2	4.49
50	74.0	5.70	79.3	5.51
40	59.2	6.70	63.4	6.54
30	44.4	7.69	47.6	7.56
20	29.6	8.69	31.7	8.59
10	14.8	9.68	15.9	9.61
0	0.0	10.68	0.0	10.64

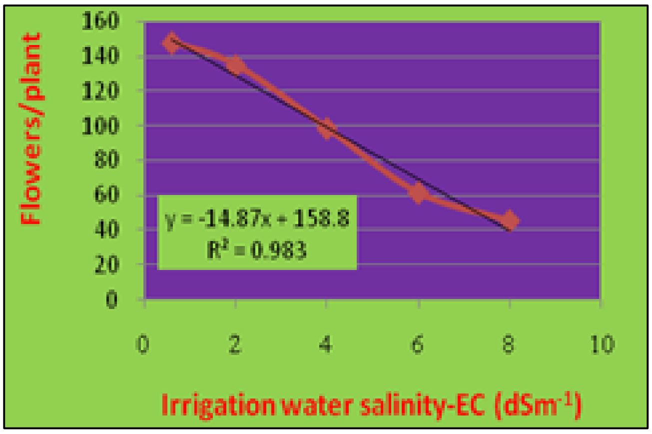

Fig 2: Marigold flowers/plant 2017-18

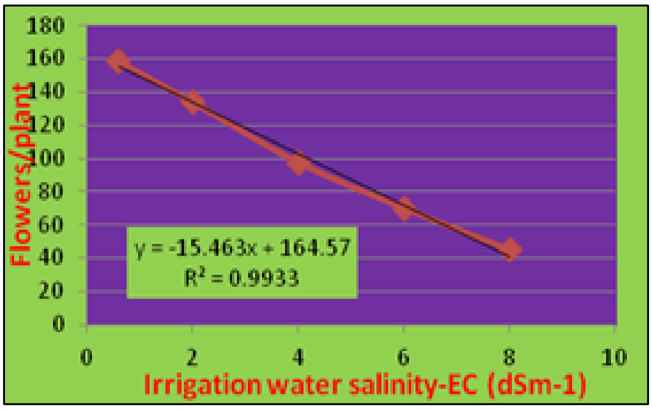

Fig 3: Marigold flowers/plant 2018-19

Growth and yield of chrysanthemum crop

Data revealed that plant growth and yield were decreased with the increase of salinity levels. In Chrysanthimum crop plant height was significantly affected by salinity levels. The highest plant height of 46.2 & 48.6 cm in chrysanthimum crop, was observed at a salinity level of 0.6 dSm^{-1} (BAW) and it was on par with 2 and 4 dSm^{-1}, which was significantly superior to the 6 and 8 dSm^{-1} whereas, the lowest plant height of 30.5 & 31.8 cm was observed at the maximum salinity level of 8 dSm^{-1}. Alam *et al*. (2004) [1] reported that low plant height was observed due to reduced photosynthesis, which in turn limited the supply of carbohydrates needed for growth. The data indicated that salinity levels and their interaction significantly influenced the number of branches. The branch number was decreased significantly with each increase in salinity level irrespective of crops. The maximum number of branches was observed with BAW treatment (12 & 11.4) and was found to be on par with 2 and 4 dSm^{-1} and these were significantly superior to 6 and 8 dSm^{-1}. The minimum number of branches was observed at the 8 dSm^{-1} treatment (4.3 and 5.4). From the data, it could be inferred that, as the salinity increased from 0.6 dSm^{-1} to 8 dSm^{-1} the number of branches was decreased. This might be due to the disruption of normal growth and development of plants with an increase in salinity. Garg, 2004 [5] and Leithy *et al*. (2009) [11] stated that salinity affected most of the morphological parameters and decreased the growth performance. The data pertaining to the number of flowers were found to be significantly influenced by salinity levels in different floriculture crops. The results revealed that the maximum number of flowers (95 and 96.8) in the chrysanthemum was recorded with BAW treatment during 2017 and 2018. The results indicated that chrysanthemum recorded 95 and 96.8 flowers/plant at 0.6 ECiw and reduced to 64.2 & 68.1% at 8.0 ECiw by recording 34.2 and 30.9 flowers/plant. The lowest number of flowers (34.2 and 30.9) was observed at the highest salinity level of 8 dS m^{-1} during the two years of study. The significant and gradual reduction in yield with a progressive increase in soil salinity could be mainly due to the cumulative effect of yield attributing characters. Under salinity stress, plants tend to record low yields because of adverse effects of salinity on such parameters as relative water content, total dry weight, plant height and the number of leaves per plant (Singh and Jain, 1989) [16].

Table 3: Performance of chrysanthemum crop at different salinity levels of water

ECiw levels	Plant height (cm)		No. of branches/ plant		No. of flowers/plant		Percent reduction	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
BAW	46.2	48.6	12.0	11.4	95.0	96.8	--	--
2EC	44.3	44.6	10.4	10.4	82.4	83.9	13.6	13.3
4EC	40.8	42.8	8.9	9.2	75.2	72.2	31.6	35.7
6EC	34.4	35.5	5.2	6.0	48.3	44.4	49.5	54.1
8EC	30.5	31.8	4.3	5.4	34.2	30.9	64.2	68.1
S.Em+	2.1	2.3	1.1	0.9	8	8.7	--	--
CD(0.05)	6.3	7.0	3.3	3.0	24	26	--	--
CV (%)	7.6	8.2	6.4	7.5	8.3	7.9	--	--

Table 4: Threshold irrigation water salinity of Chrysanthimum during 2017-18 and 2018-19

Yield Level (%)	Chrysanthimum 2017-18 No. of Flowers/Plant	Chrysanthimum 2017-18 ECiw (dSm^{-1})	Chrysanthimum 2018-19 No. of flowers/plant	Chrysanthimum 2018-19 ECiw (dSm^{-1})
100	95.0	0.47	96.8	0.48
90	85.5	1.62	87.1	1.54
80	76.0	2.77	77.4	2.60
70	66.5	3.91	67.7	3.67
60	57.0	5.06	58.1	4.73
50	47.5	6.21	48.4	5.80
40	38.0	7.36	38.7	6.86
30	28.5	8.50	29.0	7.93
20	19.0	9.65	19.4	8.99
10	9.5	10.80	9.7	10.05
0	0.0	11.94	0.0	11.12

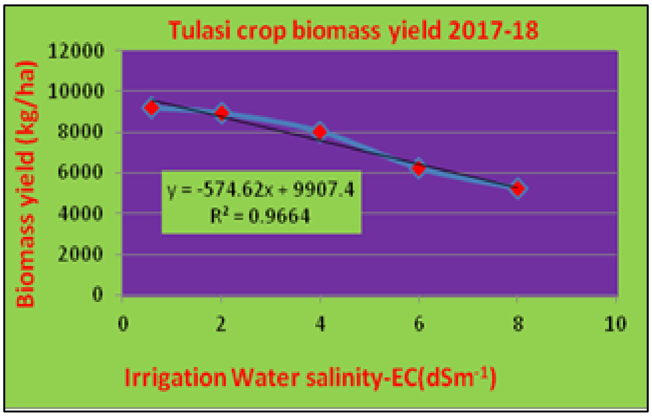

Fig 4: Tulasi crop biomass yield 2017-18

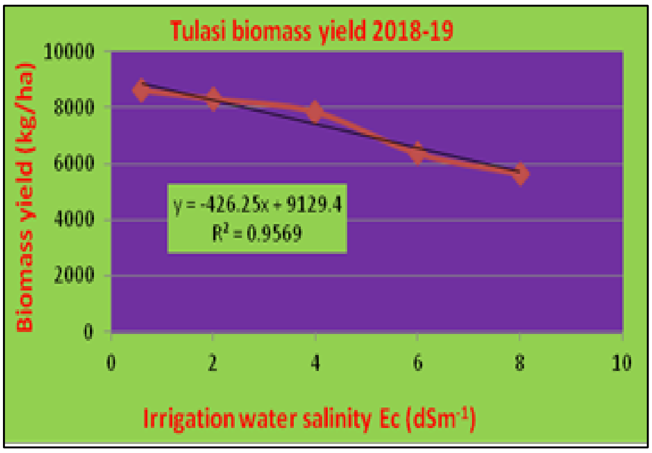

Fig 5: Tulasi crop biomass yield 2018-19

Growth and Biomass yield of Tulasi crop:

The data pertaining to biomass yield was found to be significantly influenced by salinity levels in tulasi crop. The results revealed that maximum biomass yield of 9220 and 8645 kg ha^{-1} was recorded with BAW treatment during 2017 and 2018, respectively. However, Tulasi recorded 9220 & 8645 kg ha^{-1} of biomass at 0.6 ECiw and reduced to5230 & 5652 kg ha^{-1} at ECiw of 8.0 and there was a reduction of 43.5 & 35.2%. The salinity decreases biomass production (Singh *et al*., 1989) [16]. It clearly showed that tulasi was more tolerant to salinity as compared to chrysanthemum and marigold. The lowest biomass yield of 5230 and 5652 kg ha^{-1} was observed at the highest salinity level of 8 dSm^{-1}. Saira *et al*., 2014 [15] reported that salinity decreased the fresh and dry weights of both shoots and roots of medicinal plants.

Table 5: Performance of medicinal plants at different salinity levels of water

ECiw levels	Plant height (cm)		Biomass yield (kg ha^{-1})		Percent reduction	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
BAW	65.2	67.2	9220	8645	--	--
2EC	61.0	65.1	8960	8333	10.9	3.5
4EC	57.6	60.3	8050	7862	18.5	14.0
6EC	45.3	47.2	6240	6374	32.6	26.5
8EC	42.8	43.8	5230	5652	43.5	35.2
S.Em+	3.8	4.2	533	425	--	--
CD(0.05)	11.4	12.5	1589	1276	--	--
CV (%)	7.6	6.8	8.9	9.2	--	--

Table 6: Threshold levels of irrigation water salinity to yields of Tulasi during 2017-18 and 2018-19 cropping season

Yield Level (%)	Tulasi			
	2017-18		2018-19	
	Biomass yield (t ha^{-1})	ECiw (dSm^{-1})	Biomass yield (kg ha^{-1})	ECiw (dSm^{-1})
100	9220	0.46	8645	0.94
90	8280	2.20	7740	2.96
80	7360	3.94	6883	4.97
70	6445	5.67	6024	6.98
60	5524	7.41	5168	9.00
50	4625	9.14	4387	11.01
40	3683	10.88	3446	13.03
30	2760	12.62	2582	15.04
20	1847	14.35	1720	17.05
10	925	16.09	860	19.07
0	0	17.82	0	21.08

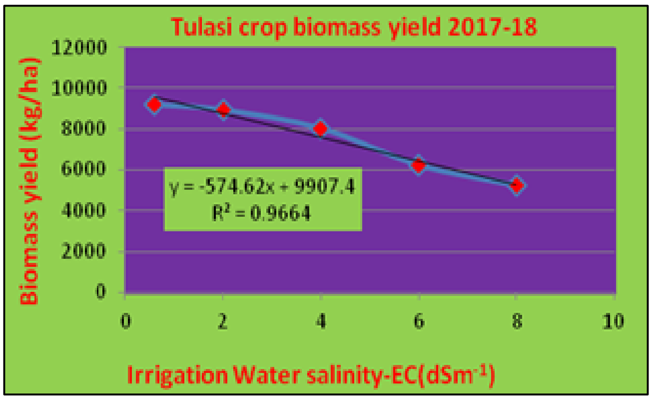

Fig 6: Tulasi crop biomass yield 2017-18

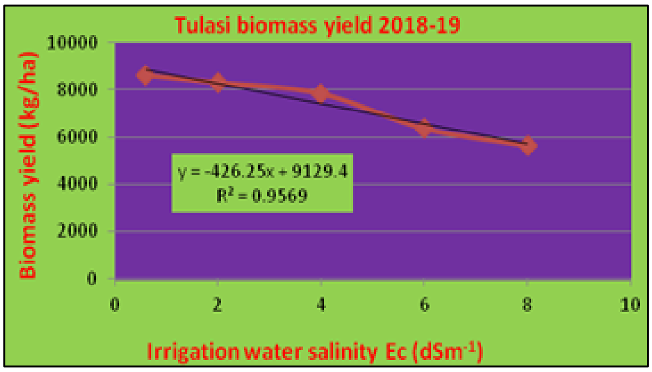

Fig 7: Tulasi biomass yield 2018-19

The relative profit analysis depicted in the figure indicated that the profitable returns are obtained only upto 4 dSm^{-1}. The data presented in table 7 regarding various properties of initial and final soils at 2 and 4 dSm^{-1} indicated an increase in EC, pH and available potassium content whereas the available nitrogen and phosphorous decreased.

Table 7: The initial and final soil properties during 2017-18

Sl.No.	Parameter	2 dS m^{-1}			4 dS m^{-1}		
		Initial	Final	Change, %	Initial	Final	Change,%
1.	E.C. dS m^{-1}	0.5	0.7	40.0	0.7	1.10	57.1
2.	pH	7.4	7.7	4.0	7.6	7.8	2.60
3.	N, kg ha^{-1}	295.0	244.0	-17.3	282.5	171.0	-39.5
4.	P_2O_5, kg ha^{-1}	27.0	24.0	-11.1	26.5	20.25	-23.6
5.	K_2O, kg ha^{-1}	320.0	330.0	3.13	310.5	328.0	5.64

The electrical conductivity of the initial and final soil samples revealed an increase of 40-57.1% rise in soil salinity due to the application of 2-4 dS m^{-1}. But for every season, the available nitrogen got reduced by 17.3-39.5%, *i.e.* 25.5 kg ha^{-1} to 27.75 kg ha^{-1} for every increment of irrigation water salinity by 1 dSm^{-1}. Similarly available phosphorous got reduced by 11.11-23.6%, *i.e.* 1.5-1.6 kg ha^{-1} for every increment of irrigation water salinity by 1 dSm^{-1}. The available potassium levels were found slightly increased due to irrigation with saline water.

Table 8: Soil fertility status at the start and at harvest of the crops during 2018-19

S. No.	Parameter	2 dSm^{-1}			4 dSm^{-1}		
		Initial	Final	Change %	Initial	Final	Change%
1.	E.C. dS m^{-1}	0.5	0.7	40	0.8	1.30	62.5
2.	pH	7.4	7.7	4	7.5	7.9	2.60
3.	Avail. N kg ha^{-1}	291	246	-15.5	272	172	-36.8
4.	Available P_2O_5 kg ha^{-1}	30	26	-13.3	26.7	20.5	-23.2
5.	Available K_2O kg ha^{-1}	324	336	3.70	312.5	330	5.60

The initial and final soil sample analysis revealed that there is a 40-62.5% rise in soil salinity due to the application of 2-4 dSm^{-1} irrigation water. But for every season, the available nitrogen is getting reduced by 15.5-36.8%, i.e. 45.0 kg ha^{-1} to 100 kg ha^{-1} for every increment of irrigation water salinity by 2 dSm^{-1}. Similarly available phosphorous got reduced by 13.3-23.2%, *i.e.* 4.0-6.2 kg ha^{-1} for every increment of irrigation water salinity by 2 dSm^{-1}. The available potassium levels are found slightly increased due to irrigation with saline water.

Conclusion

From this study, it was indicated that the maximum yield and yield attributing parameters were recorded all three crops were irrigated with BAW (0.6 dSm^{-1}) which was on par with 2 and 4 EC salinity levels and it was significantly superior to 6 EC and 8 EC irrigation water. Out of three crops studied, tulasi is more tolerant crop when compared to other two crops. Application of saline water through drip system reduced the availability of nitrogen, phosphorous even at 4 dSm^{-1}. It was concluded that marigold, chrysanthemum and tulasi crops irrigated with saline water upto 4 EC was economical when compared to 6 and 8 EC salinity levels through drip irrigation system.

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