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YIELD RESPONSE OF VEGETABLE CROPS IRRIGATED WITH DIFFERENT QUALITY OF IRRIGATION WATER UNDER DRIP

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Abstract- To obtain the irrigation water threshold salinity levels of different vegetables crops, i.e. Okra, Tomato and Brinjal for achieving 90, 75 and 50 % normal yield levels as well as to study the changes in soil salinity levels an experiment was conducted in an area of 35X27.5 sq.m through drip irrigation in the saline water scheme, Bapatla. Data on different parameters of the experiments related to the root growth, plant height, salinity levels and yield response under different salinity levels of irrigation water are collected. Among the various irrigation treatments followed, the yields of Okra were significantly different and maximum yield was observed in fresh water treatment (0.5 dSm-1) and corresponding reduction of 7.6 %, 45 % and 68 % in yield under 2 dSm-1, 4 dSm-1and 6 dSm-1treatments respectively. In case of Tomato the corresponding reduction in yield was 3.94 %, 28 % and 48 %, respectively, whereas for Brinjal the corresponding values were 9.1 %, 31 % and 76 % respectively.

Keywords: Salinity levels, Quality of Irrigation water, Drip Irrigation

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Introduction

Land and water resources are the basic needs of agriculture and economic development of any country. The demand for these resources will continue to grow due to ever increasing population. The world population is increasing faster than the food supply. India only has 2.4% of land mass and 4% fresh water resources of the world. We are however required to support 17% of the world population and growing at 2 % per annum. Whereas the per capita land availability has dwindled water from 0.48 ha to 0.15 ha and water availability has been reduced from 5300 cum to 1500 cum. Agriculture uses about 70-80 % of total available water. Water is recognized as a vital resource for life, human development and environmental sustainability. Using water, it is possible to increase the intensity of cultivation up to 300 % or more and large areas of waste lands can be brought under cultivation. There is a crying need for coherent, integrated irrigation water conservation and management policy and practices.

In micro irrigation water is applied at low pressure over a long period of time at frequent intervals directly into the plant root zone through a network of main lines, sub mains and lateral line with emission points spaced along their length. Micro irrigation system saves water, increase yield per unit of water, energy and soil. It ensures 30-70 % saving in water, a 25-100% increase in yields and 15-30% reduction in operating and crop production costs. Resultantly it can double the area under micro irrigation and crop production as well as improve quality of the end product. It can lead to value added exports, result in greater social equality, conservation of precious natural resources, promote and protect the environment and ecology and can transform agriculture. It is difficult to imagine a second green revolution without micro irrigation. It ranks near the top of the measure that offer great-untapped potential and ensure more crop per drop. It can reduce the burden of the government in the long term by reducing capital, operational and maintenance cost of surface irrigation and storage structures. It ensures user participation and promotes self-sufficiency.

In line source tubing irrigation system, emitting device are prefixed along the lateral lines. This provides continuous flow of water to form the wetting strip on the soil surface or sub surface around the root zone of the crops. For row crops, closely spaced crops like vegetables, cotton, flower crops and shrubs this system is suitable ideally. In present most of the vegetable, crops in India are grown using traditional methods of irrigation with good quality waters. Under the scares water situation, it is essential to use poor quality waters for agricultural productivity. As micro irrigation systems are proved to be water saving systems with higher productivity, it is considered to use poor quality waters with micro irrigation systems to minimize water utilization and to find the suitable tolerance levels of irrigation water quality for different levels of crop productivity. With this in view, an experiment was planned to study the response of different vegetable crops like Okra (Bendi), Tomato and Brinjal crops for different irrigation water quality under Micro irrigation system. The main objective is to study the yield response of different vegetable crops irrigated with different irrigation quality water under drip irrigation system.

Materials and methods

Experimental Details

The experiment was conducted in the field of Saline water scheme, Agriculture College Farm, Bapatla from 2nd week of December to 2nd week of April to check the response of Okra, Tomato and Brinjal with different saline water irrigations under drip irrigation. The experimental site consists of sandy soil and was analyzed for soil salinity in the layers of 0-15 cm, 15-30 cm and 30-60 cm ranges and the initial electrical conductivity (EC) is in between 0.22 dSm^{-1} and 0.46 dSm^{-1} and pH is about 7.6. For conducting an experiment, water requirement for the crop in micro irrigation system was obtained by estimating the potential evapotranspiration (PET) using Modified Penman's method. This method is based on the daily data of maximum and minimum temperatures, relative humidity, sunshine hours and wind velocity

Table-2.1 *Crop Water Requirement for different vegetables planted under drip irrigation experimental plots.*

Crop stage	Month	No of days	Mean ETP (mm/day)	Crop factor	Canopy factor	Mean CWR (mm/day)	Total CWR (mm)
Okra							
Initial 20d	December	20	3.63	0.45	1	1.634	32.68
Development 45d	January	30	4.38	0.75	1	3.285	98.55
Mid 50d	February	28	4.72	1.05	1	5.428	151.98
	March	12	5.24	1.15	1	6.026	72.31
Last	March	18	5.24	085	1	4.454	80.17
	April	7	5.23	0.85	1	4.446	31.12
Total crop period		**115**					**466.82**
Tomato							
Initial 20d	December	20	3.63	0.45	1	1.634	32.68
Development 45d	January	30	4.38	0.75	1	3.285	98.55
Mid 50d	February	28	4.72	1.05	1	5.428	151.98
	March	12	5.24	1.15	1	6.026	72.31
Last	March	18	5.24	0.85	1	4.454	80.17
	April	12	5.23	0.85	1	4.446	53.35
Total crop period		**120**					**489.04**
Brinjal							
Initial 20d	December	25	3.63	0.45	1	1.634	40.85
Development 45d	January	30	4.38	0.75	1	3.285	98.55
Mid 50d	February	28	4.72	1.05	1	5.428	151.98
	March	12	5.234	1.15	1	6.026	72.31
Last	March	18	5.24	0.85	1	4.454	80.17
	April	12	5.23	0.85	1	4.446	53.35
Total crop period		**125**					**497.21**

and is calculated by using the formula

Crop Water Requirement (CWR) = PET X Kc X Ke

Where PET = potential evapotranspiration

Kc = Crop factor

Ke = Canopy factor

Water requirement of the crop during various months of the year depends upon evapotranspiration (ET) and a crop coefficient depends upon growth stages of the crop. The irrigation water of different salinity levels applied through the drip irrigation system has been presented in ([7] [Table-2.1].

The area of the experimental field was 35 m X 27.5 m [Fig.-1]. The area of each plot was 5.85 Sq.m. The spacing between plants is 0.60 m. The spacing between two rows where there is lateral of inline drip micro irrigation system is 0.75 m.

Seeds of the Okra (Manisha-206), Tomato (Hybrid, Manasha-1702) and Brinjal (Shyama F1 Hybrid Dhaanya seed) were sown on 9th December 2009 in the experimental site. The irrigation water with different salinity levels was applied through drip from the tanks containing fresh water (0.5 dSm^{-1}), 2 dSm^{-1}, 4 $dSm^{-1}$and 6 dSm^{-1} respective plots of Okra, Tomato and Brinjal. All other field

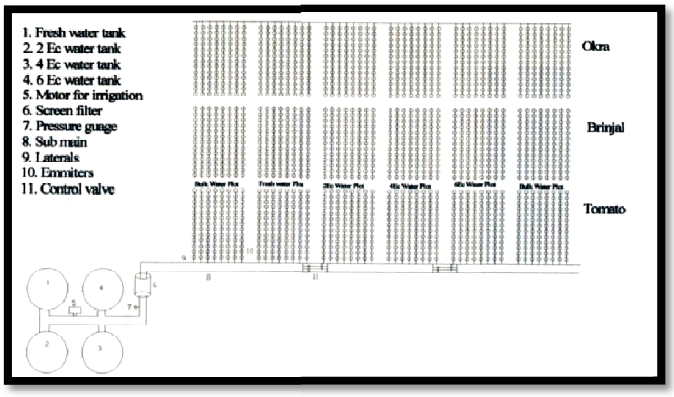

Fig-2.1 Experimental layout of AICRP Saline Water Scheme research farm, Bapatla

treatments including weeding and pest management practices are common and only irrigation treatments were varied with different levels of salinity.

Data Collection

Data on different parameters of the experiments related to the root growth, plant height, salinity levels and yield response under different salinity levels of irrigation water are collected. To know the performance of different irrigation treatments over Okra, Tomato and Brinjal crops with different levels of salinity the crop growth parameters like root growth, plant height, etc. are considered apart from the yield. For studying the response of the different irrigation water treatments on root growth and its distribution, soil around the selected plants in each plot was wetted after the completion of the crop period. After wetting the soil, it is left for afew minutes and then the crop is plugged off carefully without causing any damage to the root of the crop. This procedure is repeated to all plots of the field. Then the measurement is done by selecting two crops from each plot. The root depth was measured below the ground surface Where as the root distribution measure as the coverage. The effect of the saline water irrigation on the root depth and its coverage (as per random selection) of plant from each treatment were recorded in [Table-2.2].

After the initial stage the growth of the crops were observed and in the development stage flowers were yielded on the crop which are the indication of fruit development. When fruits were produced, the fruit of each crop i.e. Okra (Bendi), Tomato and Brinjal were harvested manually. The quantity of fruits was obtained from each row of each crop was recorded. This procedure of harvesting the each crop and knotting the harvested quantity is repeated for each harvesting time during the experimental period. The response of different crops in terms of yield to the water applied through drip is shown in [Table-2.3].

Table-2.3 *Water applied for corresponding Yield levels*

Crop	Water Applied (mm)	Yield (t ha^{-1})
Okra	466.82	3.78
Tomato	489.04	14.97
Brinjal	497.24	5.02

Results and Discussion

This chapter deals with the results of experimental observations that have been analyzed and discussed in relation to the Okra, Tomato and Brinjal under drip irrigation with different levels of saline irrigation water. The yield characteristics of the crops, root growth distribution etc are mainly discussed in this secession.

Root growth and plant height

The root depths of Okra, Tomato and Brinjal crops were measured in all the irrigation treatments. The observations on the root depth of all the above crops were presented in [Table-2.2].

The average root depth of Okra was 16.5 cm, 19.5 cm, 22 cm and 26 cm. Tomato for fresh, 2, 4, 6 dS/m irrigation waters respectively. The corresponding reading of root depth for the crop were 12 cm, 11 cm, 10.5 cm and 9.5 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively, whereas for the Brinjal crop, root depth were 12 cm, 13.5 cm, 15 cm and 16.5 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively. The minimum root depth was observed in fresh water irrigation treatment in all crops and the depth value increases as the salinity levels in the irrigation water increases. The mean coverage of roots of fruits for okra crop was 15.5 cm, 16 cm, 20 cm and 30 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively. The corresponding reading of root coverage for Tomato crop were 19 cm, 22 cm, 24 cm and 25 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} water respectively, whereas for the Brinjal crop , root coverage were 20 cm, 21.5 cm, 27 cm and 29 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively. The minimum root coverage is observed in fresh water irrigation treatments in all the crops and the coverage increases with the salinity level of irrigation water.

The heights of the Okra, Tomato and Brinjal crops were measured in all the irrigation water treatments. The observations on height were presented in the [Table-2.2]. The mean height of Okra was 110 cm, 100 cm, 88 cm and 78 cm for fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively. The corresponding reading for Tomato crop was 90 cm, 79 cm, 73 cm and 58 cm for fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-1} waters respectively and for Brinjal was 60 cm, 52 cm, 42 cm and 34 cm with fresh, 2 dSm^{-1}, 4 dSm^{-1} and 6 dSm^{-11} waters respectively. The maximum plant height was observed in fresh water treatment in all the crops and the plant height value reduces as the salinity levels in the water increases.

Response of Crop Yield

The yield of each crop decreased gradually with increased salinity ration of irrigation water [Table-3.1]. The information on mean yield of okra showed the drip irrigation with fresh water treatment recorded heights yield of 3.78 t ha^{-1} followed by 3.49 t ha^{-1}, 2.08 t ha^{-1}, 1.23 t ha^{-1}in drip irrigation with 2,4 and 6 dSm^{-1} water treatments, which means a yield reduction of 7.6%, 45% and 68% was assessed respectively.

The information on mean yield of Tomato showed that drip irrigation with fresh water treatment recorded the highest yield of 14.97 t ha^{-1} followed by 14.38 t ha^{-1}, 10.78 t ha^{-1}, 7.88 t ha^{-1} in drip irrigation with 2,4 and 6 dSm^{-1} water treatments, which means, a yield reduction of 3.94%, 28% and 48% was assessed respectively [8].

The information on mean yield of Brinjal showed that drip irrigation with fresh water treatment recorded the highest yield of 5.02 t ha^{-1} followed by 4.56 t ha^{-1}, 3.50 t ha^{-1}, 1.25 t ha^{-1} in drip irrigation with 2,4 and 6 dSm^{-1} water treatments, which means, a yield reduction of 9.1%, 31% and 76% was assessed respectively.

To develop a relation between salinity and yield, the salinity levels vs. mean yield were plotted and best-fit equations were developed for all the experimental treatments of [Fig.-3.1, 3.2 & 3.3]. The best fit curves are of polynomial in all cases and were presented below

For okra crop, $Y = -0.019x^2 - 0.366x + 4.063$

For Tomato crop, $Y = -0.113x^2 + 0.618x + 15.53$

For Brinjal crop, $Y = -0.113x^2 + 0.066x + 4.976$

In case of the fresh water scare coastal sandy regions, where rainfall is below optimum the irrigation with saline water can be used. With use of 1.7, 2.9 and 4.7 dSm^{-1} saline waters respectively in okra, and yield level of 90% (3.4 t ha^{-1}), 75% (2.84 t ha^{-1}) and 50% (1.89 t ha^{-1}) respectively of normal yield can be expected [Table -3.2].

With use of 2.4, 4.0 and 6.1 dSm^{-1} saline waters respectively in Tomato, and yield level of 90% (13.47 t ha^{-1}), 75 %(11.23 t ha^{-1}) and 50% (7.49 t ha^{-1}) respectively, of normal yield can be expected. With use of 1.4, 3.6 and 5.0dSm^{-1} saline waters respectively in Brinjal and yield level of 90% (4.52 t ha^{-1}), 75 % (3.77 t ha^{-1}) and 50% (2.51 t ha^{-1}) respectively of normal yield can be expected.

During the study period it was observed that the tomato and Brinjal crop cover the entire area with 60 cm X 75 cm spacing, where as Okra crop it was observed that the plant spacing was higher and need to be reduced for getting the following advantages. Narrow spacing of 40 X75 cm may be continued in drip line so that 50 % more population and 50 % higher yield can be expected. In sandy soils, it is generally observed that farmers are adopting more than 30 cm spacing and are realizing higher yields

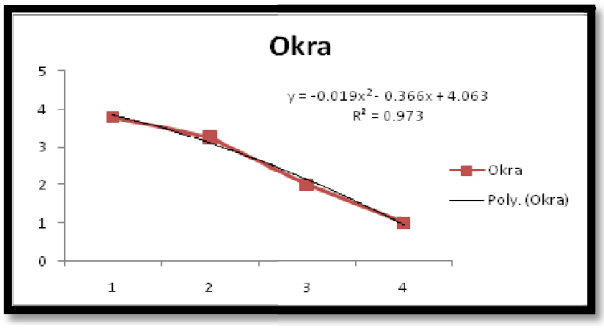

Fig- 3.1 Irrigation water salinity Vs Yield of Okra under drip

Table- 2.2 *Measurement of Plant growth in the field*

Okra					Tomato					Brinjal				
FW					FW					FW				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**
Root Depth	16.5	17.0	16.0	16.5	**Root Depth**	12.5	12.0	11.5	12.0	**Root Depth**	12.0	12.0	11.5	12.0
Root coverage	15.5	16.0	15.0	15.5	**Root coverage**	19.0	19.5	19.0	19.0	**Root coverage**	20.0	21.0	19.5	20.0
Plant height	112.5	112.0	113.0	112.5	**Plant height**	90.0	91.0	88.5	90.0	**Plant height**	64.0	63.0	65.0	64.0
2 EC					**2 EC**					**2 EC**				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**
Root Depth	19.5	20.0	19.0	19.5	**Root Depth**	11.5	11.0	10.5	11.0	**Root Depth**	13.0	13.5	13.5	13.5
Root coverage	16.0	16.5	15.5	16.0	**Root coverage**	22.0	22.0	22.5	22.0	**Root coverage**	21.5	22.0	21.0	21.5
Plant height	100.0	99.0	101.0	100.0	**Plant height**	79.0	78.0	80.0	79.0	**Plant height**	52.0	53.0	51.0	52.0
4 EC					**4 EC**					**4 EC**				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**
Root Depth	21.5	22.0	22.0	22.0	**Root Depth**	10.5	10.0	10.5	10.5	**Root Depth**	15.0	15.0	15.5	15.0
Root coverage	20.5	20.0	19.5	20.0	**Root coverage**	24.0	23.5	24.5	24.0	**Root coverage**	27.0	26.5	27.0	27.0
Plant height	90.0	90.5	90.0	90.0	**Plant height**	73.0	74.0	72.0	73.0	**Plant height**	42.0	41.5	43.0	42.0
6 EC					**6 EC**					**6 EC**				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**	**Parameters**	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**
Root Depth	26.5	27.0	26.0	26.5	**Root Depth**	9.5	9.0	9.5	9.5	**Root Depth**	16.50	17.00	16.00	16.50
Root coverage	30.0	31.5	28.5	30.0	**Root coverage**	24.5	25.5	25.0	25.0	**Root coverage**	29.00	28.00	30.00	28.00
Plant height	78.0	77.5	78.5	78.0	**Plant height**	59.0	58.0	59.5	59.0	**Plant height**	34.00	35.00	33.50	34.00

Table- 3.1 *Yield Response of Vegetables to irrigation water quality under drip irrigation (Yield in t ha^{-1})*

Drip line	FW	2 EC	4 EC	6 EC
Okra				
1	3.89	3.37	1.90	1.11
2	3.86	3.38	2.03	1.27
3	3.71	3.56	2.32	1.19
4	3.64	3.74	2.05	1.42
5	3.62	3.73	2.17	1.13
6	4.14	3.33	2.20	1.26
7	3.63	3.44	1.74	1.24
8	3.72	3.40	2.22	1.20
Mean	3.78	3.49	2.08	1.23
Tomato				
1	14.67	15.47	10.63	7.59
2	15.08	14.12	10.43	8.05
3	14.39	13.88	10.51	7.68
4	15.78	13.61	11.06	8.31
5	15.47	15.30	11.23	8.43
6	15.13	14.29	10.82	7.97
7	14.26	14.07	11.06	7.86
8	15.01	14.29	10.51	7.16
Mean	14.97	14.38	10.78	7.88
Brinjal				
1	4.72	4.52	3.68	1.28
2	4.86	4.56	3.54	1.34
3	5.36	4.48	3.36	1.48
4	5.12	4.72	3.48	1.12
5	5.20	4.78	3.64	1.28
6	5.24	4.42	3.34	1.18
7	4.92	4.50	3.70	1.10
8	4.76	4.46	3.24	1.22
Mean	5.02	4.56	3.50	1.25

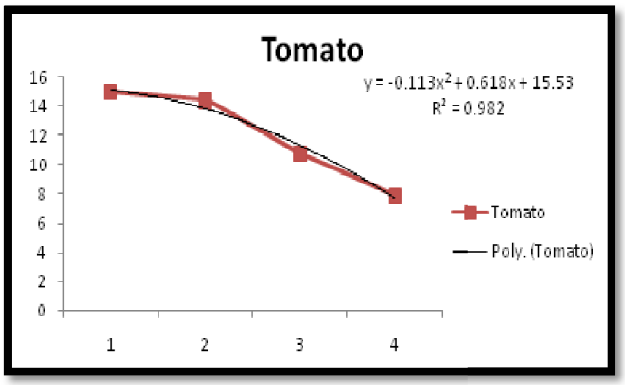

Fig- 3.2 Irrigation water salinity Vs Yield of Tomato under drip

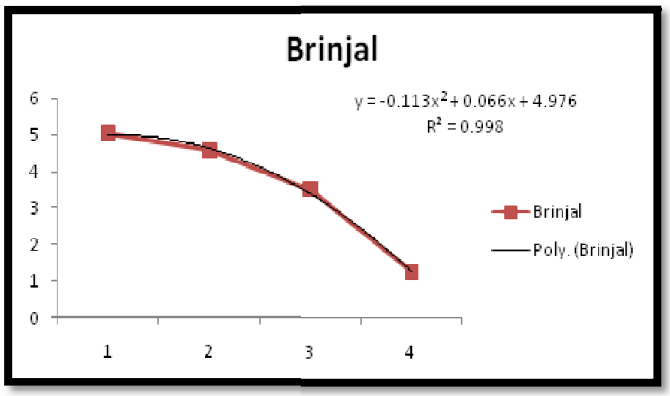

Fig- 3.3 Irrigation water salinity Vs Yield of Brinjal under drip

Table-3.2 *Salinity levels of irrigation water for different crops to achieve 90, 75 & 50 % of normal yield levels as per the established polynomial equations.*

Parameter	Possible yield and corresponding salinity of irrigation waters		
	90%	75%	50%
Okra			
Quantity (t ha^{-1})	3.40	2.84	1.89
Salinity (dSm^{-1})	1.65	2.90	4.70
Tomato			
Quantity (t ha^{-1})	13.47	11.23	7.49
Salinity (dSm^{-1})	2.40	4.00	6.10
Brinjal			
Quantity (t ha^{-1})	4.52	3.77	2.51
Salinity (dSm^{-1})	2.35	3.56	4.96

Conclusion

Okra, Tomato and Brinjal for achieving 90 %, 75 % and 50 % normal yield levels as well as to study the changes in soil salinity levels, this experiment was conducted. The salient conclusions of the experiments were as follows:

Among the various qualities of irrigation water treatments, the yields of Okra were significantly different and maximum yield was observed with fresh water treatment (0.5 dSm^{-1}) and corresponding yield reduction of 7.6 %, 45 % and 68 % were observed under 2,4 and 6 dSm^{-1} treatments respectively. In case of Tomato the corresponding reduction in yield was observed as 3.94 %, 28 % and 48 % respectively, whereas for Brinjal the corresponding reduction in yield values were observed as 9.1 %, 31 % and 76 % respectively.

In case of fresh water scarcity in coastal sandy regions, where rainfall is below the optimum level, then the irrigation with saline water can be planned. From the best fit equations developed for all the experimental treatments with the use of 1.7, 2.9 & 4.7 dSm^{-1} saline waters in Okra, 90 %, 75 % and 50 % of normal yield levels respectively can be achieved. With the use of 2.4, 4.0 and 6.1 dSm^{-1} water in Tomato crop, 90 %, 75 % and 50 % of normal yield levels respectively can be achieved. With the use of 1.4, 3.6 and 5.0 dSm^{-1} waters in Brinjal crop, 90 %, 75 % and 50 % of normal yield levels respectively can be achieved.

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