International Journal of Plant & Soil Science

Volume 36, Issue 5, Page 938-946, 2024; Article no.IJPSS.115112
ISSN: 2320-7035

Yield and Bio-Chemical Parameters of Onion (*Allium Cepa* L.) and Consequences of Saline Irrigation Water on It

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2024/v36i54590

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/115112

Original Research Article

Received: 04/02/2024
Accepted: 08/04/2024
Published: 13/04/2024

ABSTRACT

At Department of Agricultural Chemistry and Soil Science a pot experiment was conducted during the *rabi*, season of 2017-18. Department of Agricultural Chemistry and Soil Science situated at

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College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat. The objective of the study is to assess the consequences of saline irrigation water on yield of Onion (*Allium Cepa* L.) varieties. The study also possess the growth and nutrients composition of Onion (*Allium Cepa* L.) varieties and effect of saline irrigation water on it. Four levels of salinity are contained viz., < 2.0, 4.0, 6.0 and 8.0 dS m^{-1}. GJWO-3, GJRO-11, Talaj red, Pilli patti and PWF-131 these five varieties comprised in factorial completely randomized design with three replications. It found that the yield of chlorophyll a (5.77 mg/gf.wt), chlorophyll-b (4.22 mg/gf.wt), and total chlorophyll were significantly influenced by different levels of salinity, whereas; yield of fresh straw (37.03 g/pot), bulb (37.49 g/pot), RWC, proline (0.96 µmole/gf.wt), were significantly influenced among different varieties of onion tested.

Keywords: Onion; bulb yield; straw yield; salinity; proline; RWC; chlorophyll.

1. INTRODUCTION

"The most important commercial vegetable crop cultivated in India is Onion (*Allium cepa* L.). It belongs to family *Alliaceae*. It is the second most important vegetable crop after tomato grown in the world" [1]. Onion is most popular vegetable crop and widely produced within the alliums. Nearly 170 countries produce onion for their own domestic purpose, while international trade has also significantly influenced by it. According to [2] over 9.2 million acres of onion are harvested annually around the world. It is considered as hardy bulbous plant. For bulb production onion is an annual crop, while it is biennial for seed production [3,4]. Onion is a crop produced for short duration.

"It is reported that Gujarat state has 12.18 lakh ha of saline area. Plant growth and development adversely affected by soil salinity. Approximatly one-third of irrigated arable land is already affected at worldwide. This level is increasing continuously by salinity" [5]. A highly attractive approach to overcoming the salinity is to increase crop salt tolerance. Osmotic stress is increased by an excess of soluble salts in the soil. It results in ionic imbalances, specific ion toxicity and it affected on plant demise [6]. Salt-tolerant genotypes are a better alternative to salt-sensitive genotypes which are selected by conventional selection and breeding techniques.

Vegetative and reproductive stage of plant is affected by Salinity. Growth is reduced in vegetative stage, while the yield is declined in reproductive phase of plant [7]. "Quality of plant is adversely affected by stress of salinity. Leaf area and number of leaves is reduced. Leaf thickness and chloroplast per unit leaf area increased simultaneously because of lower photosynthesis [8,9]. Photosynthesis is measured in terms of chlorophyll. Proline, chlorophyll and RWC are important biochemical parameters to find out tolerence of crop varieties against salinity stress" [1]. Hence an experiment was conducted to evaluate the salinity tolerance of onion genotypes with objective of

1. To find out the consequences of saline irrigation water on production of onion varieties.
2. To find out the consequences of saline irrigation water on biochemical parameters of onion varieties.

2. MATERIALS AND METHODS

At Department of Agricultural Chemistry and Soil Science a pot experiment was conducted during the *rabi*, season of 2017-18. Department of Agricultural Chemistry and Soil Science situated at College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat above MSL with latitude of 20' 30' to 23 °N and longitude of 69°to 72°E. The silty clayey with pH 8.0, EC 0.58 dS m^{-1}, $CaCO_3$ 31.05 % and CEC 36.2 cmol (p^+) kg^{-1} was used for the experiment. The Available nitrogen was medium in soil (242 kg ha^{-1}). The available phosphorus was medium in soil of (34.20 kg ha^{-1}) with high in available potassium (298 kg ha^{-1}). The soil was high in available sulphur (23.50 mg kg^{-1}). The status of micro nutrient was law in available zinc (0.45 mg kg^{-1}) and medium in available iron (6.25 mg kg^{-1}), high in available manganese (15.20 mg kg^{-1}) with high in available copper (1.25 mg kg^{-1}). A Completely Randomization Design (CRD) with factorial concept with three replications was used in the experiment. 20 treatments comprised in the the research with all possible combinations of four levels of salinity viz; S_1 - <2 dS m^{-1}, S_2 - 4 dS m^{-1}, S_3 – 6 dS m^{-1}, S_4 - 8 dS m^{-1}, whereas; five varieties viz; V_1- GJWO-3, V_2- GJRO-11, V_3-Talaj

red, V_4- Pilli patti and V_5- PWF-131 were used. The N @ 20 kg ha^{-1} and P_2O_5 @ 40 kg ha^{-1} is the required quantity which was applied to all the pots in the research as basal dose in the form of urea (2.55 g urea/pot) and DAP (6.52 g DAP/pot). Five plants per each pot were maintained under normal practices after a of week germination. The saline water was given as per treatments when crop requires irrigation within entire growing season. First saline water was collected and then it was diluted till desired concentration was attained. At harvest of crop the yield were recorded and biochemical parameters at 45 DAS. Neck fall is the indication of maturity and crop was harvested after 3 to 4 months after sowing. The bio-chemical parameters like proline (Bates et al*.* ,1973), chlorophyll-a, chlorophyll-b and total chlorophyll (DMSO by Hiscox and Israelstam, 1979) were estimated. Statistical analysis was done by using method analysis of variance (ANOVA) for completely randomized factorial design (FCRD) by Panse and Sukhatme (1967).

3. RESULTS AND DISCUSSION

During winter season of 2017 temperature, evaporation sun shine, relative humidity, and wind velocity were the weather parameters more or less necessary for growth and development of onion crop. 27 to 37 ^{0}C and 10 to 20.5 ^{0}C was the mean maximum and minimum temperature during the crop growth and development period. The range of daily evaporation was 2.8 to 9 mm, relative humidity of 20 to 70 %, bright sun shine of 1.5 to 10.4 hrs and wind speed of 2.8 to 6.4 km hr^{-1} were recorded during the study, respectively. The growth characters like fresh weight of bulb, plant height, bulb diameter, volume of bulb and fresh straw weight were significantly influenced by salinity and varieties.

3.1 Yield Parameter

Different level of salinity affected significantly on fresh straw yield and fresh bulb yield of different varieties of onion crop (Table 1). The fresh straw yield has highest value of (23.53 g) and fresh bulb yield of (25.05 g) recorded with the variety (V_4) Pilli patti and interaction effect of salinity and varieties gives highest value in the interaction of S_1 (<2 dS m^{-1}) x V_4 (Pilli patti). Fresh straw yield (37.07 g) and fresh bulb yield (37.49 g) (Table 2 and 3). Ion uptake and capacity to adjust the osmotic pressure of the substrate without the danger of accumulating the excess salts cause for this tolerance to salinity, Hayward and Wadleigh [10]. This result has similarity with findings of Bernstein and Ayers [11] and Francois [12]. Bulb weight has decreased by salinity found by Singh and Pandita [13].

3.2 Bio-chemical Parameter

Biochemical parameters include RWC, proline, chlorophyll-a, chlorophyll-b and total chlorophyll at 45 DAT. Excluding proline all other parameters were found decreased with increasing salinity levels (Table 1).

Saline irrigation water applied of <2.0 dS m^{-1} (S_1), gave significantly higher value of RWC (73.83 %) (at 45 DAT) and chlorophyll-a content of (5.53 mg/gf.wt), chlorophyll b (3.92 mg/gf.wt) and total chlorophyll (11.75 mg/gf.wt). 8.0 dS m^{-1} gave lowest value of RWC (at 45 DAT) (61.59 %), chlorophyll-a (4.11 mg/gf.wt), chlorophyll b (2.65 mg/gf.wt) and total chlorophyll (8.54 mg/gf.wt). With increasing level of salinity, proline content was significantly increased. Application of 8.0 dS m^{-1} (S_4) saline irrigation recorded higher proline content (0.75 µmole g^{-1} of fresh weight), while lower proline content (0.35 µmole/gf.wt) was observed in <2.0 dS m^{-1} (S_1).

In case of variety significantly higher value of RWC (70.89 %) and total chlorophyll was recorded with variety V_4 (Pilli patti) which was statistically at par with V_1, chlorophyll a (4.93 mg/gf.wt), and lower value of RWC (63.66 %) (at 45 DAT), was of V_1 (GJWO-3). While in case of chlorophyll-a lower value (4.48 mg/gf.wt.) observed with V_3 (Talaja red). The highest chlorophyll-b (3.63 mg/gf.wt) was registered with V_4 (Pilli patti) and was lowest chlorophyll-b (3.00 mg/gf.wtht) V_5 (PWF-131) and lowest total chlorophyll (9.16 mg/gf.wt) was recorded of V_3 (Talaja red).

The combined effect of variety and salinity was found non-significant on RWC and total chlorophyll content of leaves of onion. Within the optimum conditions the water content of plants leaves is significantly greater than those of plants which were under high salinity conditions. The plants has limited water intake based on salt concentration in soil solution. Plants try to overcome water stress by increasing the concentrations of their intracellular osmotic compounds under these conditions. The salinity stress conditions cause decrease in relative water content [14,15]. Decrease in water content and inhibition of growth significantly induced by water stress in tolerant plants has been

Table 1. Bio-chemical parameters of onion at harvesting stage and consequences of salinity and varieties on yield

Treatment	Production parameters			Bio-chemical parameters (at 45 DAT)			
	Weight of fresh straw (gram)	Bulb Fresh weight (gram)	RWC (%)	Proline (µmole/gf.wt)	Chlorophyll a (mg per gf. weight)	Chlorophyll b (mg per gf. weight)	Total chlorophyll (mg per gf. weight)
Salinity (S)							
S_1 = <2.0 dS / m (tap water)	34.4	33.77	73.83	0.35	5.53	3.92	11.75
S_2: 4.0 dS m^{-1}	21.19	25.41	69.06	0.50	4.75	3.60	10.21
S_3: 6.0 dS m^{-1}	17.02	15.11	64.01	0.59	4.39	3.06	8.93
S_4: 8.0 dS m^{-1}	13.54	9.68	61.59	0.75	4.11	2.65	8.54
S.Em. ±	0.41	0.37	1.26	0.01	0.05	0.07	0.16
Critical Difference (P = 0.05)	1.16	1.06	3.59	0.03	0.16	0.20	0.46
Variety (V)							
V_1 - GJWO-3	23.49	24.37	69.85	0.59	4.92	3.54	10.41
V_2 -GJRO-11	19.01	19.58	65.85	0.48	4.63	3.26	9.88
V_3 -Talaja red	20.34	19.57	65.37	0.5	4.48	3.11	9.16
V_4 -Pilli patti	23.53	25.05	70.89	0.63	4.93	3.63	10.55
V_5 -PWF-131	21.33	16.38	63.66	0.53	4.52	3.00	9.28
S.Em. ±	0.45	0.41	1.40	0.01	0.06	0.08	0.18
Critical Difference (P = 0.05)	1.30	1.18	4.02	0.03	0.17	0.23	0.51
Interaction of SxV							
S.Em. ±	0.91	0.83	2.81	0.02	0.12	0.16	0.36
C.D. (P=0.05)	2.60	2.37	NS	0.07	0.35	0.45	NS
C.V.%	7.31	6.83	7.25	7.23	4.47	8.27	6.32

Table 2. Fresh weight of straw of onion and interaction effect of salinity and varieties on straw of onion

Effect of interaction		S_1 = < 2.0	S_2 = 4.0	S_3 = 6.0	S_4 = 8.0	Average
Variety	Name	dS per m (tap water)	dS per m	dS per m	dS per m	
V_1	GJWO-3	36.33	22.60	19.73	15.28	23.49
V_2	GJRO-11	33.13	16.57	14.17	12.17	19.01
V_3	Talaja red	33.60	20.27	15.07	12.43	20.34
V_4	Pilli patti	37.03	23.07	19.00	15.00	23.53
V_5	PWF-131	31.90	23.47	17.13	12.80	21.33
Average		34.40	21.19	17.02	13.54	
Standard Error of Mean ±		0.91		Critical Difference (P = 0.05)	2.60	

Table 3. Fresh weight of bulb of onion and interaction effect of salinity and varieties on bulb of onion

Effect of interaction		S_1 = < 2.0	S_2 = 4.0	S_3 = 6.0	S_4 = 8.0	Average
Variety	Name	dS per m (tap water)	dS per m	dS per m	dS per m	
V_1	GJWO-3	37.21	31.66	17.50	11.06	24.37
V_2	GJRO-11	32.01	23.89	14.99	7.45	19.58
V_3	Talaja red	31.96	22.63	13.88	9.79	29.57
V_4	Pilli patti	37.49	30.32	16.14	12.25	25.05
V_5	PWF-131	30.17	16.54	10.99	7.83	16.38
Average		33.77	25.41	15.11	9.68	
Standard Error of Mean ±		0.83		Critical Difference (P = 0.05)	2.37	

Table 4. Proline content in leaves of onion at 45 Days After Transplanting and interaction effect of salinity and varieties on proline content

Effect of interaction		S_1 = < 2.0	S_2 = 4.0	S_3 = 6.0	S_4 = 8.0	Average
Variety	Name	dS per m (tap water)	dS per m	dS per m	dS per m	
V_1	GJWO-3	0.37	0.49	0.59	0.90	0.59
V_2	GJRO-11	0.34	0.46	0.58	0.55	0.48
V_3	Talaja red	0.32	0.46	0.58	0.65	0.50
V_4	Pilli patti	0.37	0.55	0.66	0.96	0.63
V_5	PWF-131	0.34	0.52	0.55	0.69	0.53
Average		0.35	0.50	0.59	0.75	
Standard Error of Mean ±		0.02		Critical Difference (P = 0.05)	0.07	

Table 5. Chlorophyll-a content in leaves of onion at 45 Days After Transplanting and interaction effect of salinity and varieties on chlorophyll-a content

Effect of interaction		S_1 = < 2.0	S_2 = 4.0	S_3 = 6.0	S_4 = 8.0	Average
Variety	Name	dS per m (tap water)	dS per m	dS per m	dS per m	
V_1	GJWO-3	5.59	5.15	4.57	4.35	4.92
V_2	GJRO-11	5.60	4.39	4.30	4.22	4.63
V_3	Talaja red	5.57	4.54	4.09	3.73	4.48
V_4	Pilli patti	5.77	5.00	4.64	4.30	4.93
V_5	PWF-131	5.10	4.67	4.38	3.93	4.52
Average		5.53	4.75	4.39	4.11	
Standard Error of Mean ±		0.12		Critical Difference (P = 0.05)	0.35	

Table 6. Chlorophyll-b content in leaves of onion at 45 Days After Transplanting and interaction effect of salinity and varieties on chlorophyll-b content

Effect of interaction		S_1 = < 2.0	S_2 = 4.0	S_3 = 6.0	S_4 = 8.0	Average
Variety	Name	dS per m (tap water)	dS per m	dS per m	dS per m	
V_1	GJWO-3	4.06	3.47	3.43	3.21	3.54
V_2	GJRO-11	3.76	3.49	3.15	2.63	3.26
V_3	Talaja red	3.77	3.40	2.98	2.30	3.11
V_4	Pilli patti	4.22	4.01	3.40	2.89	3.63
V_5	PWF-131	3.82	3.61	2.37	2.21	3.00
Average		3.92	3.60	3.06	2.65	
Standard Error of Mean ±		0.16		Critical Difference (P = 0.05)	0.45	

universally observed [16,17]. Plant growth and development majorly affected water status. Saline conditions has been frequently observed a decrease of the leaf relative water content [18,19]. The result is similar with results of Yeo and Flowers [20]. With increasing NaCl supply Chlorophyll a and b contents and total chlorophyll decreased.

The effect of interaction of salinity and varieties levels was found significant on the proline content (Table 4). The proline content was found highest (0.96 µmole/gf.wt) observed in variety V_4 (Pilli patti) at salinity S_4 (8.0 dS m^{-1}). The lowest proline content was observed in V_3 (Talaja red) under S_1 (<2.0 dS m^{-1}). High levels of proline accumulated in many plant species in response to drought and salinity stress, which is throught to function in stress adaptation [21]. In response to salinity proline content found increased has been reported by Goudarzi and Pakniyat [22], El-Baz et al*.* [23] and Sidari et al. [24].

In respect to chlorophyll-a content of onion leaves the interaction effect of salinity and variety levels was found significant in respect to chlorophyll-a content of onion leaves (Table 5). In combination of V_4 (Pilli patti) and S_1 (<2.0 dS m^{-1}) the chlorophyll-a (5.77 mg g^{-1} of fresh weight) was observed highest which was statistically at par to those combination of V_1(GJWO-3) x S_1 (< 2.0 dS m^{-1}), V_2 (GJRO-11) x S_1 (< 2.0 dS m^{-1}) and V_3 (Talaja red) x S_3 (< 2.0 dS m^{-1}) .The lowest chlorophyll-a (3.73 mg/gf.wt) was observed in V_3(Talaja red) under 8.0 dS m^{-1} (S_4).

The data on interaction effect of salinity and varieties levels on chlorophyll-b content was presented in Table 6. Highest chlorophyll-b content was found in combination of V_4 x S_1 (< 2.0 dS m^{-1}) and lowest chlorophyll-b content was found in V_5 (PWF-131) x S_4.

“Due to the destruction of the pigments of chlorophyll causes the reduction of the chlorophyll content from the leaves under salt-stress conditions and the instability of protein complex of pigments” [25]. “The reason behind this is the interference of the salt ions with novo protein synthesis (chlorophyll structural components) rather than decomposition of chlorophyll” [26].

4. CONCLUSION

Different level of saline irrigation water significantly influenced the bulb and straw weight of onion. The maximum bulb and straw weight were observed under S_1 (2.0 dS per m) with the value of 37.49 g $plant^{-1}$ and 37.03 g $plant^{-1}$ respectively. With increase in salinity the proline content also increased. Application of 8.0 dS m^{-1} (S_4) saline irrigation water results significantly higher proline content (0.75 µmole g^{-1} of fresh weight). Biochemical parameters like RWC, chlorophyll a, chlorophyll b and total chlorophyll content had significant effect of the different salinity levels. These parameters improved significantly at salinity level S_1 (2.0 dS m^{-1}).

ACKNOWLEDGEMENT

I have deepest sense of veneration and gratitude to my major guide Dr. L. C. Vekaria, Assistant professor, Dept. of Agril. Chemistry and Soil Science, Junagadh Agricultural University, Junagadh to avail myself of this opportunity with great pleasure in acknowledging for his guidance, critical suggestions, pain staking interest, constant inspiration, judicious supervision, amiable behaviour and timely advice during the course of investigation which is chiefly responsible for preparation of this manuscript. I am thankful for insightful guidance of Dr. D. M. Solanki and A. H. Chauhan for sparing their valuable time whenever I approached them and showing me the way ahead.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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