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Evaluation of the effects of FYM and gypsum on onion (*Allium cepa* L.) production under sodic water irrigation

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Abstract: A field experiment was conducted at CCS Haryana Agricultural University, Hisar to study the effect of FYM and gypsum on onion (*Allium cepa* L.) production under sodic water irrigation. Treatments comprised of three levels of farm yard manure (FYM) (F_0- no FYM, F_1- 10 t/ha and F_2- 20 t/ha FYM) and three levels of gypsum (G_0- no gypsum, G_1- 50% neutralization of RSC and G_2- 100% neutralization of RSC) in addition to control (irrigation with sodic water and no FYM and no gypsum F_0G_0). Results of the study showed that the seedling mortality was maximum (77.50 %) in control (F_0G_0) treatment, while minimum number of seedlings mortality (18.17 %) was observed in (F_2G_2) treatment followed by (25.17 %) (F_2G_1) treatment. There was significant increase in growth and yield of onion with application of FYM and gypsum. Moreover, maximum bulb yield (180.83 q/ha) was recorded in (F_2G_2) followed by F_2G_1 (152.22 q/ha) where 100% sodicity of water was neutralized by the application of gypsum and 20 t/ha FYM. Under sodic water conditions, increasing level of gypsum and FYM help in reducing the sodicity of irrigation water and thereby, increasing the yield of onion. The study concluded that in present situation of scarcity of good quality water for agricultural purposes, use of amendments like FYM and gypsum were best alternative for the best possible use of poor quality ground water and simultaneously sustain the yield of vegetable crops like onion which are sensitive to sodic water.

Keywords: Farm yard manure, Gypsum, Onion yield, Sodic water

INTRODUCTION

Currently, India's share in the world's total vegetable production is 13.6% and demand for vegetables is projected to rise to 170 million tons by the year 2025. Moreover, the per capita consumption of vegetables in our country is 135 g/day against the recommendation of 280 g/day (Anonymous, 2009). Onion is one of the most important vegetable crops grown throughout the world. India is the second largest producer of onion in the world after China. During 2012-13, area under onion cultivation is 10.64 lakh hectares with production of 151.18 lakh tonnes in India. In Haryana, the area under vegetable production is 0.28 million ha with an annual production of 3.3 million tons (Tiwari *et al.*, 2013). The area and production of vegetables may be increased with proper management practices such as management of poor quality water. Good quality water is the most critical and scarce resource for drinking, agriculture and industry, more so in arid and semi-arid regions. The continuous increase in the human and animal population has resulted in increased demand of water for domestic, industrial and agriculture needs. Presently, about 15% of India's water resources are consumed to meet out the domestic and industrial requirements and share of these two sectors will grow to about 30% by 2050 (Minhas and Samra, 2004). In the arid and semi-arid tracts of Haryana, about 70% underground water is of poor quality from irrigation point of view. Of the total 70%, 20% is sodic, 14% saline and 36% saline-sodic. Because of the inadequate canal irrigation facilities, these water categories constitute either the major or the only source of irrigation. Continuous and indiscriminate use of sodic water for irrigation as such causes soil sodicity and at the same time, adversely affects the growth and yield of crops under most situations. Although lot of research work has been done on various field crops by using sodic water with amendments like farm yard manure (FYM) and gypsum, yet there is a lack of information on vegetable crops in general andonion crop in particular. Therefore, the present study was undertaken to study the effect of FYM and gypsum on onion (*Alliumcepa* L.) production under sodic water irrigation.

MATERIALS AND METHODS

The experiment was carried out at Vegetable Research Farm of CCS Haryana Agricultural University, Hisar during 2012-13 on an ongoing permanent experiment, which had been in progress since 1994. The soil of the experimental field was sandy loam Typic ustochrept having 19.6% clay and CEC 9.3 C mol/kg in 0-30 cm layer. The soil pH and ESP of soil of different treatment plots are presented in Table. The pH ranged between (7.9 to 9.8) and ESP values had a wide variation (13.5 to 45.6) among the plots with and without gypsum. The treat-

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ments comprised of three levels of gypsum (G_0-no gypsum, G_1-50% neutralization of RSC of sodic water with gypsum, G_2-100% neutralization of RSC of sodic water with gypsum) and three levels of farm yard manure (F_0-no FYM, F_1-10 t/ha and F_2-20 t/ha FYM) which were replicated thrice in a randomized block design. Different growth parameters analyzed during the study includes plant height, number of leaves per plant, grading of bulbs, bulb length, bulb dry matter, Total soluble solids (TSS), bulb diameter, seedling mortality (%), plants survival (%) at harvest, bulb yield and per cent marketable bulbs. Since the weather components during the season greatly influence the growth, development, yield and quality of the crop considerably, therefore, the data recorded on various meteorological aspects during the course of experimentation from the agro-meteorological station located at Research Farm Department of Agrometeorology, CCS HAU, Hisar are presented in Table 1. Statistical analysis of data collected during the study was done by applying the technique of analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984) and Panse and Sukhatme (1961). All the statistical analysis was carried out by using OPSTAT statistical software.

RESULTS AND DISCUSSION

Growth and development parameters

Per cent seedling mortality: The per cent seedling mortality of onion crop was recorded at 15 days after transplanting. Data on seedling mortality per cent clearly revealed that the various levels of FYM and gypsum significantly influenced the per cent seedling mortality **(**Table 2**)**. The mean value of per cent mortality was 71.61, 43.94 and 36.15 for G_0, G_1 and G_2 treatments, respectively. The corresponding values were 67.78, 47.50 and 36.43 for F_0, F_1 and F_2 treatments, respectively. Minimum per cent mortality (18.17) was recorded with F_2G_2, whereas, in F_0G_0 treatment the maximum per cent mortality (77.50) was observed in F_oG_0. Furthermore seedling mortality difference between G_1 and G_2 was lower than where no gypsum was applied i.e. G_0. However, the per cent seedling mortality was found to decrease significantly with increasing level of gypsum and FYM. Application of FYM and gypsum reduced the per cent seedling mortality than in absence of FYM and gypsum. Minimum per cent mortality (18.17) was recorded in F_2G_2 treatment whereas in F_0G_0 treatment the maximum per cent mortality (77.50) was observed. However, the seedling mortality per cent was found to decrease significantly with increasing level of gypsum and FYM. Application of FYM and gypsum reduced the seedling mortality per cent than in absence of FYM and gypsum. It might be due to the application of gypsum and FYM which minimizes the harmful effect of sodicity and increase nutrient availability as well as better growth conditions. These results are in line with the findings of Yadav *et al.* (2005) who reported that in case of tomato, maximum numbers of plants (31.0) were survived in treatment where RSC of sodic water was neutralized 100% and FYM was applied @ 20t/ha and minimum (0.6) was observed in control plot (without any application of gypsum and FYM).

Plant height: The height of onion was recorded at 30, 60 and 90 days after transplanting (DAT). The mean height of plant at 30 days after transplanting was 31.36, 38.11 and 40.54 cm for G_0, G_1 and G_2, respectively, whereas the corresponding values were 32.41, 36.80 and 40.80 for F_0, F_1 and F2 (Table 3), plant height was lowest where no FYM and gypsum was applied. However, plant height increased with increasing levels of FYM and gypsum. Similar trends for plant height were observed at 60 and 90 days after transplanting. Maximum plant height (51.07cm) was observed under in F_2 (20 t/ha FYM) treatment and minimum (40.26 cm) in no FYM treatment at 90 DAT while, in gypsum application, highest plant height (51.06) was recorded with 100% neutralization of RSC (G_2) and minimum with no gypsum application. Plant height was increased with increasing level of FYM and gypsum. These results are in accordance with Kaswan *et al.* (2013) who carried his research on onion and reported that plant height, number of leaves and yields were increased with increasing levels of FYM. The possible reason for this is that FYM increase the fertility as well as provided the favorable environment for growth.

Number of leaves: The mean number of leaves of onion was counted and recorded at 30, 60 and 90 (DAT). The mean number of leaves was at 30, 60 and 90 days after transplanting was 4.20, 5.23 and 5.81 for G_0, G_1 and G_2, respectively. Whereas corresponding values were 4.64, 4.87 and 5.73 for F_0, F_1 and F_2 (Table 4). The data clearly indicated the number of leaves per plant was lowest (4.07) in F_0G_0 and highest (7.02) in F_2G_2 treatment at 30 DAT. Moreover the number of leaves per plant also increased significantly with the application of FYM and gypsum. The increase in number of leaves is significantly higher between G_0 and G_1 and G_0 and G_2 than between G_1 and G_2. Similar trends were recorded for number of leaves at 60 and 90 (DAT). The maximum number of leaves (8.49) was recorded under combined application of FYM at 20 t/ha and 100% neutralization of RSC (G_2) while minimum number of leaves was with no FYM and gypsum application at 30, 60 and 90 (DAT). These results are in conformity with the finding of Kadlag *et al.* (2010) who reported that highest number of leaves and plant height in okra (*Abelmoschus esculentus* L. (Moench) cv. Gujarat Okra-2 was found where application of FYM @ 20 t/ha was done and this might br due to the reason that more favorable conditions are provided with FYM application which results in better plant growth.

Bulb diameter and bulb length: The diameter of bulbs was recorded after harvesting of onion crop. The mean diameter of onion bulb was 3.81, 4.04 and 4.17 cm for G_0, G_1 and G_2 treatments, respectively, and the corresponding values were 3.80, 4.01 and 4.21 for F_0, F_1 and F_2 treatments, respectively (Table 5). The data showed the

Table 1. Mean monthly meteorological data recorded during crop season 2013.

Month and Year	Mean atmospheric Temperature (°C)		Relative humidity (%)		Average rainfall (mm)
	Maximum	Minimum	Morning	Evening	
January, 2013	17.6	4.2	95	58	43.0
February, 2013	21.5	8.9	96	60	32.7
March, 2013	28.4	12.0	92	77	31.1
April, 2013	35.0	17.2	68	27	2.3
May, 2013	41.5	22.7	48	17	0.0

Table 2. Effect of FYM and gypsum on per cent seedling mortality irrigated with sodic water.

FYM	G_0	G_1	G_2	Mean
F_0	77.50	68.33	57.50	67.78
F_1	71.39	38.33	32.78	47.50
F_2	65.95	25.17	18.17	36.43
Mean	71.61	43.94	36.15	
CD at 5%	Gypsum = 2.32	FYM = 2.32	Gypsum x FYM = 4.04	
SE (d)	Gypsum = 1.09	FYM = 1.09	Gypsum x FYM = 1.88	

Table 3. Effect of FYM and gypsum on plant height (cm) of onion at different intervals under irrigation with sodic water.

FYM	30 DAT				60 DAT				90 DAT			
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean
F_0	25.27	34.20	37.77	32.41	27.73	37.93	42.13	35.93	32.06	42.26	46.46	40.26
F_1	32.80	38.53	39.07	36.80	36.67	44.47	45.17	42.10	41.00	48.80	49.50	46.43
F_2	36.00	41.60	44.80	40.80	39.27	48.07	52.90	46.74	43.60	52.40	57.23	51.07
Mean	31.36	38.11	40.54		34.56	43.49	46.73		38.89	47.82	51.06	
CD at 5%		Gypsum =1.98 FYM= 1.98 Gypsum x FYM= NS				Gypsum =1.82 FYM= 1.82 Gypsum x FYM= NS				Gypsum =2.31 FYM= 2.31 Gypsum x FYM=NS		
SE (d)		Gypsum =0.92 FYM= 0.92 Gypsum x FYM= 1.60				Gypsum =0.85 FYM= 0.85 Gypsum x FYM= 1.47				Gypsum =1.08 FYM= 1.08 Gypsum x FYM=1.87		

Table 4. Effect of FYM and gypsum on number of leaves of onion under irrigation with sodic water at different intervals.

FYM	30 DAT				60 DAT				90 DAT			
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean
F_0	4.07	4.87	5.00	4.64	5.11	5.70	5.87	5.56	5.42	6.02	6.20	5.88
F_1	4.20	5.00	5.40	4.87	5.20	5.90	6.33	5.81	5.55	6.24	6.79	6.19
F_2	4.33	5.83	7.02	5.73	5.30	6.63	8.13	6.69	5.64	6.98	8.49	7.04
Mean	4.20	5.23	5.81		5.20	6.08	6.78		5.54	6.41	7.16	
CD at 5%		Gypsum = 0.31 FYM= 0.31 Gypsum x FYM=0.54				Gypsum =0.26 FYM= 0.26 Gypsum x FYM=0.46				Gypsum =0.30 FYM= 0.30 Gypsum x FYM=0.53		
SE (d)		Gypsum =0.14 FYM= 0.14 Gypsum x FYM= 0.25				Gypsum =0.12 FYM= 0.12 Gypsum x FYM= 0.21				Gypsum =0.14 FYM= 0.14 Gypsum x FYM= 0.24		

increasing trends in respect to bulb diameter with increasing level of FYM and gypsum. Minimum mean bulb diameter (3.81 cm) was recorded in G_0 whereas maximum (4.21 cm) was recorded in F_2 treatment. However, the combined effect was non-significant. The mean bulb length was 3.49, 3.75 and 3.89 cm for G_0, G_1 and G_2, respectively. Whereas the corresponding values for F_0, F_1 and F_2 were 3.55, 3.69 and 3.89 cm, respectively. Furthermore, there was a significant increase in bulb length with the application of FYM and gypsum. Bulb length and bulb diameter increased as gypsum and FYM levels increased in G_1, G_2 as compared to G_0 and F_1 and F_2 as compared to F_0. The minimum bulb diameter (3.48 cm) was recorded with no gypsum and no FYM treatment whereas maximum bulb diameter (4.45 cm) was recorded in F_2G_2 i.e. 100% neutralization of RSC and FYM @ 20

Table 5. Effect of FYM and gypsum on length and diameter of onion bulb irrigation with sodic water.

FYM	Bulb diameter (cm)			Mean	Bulb length (cm)			Mean
	G_0	G_1	G_2		G_0	G_1	G_2	
F_0	3.48	3.91	4.01	3.80	3.38	3.55	3.70	3.55
F_1	3.98	4.01	4.05	4.01	3.41	3.78	3.88	3.69
F_2	3.98	4.19	4.45	4.21	3.68	3.92	4.07	3.89
Mean	3.81	4.04	4.17		3.49	3.75	3.89	
CD at 5%	Gypsum = 0.17	FYM= 0.17	Gypsum x FYM=NS		Gypsum =0.14	FYM= 0.14	Gypsum x FYM=NS	
SE (d)	Gypsum = 0.07	FYM= 0.07	Gypsum x FYM=0.13		Gypsum =0.06	FYM= 0.06	Gypsum x FYM=0.11	

Table 6. Effect of FYM and gypsum on onion yield (q/ha) and per cent marketable bulbs under sodic water irrigation.

FYM	onion yield (q/ha)				per cent marketable bulbs			Mean
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	
F_0	49.27	80.00	109.00	79.42	47.10	59.27	63.75	56.71
F_1	71.70	113.50	140.00	108.40	56.15	64.90	66.00	62.35
F_2	82.77	152.22	180.83	138.61	59.17	67.62	67.75	64.84
Mean	67.91	115.24	143.28		54.14	63.93	65.83	
CD at 5%	Gypsum = 2.79	FYM = 2.79	Gypsum x FYM= 4.84		Gypsum =2.18	FYM= 2.18	Gypsum x FYM=3.78	
SE (d)	Gypsum = 1.30	FYM= 1.30	Gypsum x FYM= 2.26		Gypsum =1.02	FYM= 1.02	Gypsum x FYM=1.77	

Table 7. Effect of FYM and gypsum on plant survival (%) at harvest after irrigation with sodic water.

FYM	G_0	G_1	G_2	Mean
F_0	21.94	30.28	41.83	31.35
F_1	24.83	60.83	67.22	50.96
F_2	32.89	75.39	81.94	63.41
Mean	26.56	55.50	63.67	
CD at 5%	Gypsum = 1.33	FYM = 1.33	Gypsum x FYM = 2.30	
SE (d)	Gypsum = 0.62	FYM = 0.62	Gypsum x FYM = 1.07	

Table 8. Effect of FYM and gypsum on weight of bulbs (kg/plot) of different sizes under sodic water irrigation.

FYM	Under size (<40g)				Medium size (40-80g)				Large size (>80g)			
	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean	G_0	G_1	G_2	Mean
F_0	2.61	3.28	3.95	3.28	1.69	3.00	4.95	3.21	0.63	1.79	2.00	1.48
F_1	3.14	3.98	4.80	3.98	2.99	4.81	6.02	4.61	1.03	2.58	3.30	2.31
F_2	3.37	4.93	5.83	4.71	3.73	6.73	8.05	6.17	1.14	3.55	4.20	2.96
Mean	3.04	4.07	4.86		2.81	4.85	6.34		0.94	2.64	3.17	
CD at 5%	Gypsum=0.25	FYM= 0.25	Gypsum x FYM=0.43		Gypsum =0.20	FYM= 0.20	Gypsum x FYM=0.35		Gypsum =0.27	FYM= 0.27	Gypsum x FYM=0.47	
SE (d)	Gypsum=0.11	FYM= 0.11	Gypsum x FYM=0.20		Gypsum =0.09	FYM= 0.09	Gypsum x FYM=0.16		Gypsum =0.12	FYM= 012	Gypsum x FYM=0.27	

t/ha. The bulb length in no FYM and no gypsum treatment was lowest (3.38 cm) and highest (4.07 cm) in F_2 and G_2 treatment. The significant increase in bulb length with the application of FYM and gypsum was observed. Increasing level of gypsum and FYM increased the bulb length and bulb diameter. The increase in bulb diameter was due to the amelioration of adverse effect of sodicity by application of FYM and gypsum. Similar findings were also reported by Kaswan *et al.* (2013) in onion who reported that bulb length, volume of bulb and yield was maximum with increasing level of FYM.

Yield: The onion yield (q/ha) and per cent marketable bulbs of onion in relation to FYM and gypsum application irrigated with sodic water is presented in Table 6. The mean yield with gypsum as well as FYM application showed a significant increasing trend. The yield was 67.91, 115.24 and 143.28 q/ha for G_0, G_1 and G_2 treatments, respectively. Whereas the corresponding values for F_0, F_1 and F_2 were 79.42, 108.40 and 138.61 q/ha, respectively. The lowest yield of onion was recorded under F_0G_0 which increased significantly with FYM and gypsum application. The per cent marketable bulbs of onion were 54.14, 63.93 and 65.83 for G_0, G_1 and G_2 treatments, respectively. The corresponding values were 56.71, 62.35 and 64.84 for F_0, F_1 and F_2 treatments, respectively. Moreover the minimum per cent marketable

Table 9. Effect of FYM and gypsum on total soluble solids (^{0}B) under irrigations with sodic water.

FYM	G_0	G_1	G_2	Mean
F_0	12.83	12.73	12.30	12.62
F_1	12.43	11.58	11.70	11.91
F_2	11.98	11.37	11.27	11.54
Mean	12.42	11.89	11.76	
CD at 5%	Gypsum = 0.20	FYM = 0.20	Gypsum x FYM = NS	
SE (d)	Gypsum = 0.09	FYM = 0.09	Gypsum x FYM = 0.16	

Table 10. Effect of FYM and gypsum on dry matter (%) of bulbs under irrigation with sodic water.

FYM	G_0	G_1	G_2	Mean
F_0	8.90	8.70	8.60	8.73
F_1	8.83	8.07	8.03	8.31
F_2	8.68	7.93	7.82	8.14
Mean	8.81	8.23	8.15	
CD at 5%	Gypsum = 0.24	FYM = 0.24	Gypsum x FYM = NS	
SE (d)	Gypsum = 0.11	FYM = 0.11	Gypsum x FYM = 0.19	

bulbs were recorded under F_0G_0 which increased significantly with FYM and gypsum application. Total yield increased significantly with 50% neutralization (G_1) and 100% neutralization (G_2) compared to G_0 where no gypsum was applied. The increase in yield of onion increased with increasing levels of gypsum and FYM. The increase in yield was more with gypsum application than FYM application. This showed the addition of FYM alone is not sufficient to mitigate the harmful effect of sodic water. But in conjunction with gypsum, FYM played a crucial role. The data showed that the yield per plot was lowest in no FYM and no gypsum application and highest in combination of 20 t/ha FYM and 100% neutralization of RSC (F_2G_2). The yield with gypsum as well as FYM application showed a significant increasing trend. It was observed that the application of 100 kg N+60 kg P_2O_5+60 kg K_2O/ha in association of 400 kg gypsum/ha gave significantly superior bulbs yield of onion over lower doses of gypsum (Singh *et al.*, 2009). In another study Kaswan *et al.* (2013) also observed the similar effect of FYM in onion. Minimum per cent marketable bulbs were recorded under no FYM and no gypsum application treatment which increased significantly with FYM and gypsum application.

Plant survival (%) at harvest: The number of plant survival was recorded at harvest. The mean values for plants survival at harvest were 26.56, 55.50 and 63.67 for G_0, G_1 and G_2 treatments, respectively. Whereas the corresponding values were 31.35, 50.96 and 63.41 for F_0, F_1 and F_2 treatments, respectively (Table 7). The plant survival at harvest in F_0G_0 treatment was lowest (21.94) and maximum (81.94) in F_2G_2 treatment. Furthermore, plant survival at harvest increased significantly with the application of FYM and gypsum. This showed that addition of FYM alone is not sufficient to mitigate the harmful effect of sodic water. But with gypsum, FYM in conjunction played a pivotal role. Plant survival at harvest was lowest (21.94%) in no FYM and no gypsum treatment and highest (81.94%) in combined application of 20 t/ha FYM and 100% neutralization of RSC (G_2). Plant survival at harvest increased significantly with the application of FYM and gypsum. The similar findings were also observed by Nandal and Bedi (2010) who observed that maximum plant survival at harvest stage was observed with the application of FYM @ 20 t/ha + recommended dose of fertilizers in onion.

Weight of bulbs/plot of different sizes: The grading of bulbs was done after harvest into three categories under size (<40g), medium size (40-80 g) and large size (>80g). The mean values for under size (<40 g) were 3.04, 4.07 and 4.86 for G_0, G_1 and G_2 treatments, respectively. Whereas the corresponding values were 3.28, 3.98 and 4.71 for F_0, F_1 and F_2 treatments, respectively (Table 8). Similar increasing trends were observed for medium size (40-80 g) and large size (>80 g). The size of bulbs in all the three categories with F_0G_0 treatment was lowest (2.61), (1.69) and (0.63) and maximum (5.83), (8.05) and (4.20) with F_2G_2 treatment. Furthermore the size of bulbs increased significantly with the application of FYM and gypsum. The bulb weight in all the categories i.e. under size (<40g), medium size (40-80g) and large size (>80g) increased significantly with the application of FYM and gypsum in all the treatments. Increasing trends in medium and large size was also observed. The lowest bulbs weight (1.69 kg) in medium and large size (0.63 kg) was recorded in no FYM and no gypsum application treatments and maximum (5.83 kg) and (8.05 kg) was with the application of FYM at 20 t/ha and 100% neutralization of sodicity F_2G_2.The increase in yield was more with gypsum application than FYM application. These results are in agreement with the findings of Singh *et al.* (2009) who reported that the maximum shape and size with application of gypsum over control and RDF (recommended dose of fertilizer).

Total soluble solids (TSS) (%): The total soluble solids of onion crop were recorded at harvest and data are presented in Table 9. The mean TSS values were 12.42, 11.89 and 11.76 ^{0}B for G_0, G_1 and G_2 treatments,

respectively. The corresponding values were 12.62, 11.91 and 11.54 ^{0}B for F_0, F_1 and F_2 treatments, respectively. There was a decreasing trend in TSS with the increasing level of FYM and gypsum. Maximum TSS (12.83 ^{0}B) was recorded in G_0, whereas, minimum TSS (11.27 ^{0}B) in F_2 treatment. However, the combined effect was non-significant. Furthermore TSS ^{0}B decreased with increasing levels of FYM and gypsum. Maximum TSS (12.83 ^{0}B) was recorded under no FYM and no gypsum application treatments and minimum (11.27 ^{0}B) TSS was recorded with combined application of FYM at 20 t/ha and 100% neutralization of RSC (F_2G_2). However under gypsum application, minimum TSS (11.76 ^{0}B) was observed in 100% neutralization of sodicity G_2 and maximum (12.42 ^{0}B) in no gypsum application. The decreasing trends in TSS were observed with the increasing level of FYM and gypsum. This might be due to fact that the gypsum had neutralized the sodicity effect of water and FYM in general improved the physical properties like structure of soil. Similar findings were reported by Yadav *et al.* (2005) who found that minimum TSS in tomato was observed with combined application of FYM @ 20 t/ha and 100% neutralization of RSC (F_2G_2) and Kaswan *et al.* (2013) in onion also found the decreasing trend in TSS with increasing level of FYM.

Dry weight: The dry weight of bulbs was recorded after harvesting of onion crop. The mean weight was 8.81, 8.23 and 8.15 (%) for G_0, G_1 and G_2 treatments, respectively. Whereas corresponding values were 8.73, 8.31 and 8.14 (%) for F_0, F_1 and F_2 treatments, respectively (Table 10). The dry weight of bulbs decreased significantly with the application of gypsum and FYM. However, the combined effects were non-significant. The bulb dry weight was highest (8.90%) where no FYM and no gypsum were applied and lowest (7.82 %) in F_2G_2 treatment. Furthermore the decreasing trend in dry weight of bulbs was observed with the application of FYM and gypsum. The minimum values of dry weight under FYM and gypsum was due to neutralization of sodicity. Similar findings were also observed by Yadav *et al.* (1998) in onion and found that as dry weight of bulbs decreased with decreasing level of salinity.

Conclusion

From the study, it was observed that the maximum seedling mortality per cent was recorded where no FYM and no gypsum were applied and minimum was with FYM when applied @ 20 t/ha and 100% neutralization of RSC. Maximum increase in plant height, number of leaves per plant, bulb length, bulb diameter, bulb yield, plants survival at harvest, per cent marketable bulbs and bulb size were observed in 100% neutralization of RSC and FYM @ 20 t/ha application while, minimum increase in plant height, number of leaves per plant, bulb length, bulb diameter, bulb yield, plants survival at harvest, per cent marketable bulbs and bulb size .(including all grades viz. under size, medium size and large size bulbs) were in no FYM and no gypsum treatment. Combined application of FYM and gypsum minimizes the adverse effect of sodic water and improve the soil properties also. Moreover, in the Quality parameters of onion, the highest TSS was observed under no FYM and no gypsum application and minimum TSS was in FYM at 20 t/ha and 100% sodicity was neutralized by gypsum application application. Maximum bulb dry mater was observed in no FYM and gypsum application treatment while minimum was in FYM at 20 t/ha and 100% sodicity was neutralized by gypsum application.

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