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Assessment of soil and water quality status of rose growing areas of Rajasthan and Uttar Pradesh in India

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ABSTRACT

Rose is a commercial flower crop widely grown across India. It is highly sensitive to salinity and alkalinity. In the process of identification of salt and alkalinity resistant rootstocks of rose cultivars, a survey was conducted in the rose growing areas of Uttar Pradesh (UP) and Rajasthan. Total of 28 representative surface soil samples were collected from rose fields of these regions, processed and analyzed for the soil quality parameters. Similarly water samples (20 samples) from the bore wells of these fields were collected and analyzed. The results revealed that most of the soils of rose growing fields in UP were alkaline (pH >8.0) with normal salt content (electrical conductivity, EC < 0.5 dS m^{-1}). Many of these soils also had higher bicarbonates (> 3 meq 100 g^{-1}). In case of Rajasthan, few samples had higher pH, EC, chloride (>2 meq 100 g^{-1}) and bicarbonate contents. Exchangeable sodium percentage (ESP) of UP and Rajasthan samples ranged from 5.21-20.7% and 2.94-24.9%, respectively. In case of water parameters in these areas, pH was slightly in alkaline range, EC of some of the samples were high (>1 dSm^{-1}). Sodium content was slightly higher than other cations. Soluble sodium percentage (SSP) of water samples was also slightly higher than normal range (0-50%). Few samples had slightly higher chloride above the threshold limit. From the results, it is concluded that soil and water quality of the rose growing areas of UP and Rajasthan is marginal and proper management/reclamation measures need to be carried out for sustaining the production system.

Keywords: Rajasthan, rose, Soil quality, Uttar Pradesh and water quality

INTRODUCTION

Rose (*Rosa* spp.) is one of the most economically important ornamental crops in the world. Increasing demand for cut-flowers both in domestic and export markets encouraged many entrepreneurs to enter into the commercial cultivation of roses. Rose has been traditionally categorized as a salt-sensitive species with salt injury reported within a range of 0.5 to 3 dS m^{-1} electrical conductivity (EC) depending on species, cultural medium, leaching fraction, and environmental conditions (Urban, 2003). Bernstein *et al*. (1972) classified roses as having very poor tolerance to salinity with a 25-50% decrease in shoot growth at electrical conductivity values in the saturation extract (ECe) between 2 and 3 dS m^{-1}, and experiencing lethal effects at EC_e of 4 dS m^{-1}. In green houses electrical conductivity levels will increase significantly as roses are irrigated with water soluble fertilizers. High content of salts affect the plants by reducing water availability to the plants and by specific ion toxicity of Na, Cl, B, *etc*.

As the availability of good quality water has become scarce, farmers are using poor quality water with high salt content and ground water from deep layers of borewells which contain high amounts of bicarbonates for rose cultivation. The poor quality water affects the pH and EC of the growing medium which inturn affects the nutrient availability to the plants. High bicarbonate content in soil affects soil pH and affects availability of micronutrients especially iron. This bicarbonate induced iron deficiency or iron chlorosis results in poor flower yield and quality. The high bicarbonate (HCO_3-) concentration and associated high pH of irrigation water is detrimental to plant growth, due to its adverse effects on availability and solubility of nutrients (Marschner, 1995). By application of phosphoric and sulfuric acids through fertigation, many polyhouse units try to control the pH. This is a costly, cumbersome and unsafe practice. Sustainable rose production will have to incorporate economically feasible and environmentally sound solutions to problems associated with high levels of salts and HCO_3- in irrigation water. One of the ways to manage this problem is to use resistant varieties or rootstocks. Though there are good number of studies on rootstocks for high pH in other countries, the work on this aspect in India is scanty.

The area under salinity and alkalinity problems in Rajasthan is 1,95,571 ha and 1,79,371 ha, respectively. Similarly 21,989 ha of cultivated land is affected with salinity problems and 13,46,971 ha of land is affected with alkalinity problems in Uttar Pradesh (Mandal *et al.,* 2011). Rose is being cultivated in 1342 ha- in Rajasthan (Shekhawat, 2012) and 612 ha- in Uttar Pradesh (Sachan *et al.,* 2014). The present investigation was conducted to assess the soil and water quality status of rose growing areas of Rajasthan and Uttar Pradesh as a preliminary study for collection of rose germ-plasm for screening to tolerance of salinity and alkalinity problems of soil and water.

MATERIALS AND METHODS

Investigative surveys were conducted in Udaipur, Haldighati, Sirohi, Pali and Jodhpur areas of Rajasthan during October, 2017 and in Lucknow, Kannauj, Etah, and Aligarh areas of U.P. during January, 2018. Representative soil and water samples were collected from rose fields to assess quality status with respect to rose cultivation. About 28 surface soil samples and 20 water samples from these regions have been collected and analyzed for quality parameters. Soil samples were analyzed for pH using glass electrode and EC using conductivity meter in 1:2.5 soil: water suspension (Richards, 1954). The exchangeable Na, K, Ca and Mg in the soils were analyzed using neutral normal ammonium acetate extraction method (Chapman 1965). Soluble bicarbonate and chloride content in the soil were analyzed by titration method (Richards, 1954). Exchangeable sodium percentage (ESP) of soil was calculated using the Equation 1 as given below (Richards, 1954).

$$ESP(\%) = \text{Exchangeable } \{(Na)/(Ca + Mg + K + Na)\} \times 100 \quad \text{........Eq.(1)}$$

Similarly water samples have been analyzed for pH and EC using pH meter and conductivity meter (Richards, 1954). Na, K, Ca, Mg, HCO_3 and Cl were analyzed following standard analytical procedures (Richards, 1954). Sodium adsorption ratio (SAR) of water samples had been calculated by adopting the following equation (Richards, 1954).

$$SAR\ (me/L)^{1/2} = \{(Na)\ /\ [(Ca + Mg)/2]^{1/2}\} \quad \text{........Eq.(2)}$$

Soluble sodium percentage was also calculated adopting equation 3(Richards, 1954).

$$SSP\ (\%) = \{(Na + K)\ /\ (Ca + Mg + K + Na)\} \times 100 \quad \text{........Eq.(3)}$$

All the data were introduced to descriptive statistics for arithmetic mean and co-efficient of variation calculation.

RESULTS AND DISCUSSION

Soil quality parameters

Soil reaction in the study areas was found to slightly alkaline to highly alkaline range. The soil pH ranged from 7.83-9.34 in U.P with an average value of 8.55 (Table 1) and 7.18-8.42 in Rajasthan (average 7.91) (Table 2). The EC ranged from 0.12-0.76 dS m^{-1} which was normal range in UP soils, whereas in Rajasthan soil it ranged from 0.14-4.59 dS m^{-1}, mostly under normal range but few samples had higher EC particularly in Haldigati and Pali areas. The exchangeable cations Na, K, Ca and Mg in the U.P soils ranged from 174-730 mg kg^{-1}, 48-228 mg kg^{-1}, 1109-2526 mg kg^{-1} and 369-548 mg kg^{-1}, respectively. In Rajasthan, the corresponding values were 128-1575 mg kg^{-1}, 65-367 mg kg^{-1},1289-2923 mg kg^{-1} and 289-508 mg kg^{-1}, respectively. The results showed some soil samples had higher exchangeable sodium. The same had been reflected in the ESP of the respective soils. Soils of U.P had 5.21-20.7% ESP (mean 8.65%) and soils of Rajasthan had 2.94-24.9% ESP (mean 9.52%). This showed that many soils had ESP above the limit of 6% ESP, that reflect prevalence of alkalinity problems in the study area. The exchangeable sodium percentage (ESP) measures the proportion of cation exchange sites occupied by sodium. Soils are considered sodic when the ESP is greater than 6, and highly sodic when the ESP is greater than 15 (Tim *et al.,* 2019). This showed that many rose growing farms are having sodicity problems in Uttar Pradesh and some in Rajastan. Further bicarbonate content of soils were also high

Table 1. Soil quality parameters of rose growing areas of Uttar Pradesh

S.No.	Location	pH	EC (dS m^{-1})	Na^+ (mg kg^{-1})	K^+ (mg kg^{-1})	Ca^{2+} (mg kg^{-1})	Mg^{2+} (mg kg^{-1})	HCO_3^- (meq 100 g^{-1})	Cl^- (meq 100 g^{-1})	ESP (%)
1	Lucknow-1	8.44	0.21	179	147	1800	462	3.1	0.4	5.56
2	Lucknow-2	8.34	0.38	323	216	2526	539	2.5	1	7.36
3	Basheerpur-1	8.61	0.12	175	48	1344	450	2.3	0.6	6.70
4	Basheerpur-2	8.23	0.31	187	69.3	1109	369	3.2	1.2	8.46
5	Narora-1	9.34	0.23	363	103	2006	473	2.0	3.6	9.98
6	Narora-2	8.59	0.37	278	206	1694	436	0.3	4.0	8.73
7	Sarkari-1	8.22	0.39	212	228	1797	548	0.5	4.0	6.12
8	Sarkari-2	8.23	0.31	187	69.3	1109	369	0.3	2.4	8.46
9	Jagdevpura-1	8.91	0.38	463	127	1417	479	3.5	10	15.0
10	Jagdevpura-2	9.24	0.76	730	195	1577	452	3.9	2.4	20.7
11	Safedpura-1	8.56	0.23	174	199	1862	472	3.6	3.6	5.21
12	Sagedpura-2	8.40	0.25	215	110	1435	526	3.0	0.6	7.32
13	Safedpura-3	8.45	0.20	174	199	1862	472	0.5	1.2	5.21
14	Hapur-1	7.83	0.67	198	134	1475	431	3.2	1.4	7.07
15	Hapur-2	8.83	0.27	250	193	1684	471	0.5	0.6	7.80
Mean		8.55	0.34	274	150	1646	463	2.2	2.5	8.65
CV (%)		4.67	50.9	55.3	40.1	22.1	11.1	63.1	100	47.7

in some soil samples (>2 meq 100 g^{-1}) and it ranged from 0.3-3.9 meq 100 g^{-1} (mean 2.2 meq 100 g^{-1}) in UP and 0.3-10.1 meq 100 g^{-1} (mean 2.83 meq 100 g^{-1}) in Rajasthan. The presence of higher sodium and bicarbonate in the soil could increase the soil alkalinity that is adverse to the plant growth. This is evident from the pH values of soil samples from the rose fields in both Rajastan and U.P. The chloride content of the soil varied from 0.4-4.0 meq 100 g^{-1} (mean 2.5 meq 100 g^{-1}) in the UP region and 0.6-13.0 meq 100 g^{-1} (mean 3.23 meq 100 g^{-1}) in Rajasthan samples. This indicated that chloride problem was more in Pali, Balarwa, and Haldigati regions of Rajasthan and in some pockets of Etah and Kannauj in UP.

Soil alkalinity will result in poor soil structure and surface crust formation. High pH is usually associated with high exchangeable sodium percentage. On the other hand, soil salinity and chloride toxicity could also be a serious problem that affects the germination, root growth and water availability of the plant (Munn and Tester, 2008). Excess Na^+ had been assumed to be largely responsible for reduction in crop growth and yield under salinity (Tsai *et al.,* 2004; Hong *et al.,* 2009). Though Cl- is an essential plant nutrient, it could be toxic to plants at high concentrations (Xu *et al.*, 2000; White and Broadley, 2001).

Table 2. Soil characteristics of rose growing areas of Rajasthan

S.No.	Location	pH	EC (dS m^{-1})	Na^+ (mg kg^{-1})	K^+ (mg kg^{-1})	Ca^{2+} (mg kg^{-1})	Mg^{2+} (mg kg^{-1})	HCO_3^- (meq 100 g^{-1})	Cl^- (meq 100 g^{-1})	ESP (%)
1	Chikada, Udaipur	7.18	0.35	1223	68	2760	428	3.0	0.8	2.94
2	Fatehnagar, Udaipur	8.29	0.33	1341	123	2617	497	2.3	1.0	24.9
3	Haldigati-1	7.67	0.35	194	367	2923	508	2.4	0.6	4.09
4	Haldigati-2	7.93	0.31	207	103	2140	493	3.0	5.0	5.63
5	Haldigati-3	8.08	0.18	168	187	2559	454	3.2	3.0	4.11
6	Haldigati-4	7.55	4.59	1575	228	1633	483	2.2	2.0	34.9
7	Arathwada	8.42	0.15	195	65	1289	409	0.3	1.8	7.80
8	Posalia	8.02	0.15	138	119	1913	410	0.5	2.0	4.32
9	Balarwa-1	7.95	0.14	128	107	1677	289	0.5	1.2	4.79
10	Balarwa-2	8.05	0.14	207	180	1719	313	3.0	5.0	7.16
11	Balarwa-3	7.87	0.24	138	174	1724	311	2.5	3.6	4.89
12	Balarwa-4	7.83	0.37	186	172	1696	313	3.8	3.0	6.55
13	KVK, Pali	8.02	0.45	428	222	2045	404	10.1	13.0	11.6
Mean		7.91	0.60	387	163	2053	409	2.83	3.23	9.52
CV (%)		4.01	202	125	49.9	24.8	19.3	86.7	102	100

Irrigation water quality parameters

The irrigation water quality parameters of rose growing areas of UP (Table 3) and Rajasthan (Table 4) were analyzed and the results revealed that pH of the water samples were slightly alkaline in nature. Particularly water samples of UP had pH of 7.53-8.36, and water samples of Rajasthan had 7.23-7.70 pH range. It showed that irrigation waters of both the region had slightly higher pH (i.e.,) above the neutral pH (6.5-7.5). In case of EC, it ranged from 0.07-2.44 dS m^{-1} in UP samples and 0.45-2.63 dS m^{-1} in Rajasthan samples and few samples from Pali, Haldigati and Udaipur (Rajasthan), and Etah and Aligarh (UP) had higher EC (>1 dS m^{-1}). The cationic concentrations of the samples were within the safe range for K and Ca, but Na and Mg were higher than the FAO threshold levels in some samples (Ayers and Westcot, 1985). Further SAR of the water samples of UP region was 2.4-10.5 (4.5 meq L^{-1}) and Rajasthan region was 2.92-10.3 (5.41 meq L^{-1}). The SSP of the water samples were also very high that ranged from 33.5-82.5% in UP samples and 45.7-75.7% in Rajasthan samples. Most of the samples had higher SAR (more than 3) and SSP (>50%), which indicated presence of more Na than other cations. It was also reflected in higher pH of water samples. The SSP and the SAR were important factors for studying sodium hazards. The water samples with greater than 50% SSP and more than 3 (meq L^{-1}) SAR might result in accumulation of sodium in soil that cause the

Table 3. Irrigation water quality of rose growing areas of Uttar Pradesh

S.No.	Location	pH	EC (dS m^{-1})	Na^+ (mg L^{-1})	K^+ (mg L^{-1})	Ca^{2+} (mg L^{-1})	Mg^{2+} (mg L^{-1})	HCO_3^- (meq L^{-1})	Cl^- (meq L^{-1})	SAR (meq $L^{-1})^{1/2}$	SSP (%)
1	Lucknow	7.59	0.65	5.28	0.02	2.98	0.51	5.0	0.6	4.0	60.3
2	Bashirpur Khannoj	7.66	0.48	6.26	0.03	0.75	0.58	5.2	1.2	7.7	82.5
3	Bashirpur Khannoj	8.32	0.07	16.9	0.02	3.5	1.67	1.0	0.6	10.5	76.6
4	Narora, Etah	7.55	2.44	3.87	0.08	2.81	2.6	7.0	5.0	2.4	42.2
5	Narora, Etah	7.54	0.76	8.83	0.08	3.38	3.87	5.1	0.6	4.6	55.1
6	Sarkari Gram, Awaghad	7.53	1.00	8.75	0.02	3.51	6.34	3.8	1.8	3.9	47.1
7	Jagdevpura, Hasayan	7.77	0.63	6.20	0.01	4.54	6.00	3.9	1.7	2.7	37.1
8	Jagdevpura, Hasayan	7.7	2.07	5.28	0.01	3.60	1.67	3.8	0.2	3.3	50.1
9	Safed pura, Alighar	7.63	0.60	6.26	0.04	1.56	6.26	4.1	1.2	3.2	44.6
10	Hapur	7.53	0.85	6.08	0.04	5.10	7.07	5.0	2.0	2.5	33.5
Mean		7.68	0.96	7.37	0.04	3.17	3.66	4.39	1.5	4.5	52.9
CV (%)		3.10	76.7	49.8	74.1	40.2	70.3	35.0	92.0	58.8	30.6
FAO threshold (Ayers and Westcot,1985)		6.5-8.0	1.0	3.0	0.5	5.0	1.0	1.5	3.0	3.0	50.0

breakdown of physical properties and reduce permeability of soil, and stunted growth in plants (Joshi *et al.* 2009). The bicarbonate content was also higher than threshold value of 1.5 meq L^{-1} in both the region, as per the FAO guidelines. The chloride concentration of the samples were within the safe limit (below 3 meq L^{-1}) in some samples and exceeded in some samples as in soil samples of Pali (17.5 meq L^{-1}) which was excessively high. Necessary precautionary measures could be taken while using the poor quality waters for irrigation over a longer period, because these lead to accumulations of salts and other hazards in the soil become harmful to production system.

CONCLUSIONS

In comparison with other crop species, rose crop is highly sensitive to salinity and alkalinity. In the current study, it has been observed that most of the soil and water samples of the rose growing areas of Uttar Pradesh and Rajasthan are degraded due to alkalinity, sodium and bicarbonate hazards, and in some cases chloride hazards and salinity problems. Long term use of marginal quality water for irrigation can further aggravate the problems of soil salinity and alkalinity. Therefore, proper precautionary measures, reclamation and management of degraded soils and marginal quality waters is inevitable for sustaining the production system.

Table 4. Irrigation water quality of rose growing areas of Rajasthan

S.No.	Location	pH	EC (dS m^{-1})	Na^+ (mg L^{-1})	K^+ (mg L^{-1})	Ca^{2+} (mg L^{-1})	Mg^{2+} (mg L^{-1})	HCO_3^- (meq L^{-1})	Cl^- (meq L^{-1})	SAR (meq $L^{-1})^{1/2}$	SSP (%)
1	Chapiri, Udaipur	7.70	0.62	5.86	0.087	1.73	1.75	5.8	0.8	4.44	63.1
2	Chikada, Udaipur	7.59	1.05	8.74	0.032	1.01	1.80	7.1	3.0	7.37	75.7
3	Fatehnagar, Udaipur	7.51	1.57	15.90	0.043	3.50	2.08	10.0	5.0	9.52	74.1
4	Haldigati-1	7.52	0.45	4.86	0.076	1.56	1.95	5.3	1.2	3.67	58.4
5	Haldigati-2	7.32	1.76	7.74	0.076	4.54	2.24	10.9	3.6	4.20	53.5
6	Posalia	7.31	0.99	7.57	0.043	2.33	1.59	5.1	3.0	5.41	66.0
7	Balarwa-1	7.50	0.53	5.18	0.022	3.81	1.82	3.0	2.0	3.09	48.0
8	Balarwa-2	7.56	0.63	5.12	0.043	4.25	1.88	4.0	1.8	2.92	45.7
9	Balarwa-3	7.58	0.62	5.27	0.011	3.60	1.82	3.8	2.0	3.20	49.4
10	KVK, Pali	7.23	2.63	20.8	0.151	6.01	2.09	3.9	17.5	10.3	72.1
Mean		7.48	1.09	8.70	0.06	3.23	1.90	5.89	3.9	5.42	60.6
CV (%)		1.98	64.7	61.8	69.9	48.1	10.0	45.5	123	50.3	18.6
FAO threshold (Ayers and Westcot,1985)		6.5-8.0	1.0	3.0	0.5	5.0	1.0	1.5	3.0	3.0	50.0

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