Impact of salt-affected soil on the growth and yield of Thompson seedless grapes

Abstract

In two separate locations within Maharashtra's grape-growing region, the study was carried out on soils damaged by salt. The purpose of the study was to find out how well grapevines performed in terms of growth indices on sodic soils in Maharashtra under various climate conditions. Five distinct locations were used to select the variety Thompson seedless grafted on dog ridge rootstocks. The grapevines were trained on the Y system and planted with a spacing of 3.3 × 1.6 m. Two of the five places were in the Sangli district, two were in the Solapur district, and one was in Pune (no sodic soil). The vines growing under MRDBS site (no sodic soil) exhibited the highest vegetative growth, as measured by shoot length (cm), intermodal distance (mm), cane thickness (mm), leaf area (m2), and total chlorophyll contents.

The sodicity of the soil affected the growth at other locations, however for yield observations, the grape bunches were picked when they reached harvestable maturity, which was defined as total soluble solids of 17.50° Brix. The available nitrogen, phosphorus, potassium, and micronutrient findings on soil were substantially lower than the control. According to the study, grapevine growth, yield, gas exchange parameters, and nutrient status were all negatively impacted by the highly sodic soil.

Key words: Yield quality, Grapevines, Nutrient status, Sodic soil, Growth parameters

Introduction

Although salt-affected soils are also common in sub-humid and humid climates, problems with soil salinity are most prevalent in arid and semi-arid locations. In regions where irrigation uses high-salinity groundwater, soil salinity is also a significant issue. The irrigated desert and semi-arid regions of India are experiencing the worst salinity issues. Irrigation systems built without sufficient drainage capacity have exacerbated the issues, which are further compounded by shoddy reclamation techniques and water management strategies. Sodic and saline soils are the two categories for the salt-affected soils. The current study aims to determine how sodic soils affect growth, photosynthetic activity, yield, and nutrient status.

Materials and Methods

Experimental locations

During the 2018 growing seasons, the Maharashtra State Grape Growers’ Association's R&D Unit at Manjri Farm in Pune, India, conducted this study. In order to compare the performance of grafted Thompson seedless grape vine, salt-affected vineyards were chosen from Sangli districts [village Kavathe Piran (16.8817 °N 74.4630 °E), Bendri village (17.0300 °N, 74.6000 °E), located on the southern bank of the Warana and Krishna rivers]; Solapur district [Sadashiv Nagar village (17.882444 °N, 75020531 °E), Kumate village (17.6037 °N 75.9402 °E)]; Pune district [Manjri village (18.4921 °N 73.9869 °E)]. The soils had a substantial $CaCO_3$ content, a clayey texture, a dark brown color, and a sodic character. The method of watering used a drip system.

Grapevines and experimental designing

In 2018, a study was carried out at all the locations on Thompson seedless vine grafted on Dogridge rootstocks. In all studded locations, the vines were planted in 2011–2012. Among the nation's most extensive grape-growing regions is the one chosen for this study. No summer rains are experienced, and the climate is semiarid Mediterranean. In a randomized block design, each treatment had four replicates, totaling 36 plots. Twelve vines were planted in three rows for per treatment site. Only ten of the middle row's center vines were sampled in order to reduce edge effects. 2.13 m separated rows and 1.52 m among rows of vines. The vines were trained, and rows were orientated from north to south.

Soil sampling and analysis

Following the start of the experiment, an annual soil sample was taken in October, the end of each irrigation season. A composite sample was created by combining soil samples collected with an auger at depths of 0–15, 15–30, 30–60, and 60–100 cm, approximately 40 cm from the drip line, and in front of a dripper halfway between two vines. Soil samples were preserved until examination by being oven-dried at 65°C. Since there is no gypsum in the soil in this area, this drying preparation shouldn't cause any dehydration. Rhoades et al. (1982) reported that EC2, pH2, Na^+, Cl^-, K^+, Mg^{2+}, Ca^{2+}, and NH_4^+ were measured in saturated paste extracts of dry soils.

Petiole sampling and chemical analysis

As recommended by Christensen (1969), 30 basal leaves across from a bunch cluster were sampled from each replicate during harvest, which occurred between mid-March and mid-April. Instead of analyzing entire leaves, petioles were examined using the techniques developed by Downton (1977b), Prior et al. (1992), and Fisarakis et al. (2001). After rinsing the petioles three times with tap water and twice with distilled water to get rid of any remaining dust and pesticide, they were oven-dried for seventy-two hours at 70°C. After that, the samples were ground up in an electric mill, and 150 mg of dry matter were broken down at 130 °C using 5 ml of concentrated reagent-grade nitric acid. The digest was diluted with double-distilled water to a volume of 50 ml and stored at 4 °C until the Na+ content was measured using a flame photometer ((Thermo Fisher Chemito FP-114, Mumbai, India).

In 2018, 90 days after pruning, vegetative growth parameters were measured using a portable laser leaf area meter (CID, Bioscience, Mumbai, India), including shoot length by tailor tap, intermodal distance by Vernier caliber (RSK™, China), cane thickness by Vernier caliber (RSK™, China), and total chlorophyll contents using the method recommended by Arnon (1949). The grapes were harvested from the vineyard between the middle of March and the middle of April, or whenever the total soluble solids (TSS) exceeded 18.00 °Brix. Fruit was collected and weighed independently from each copy of the various treatments. Using a digital Vernier caliper (RSKTM, China), the average bunch weight, berry weight, berry length, and berry diameter were measured at harvest. From each replicate, one hundred berry samples were chosen at random, blended, and filtered.

Statistical analysis

An average of the data was shown for each of the many characters that were examined. The study was carried out using a randomized block design that included. The SAS System software, version 9.3, GLM technique was used for all calculations.

Results and Discussions

Vegetative growth and yield parameters

Table 1 displays the information gathered on the different vegetative characteristics of grapevines planted in sodic soil at all locations. In vines grown on sodic soils, the highest vegetative parameters, such as shoot length, intermodal distance, cane thickness, leaf area, and total chlorophyll contents, were in the control (normal soil) and decreased throughout the control treatment. Osmotic stress is the main cause of the decrease in vegetative development, and ionic stress (Na+) is the second factor that reduces biochemical processes (Munns and Tester, 2008). The reduction of nutrient absorption caused by the uptake of NaCl in competition with nutrient ions has also been proposed as an explanation for the growth inhibition caused by salt. have documented a link between Cl and reductions in grapevine shoot growth in saline environments.

Yield and quality

Table 1 displays the yield and quality data for grapevines growing in sodic soil at all locations. Average bunch weight, berry weight, berry diameter, and berry length were among the yield qualities that decreased in sodic soil; this was especially true in greater sodic soil treatments when compared to the control soil. The outcomes matched those of Netzer et al. (2014), who stated that irrigation was given to table grapes for eight years, and as a result, visual salinity-like symptoms increased on the leaves; in some extreme cases, yield-bearing vines completely collapsed. The findings of this study on yield characteristics and vegetative growth for every location may be the consequence of an increase in reduced the uptake of phosphorus and nitrogen in the sodicity, which directly impacted the growth of the plant and, eventually, the length of the shoot. High quantities of salt actually inhibited the uptake of nutrients from the soil and had an impact on harvestable yield, cane thickness, shoot length, and intermodal distance. Abiotic stress in grapevines can impact multiple physiological processes, such as decreased grape yield, increased concentrations of Na and Cl in the fruit, shoot growth, number of bunches per vine, and number of berries per bunch (Lanyon et al., 2004). According to Sudhir and Murphy (2004), excessive accumulation of Na and Cl ions causes ion toxicities and an increase in respiration reduced the uptake of phosphorus and nitrogen in the sodicity, which directly impacted the growth of the plant and, eventually, the length of the shoot. In actuality, excessive salt inhibits the absorption of other minerals like calcium, potassium, and manganese. Salinity-stressed grapevines are also associated with changes in plant development, mineral distribution, membrane instability brought on by the displacement of Ca by Na ions, membrane permeability, and a reduction in photosynthesis. Rate, whereas salt stress causes.

Soil nutrient status

Tables 3 and 4 give the findings of the soil nutrient contents for every location over the two years of study. According to data, all of the locations' sodic soil had higher pH, EC, $CaCO_3$, and sodium concentration than the control plot (the Pune location). The available nitrogen, phosphorus, potassium, and micronutrient data in the soil were significantly lower than the control group; this could be because the soil contains more salt. The soil has poor physical qualities due to structural instability caused by an excess of salt in the soil exchange complex. The soils have restricted internal drainage and a poor rate of infiltration. Because of this, after irrigation or rain, the top soil layers stay almost completely wet for extended periods of time. Resulting in temporary anaerobic conditions.Patrick and Wyatt (1964), reviewing the literature on elemental nitrogen losses from soil, concluded that losses were likely to be highest under alternate aerobic and anaerobic conditions, a situation exactly met within sodic soils. Sodic soils contain excess amounts of Na salts, where the effect on the grapevines' physiological processes is mainly due to the adverse effects that high Na concentrations have on the soil structure (Lanyon et al., 2004). The poor soil structure and the low permeability of sodic soils have a negative effect on plant growth. Water, gasses (oxygen and carbon dioxide), and solutes can easily pass through good soil and reach the roots of plants. Hard, acidic soils that are found on or near the soil's surface might be a hindrance to the growth of roots. This prevents solutes, gases, or water from penetrating the deeper subsurface layers. This effect on plant growth is comparable to the signs of salinity or drought (Fitzpatrick, 2002). The amount of salt that seeps down into the subsurface layers is largely dependent on the nature of the soil. Water moves more quickly through coarse-textured soils, carrying the salts that have accumulated on the soil's surface with it.

Petiole nutrient status

A delayed cane maturity, a flagging cell wall, and a decreased rate of photosynthesis were the outcomes of the data on petiole nutrient status, which revealed that the sodic soils had an impact on the uptake of cations (potassium, calcium, and magnesium). These factors ultimately affected sugar accumulation, mummification, and short berries in grapevines, respectively. Plants consistently take in more salt and absorb fewer cations when soil sodicity increases. The increase in plant sodium concentration is typically significantly greater than the drop in plant cation concentration when exchangeable sodium percentage rises. Because of this, before the cations become limiting for plant growth, the plants frequently store sodium to the point of lethal levels (Singh et al., 1979, 1980, 1981; Chhabra et al., 1979). According to several studies, petiole Na and Cl contents shouldn't be higher than 217 mmol kg-1 for sodium dry weight and 423 mmol kg-1 for chlorides dry weight because doing so will lower pruning mass, shoot length, cane number, leaf mass, and petiole mass in high saline soil (Robinson and McCarthy, 1985).

Conclusions

This investigation leads to the conclusion that soils damaged by salt have a negative impact on the quality and yield parameters, petiole nutrient status, and soil of vines growing in tropical climates.

Table 1. Effect of sodic soil on vegetative parameters after 90 days of pruning

Plot No.	shoot length (cm)	Internodal distance (mm)	Cane thickness (mm)	Leaf area (m^2)	Total chlorophyll (mg g^{-1}FW)
1	43.75	44.86	5.65	111.88	0.90
2	37.75	43.37	5.45	98.90	0.93
3	46.5	45.13	5.50	104.15	0.77
4	46.75	50.48	5.35	96.82	0.88
Control	51.00	43.40	6.12	111.57	1.25
C.V.	17.11	16.94	13.25	23.52	27.27
C.D (5%)	N.S	N.S	N.S	N.S	N.S

Table 2. Effect of sodic soil on yield and quality parameters in grapes

Plot no	Bunch weight (gr)	50 Berry weight (gr)	Berry length (mm)	Berry Diameter (mm)	TSS (°B)	Yield/ wine kg	yield/ acre ton
1	164.04	68.54	15.53	15.02	19.02	7.38	5.54
2	183.61	65.03	15.92	15.44	19.86	8.26	6.20
3	163.81	72.27	15.96	14.93	18.68	7.37	5.53
4	145.86	65.24	16.09	14.88	19.90	6.56	4.92
Control	289.67	88.40	18.93	18.10	18.20	13.04	9.78
C.V.	10.16	7.39	5.44	4.42	4.33	10.16	10.16

C.D (5%)	36.79	10.16	1.72	1.33	N/A	1.66	1.24

Table 3. Effect of sodic soil on soil nutrient status in grapevine.

Plot No.	pH	EC_2 (dS m^{-1})	$CaCO_3$ (%)	OC (%)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)	W.H.C. (%)
1	8.35	0.44	15	1.41	116	98	640	3925	2250	651	8.17	10.5	2.75	5.35	1520	41.10
2	7.9	1.91	13	1.8	76	225	720	4200	2225	861	8.52	10.8	4.22	3.8	4000	39.80
3	7.89	1.1	15	1.57	173	475	370	5550	1900	160	9.00	12.3	1.78	4.15	1640	41.60
4	7.96	0.81	13	4.49	180	352	1260	4800	1875	703	14.9	12.6	6.00	13.4	1640	41.00
Control	7.15	0.28	5	1.84	102	78	620	4375	2125	60	5.42	8.77	5.93	10.9	500	47.70

Table 4. Effect of sodic soil petiole nutrient status After 90 days'

Plot No.	N (%)	NO_3 – N ppm	P %	K %	Ca %	Mg %	S %	Fe ppm	Mn ppm	Zn ppm	Cu ppm	Na %
1	1.17	488	0.46	4.2	1.14	0.93	0.14	89	302	132	57	0.95
2	1.34	453	0.53	3.4	1.22	0.75	0.14	76	124	87	45	1.1
3	1.17	457	0.58	3.8	1.08	0.45	0.12	61	113	72	119	0.55
4	1.51	641	0.38	2.6	0.98	0.49	0.18	59	101	140	344	0.9
Control	1.08	647	0.27	2.80	1.48	0.6	0.13	255	133	121	118	0.45

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