Impact of Salt affected soil on the Growth and Yield of Thompson seedless Grapes.

Abstract

This Research study was conducted on salt affected soils at two different locations grape growing area of Maharashtra. The study was conducted to investigate the performance of growth parameters in grapevines on sodic soils under different climatic conditions in Maharashtra. The variety Thompson seedless grafted on dog ridge rootstocks were selected from 5 different locations. The grapevines were planted byadapting a spacing of 3.3m × 1.6 m and trained on Y system.Out of five locations two were from Sangli district, two from Solapur district and one (no sodic soil) was from Pune. The highest vegetative growth *viz* shoot-length (cm), intermodal distance (mm), cane thickness (mm), leaf area (m^2) and total chlorophyll contents were recorded with vines growing under MRDBS location (no sodic soil, control). While growth at other locations varied as per sodicity of soil. For yield observations, the grape bunches wereharvested after attaining harvestable maturity with total soluble solids of 17.50° Brix. The results obtained on soil nutrients on available nitrogen, phosphorus, potassium and micronutrient in soil were significantly reduced over control. The study showed that the high sodic soil had negative impact on growth, yield, gas exchanges parameters and nutrients status in grapevines.

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

Introduction

The problems of soil salinity are most widespread in the arid and semi-arid regions but salt-affected soils also occur extensively in sub-humid and humid climates. Soil salinity is also a serious problem in areas when groundwater of high salt content is used for irrigation. The most serious salinity problems are being faced in the irrigated arid and semi-arid regions of India.The problems have been made worse by development of irrigation systems without adequate provision for drainage and are being aggravated by poor water management practices and unsound reclamation procedures.The salt-affected soils have been classified into saline and sodic soils. The objectives of the presentinvestigation are to know the effect of sodic soils on growth,photosynthesis activity, yield and nutrient status from soil and petioles in Thompson seedless grafted vines cultivated in different agro-climatic regions of Maharashtra.

Materials and Methods

Experimental locations

This study was carried out by R & D Unit of Maharashtra State Grape Growers' Association, Manjri Farm, Pune, India during the growing seasons of 2018Salt-affected vineyards were selected from Sangli districts[village Kavathe Piran (16.8817°N 74.4630°E),Bendri village (17.0300 °N, 74.6000°E) situated on southern bank of Warana and Krishna river]; Solapur district [Sadashiv Nagar village (17.882444°N, 75020531°E), Kumatevillage (17.6037°N 75.9402°E)situated in dryland] and Pune district[Manjri village (18.4921°N 73.9869°E)] to compare the performance of grafted Thompson seedless grape vine. The soils were of dark brown color, clayey texture and sodic in nature having predominant $CaCO_3$ contents. Drip system was employed for irrigation.

Grapevines and experimental designing

A study2018 was conducted on Thompson seedless vine grafted on Dogridge rootstocks at all the locations. The vines were planted in the year 2011- 2012 at all the locations studded. The regions selected for this study is one of the largest grape-growing areas in the country. It is characterized by a semiarid Mediterranean climate with no summer rains. Each treatment consisted of four replicates (36 plots in total) arranged in a randomized block design. Each treatment plot consisted of three rows with 12 vinesper row. To minimize edge effects, only 10 centralvines from the middle row were sampled. Vine spacingwas 1.52 m within rows and 2.13 m between rows. Rows wereoriented from north to south and the vines were trained toa 2-m-high Y-shaped open-canopy gable system with sixfoliage wires on each side. Each vine was pruned to eightfruiting canes of 14 buds each. The canes were tied to thesecond- and third-lowest foliage wires supported by theY-shaped cross-arms. Vine and row spacing, and trainingand trellis systems, were set according to standard practicesfor commercial table grape production in the area. Standardhorticultural practices to control insects, fungi and weedswere employed throughout the experiment. A drip irrigationsystem with one line per row and in-line pressurecompensated2.4 Lh^{-1} drippers was employed, with 0.5-mspacing between drippers (Jain irrigation system, Jalgaon 425001. Maharashtra, India.).All the crop managements such as cultural practices, fertilization, pesticide application was performed for kept healthy vines.

Soil sampling and analysis

After initiation of the experiment, the soil was sampled annually at the end of each irrigation season(October). Soil samples were taken using auger at depths of 0-15, 15-30, 30–60, and 60–100 cmat about 40 cm from the drip line, in the front of a dripper midway between two vines and made a composite sample. Soil samples were oven-dried at 65 °C for preservation until analysis. The soil of this region is gypsum-free thus no dehydration is expected by this drying pretreatment. Saturated paste extracts of dried soils were analyzed for EC_2, pH_2, Na+, Cl^-, K^+, Mg_2^+, Ca_2^+, and NH_4^+according toRhoades *et al.* (1982).

Petiole sampling and chemical analysis

From each replicate, 30 basal leaves opposite a bunch cluster were sampled at harvest (mid-March to mid-April) as suggested by Christensen (1969). Petioles, rather than whole leaves were analyzed following methods of Downton (1977b),Prior *et al.* (1992) and Fisarakis*et al*. (2001). Petioles were rinsed three times in tap water then twice in distilled water to remove dust and pesticide residues, and oven-dried at 70 °C for 72 h. Samples were subsequently pulverized in an electric mill, and 150 mg of dry matter was digested with 5 ml of concentrated reagent-grade nitric acid at 130 °C. The digest was brought to a volume of 50 ml with double distilled water and kept at 4 °C untilanalysis for Na^+concentration by flame photometer (ThermoFisher Chemito FP-114 Mumbai, India).

Growth and yield parameters

The vegetative growth parameters such as, shoot length ~~(cm)~~ by tailor tap, intermodal distance by Vernier caliber (RSK™, China), cane thickness by Vernier caliber (RSK™, China), leaf area by portable laser leaf area meter (CID, Bioscience, Mumbai, India), and total chlorophyll contents using method suggested by Arnon (1949) were recorded at 90 days after pruning during 2018. The vineyard was harvested from mid-March to mid- April when the total soluble solids (TSS) of the grapes reached above18.00 °Brix. Fruit from each replicate of the differenttreatments was harvested and weighed separately.At harvest, average bunch weight ~~(g)~~, berry weight ~~(g)~~, berry length ~~(mm)~~ and berry diameter ~~(mm)~~were measured by using the digital Vernier caliper (RSK™, China). Hundred berry samples were randomly selected from each replicate and processed in a blender and strained through two layers of muslin cloth. Soluble solids concentration was determined from the juice using a digital refractometer (model ERMA of Japan).

Statistical analysis

The data were presented as an average for all the different characters studied. The experiment was conducted in randomized block design consisting of three treatments as different bunch load. All calculations were performed using the GLM procedure of SAS System software, version 9.3.

Results and Discussions

Vegetative growth and yield parameters

The data collected on various vegetative parameters of grapevines grown on sodic soil at all the location are presented in Table 1.The highest vegetative *viz,* shoot length ~~(cm)~~, intermodal distance ~~(mm)~~, cane thickness ~~(mm)~~, leaf area ~~(m^2)~~ andtotal chlorophyll contents ~~(mgg^{-1})~~were in control (normal soil) and reduced over the control treatmentin vines cultivated on sodic soils.The reduction in the vegetative growth is primarily due to osmotic stress followed by the ionic effect (Na^+) that caused reduction in biochemical phenomenon (Munns and Tester, 2008). The growth inhibition due to salinity has also been explained by a suppression of nutrientabsorption due to uptake of NaCl in competition with nutrient ions. Walker *et al*. (1984) have reported thatdecreases in shoot growth of grapevines under saline conditions are related to Cl accumulationin the plant.Behboudian*et al*. (1986) have also concluded that lower photosynthesis due to salinity is correlated with chlorophyll content. The present results in grapevine cultivars showed that excessive Na contents in soil caused significant decrease in the chlorophyll content of explants due to salt levels and treatment periods. These findings are compatible with those of Downton and Millhouse (1986)working with grapes.

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Yield and quality

Data obtained for yield and quality of grapevines grown in sodic soil at all the locationare presented in Table 1. Yield attributes such as average bunch weighty, berry weight, berry diameter and berry length declined in sodic soil, more so in higher sodic soils treatments as compared to the control soil. The results were similar to the findings of Netzer *et al.*(2014) who reported that the irrigation applied in table grapes for 8 years and as a consequence an increase in visual salinity –like symptoms appeared on the leaves, in some extreme cases, total collapse of yield bearing vines occurred.The results obtained in this investigation on vegetative growth and yield parameters for all the location might be due to the fact that an increase in the sodicity decreased the uptake of nitrogen and phosphorus, which had a direct effect on the plant growth and ultimately on the shoot length.Actually, high salt concentration reduced the uptake of soil nutrients and affected shoot length, intermodal distance, and cane thickness and harvestable yield. The abiotic stress in the grapevine can affect various physiological processes including reduction in grape yield, shoot growth, number of bunches per vine, berries per bunch, as well as may increase the Na and Cl concentrations in the fruit (Lanyon *et al*., 2004). Sudhir and Murphy (2004) reported that salt stress leads to an increase in the rate of respiration and ion toxicities, where an excessive accumulation of Na and Cl ions leads to a decrease in the uptake of other minerals such as Ca, K and Mn. Plant growth, mineral distribution, membrane instability resulting from the displacement of Ca by Na ions, membrane permeability and decrease in photosynthesis are also linked to salinity stressed grapevines.

Soil nutrient status

The results obtained on the soil nutrient contents for all the location during both the year studiedare presented in Table 3 and 4. Data revealed that the sodic soil from all the location recorded high pH, EC ~~(dSm^{-1})~~, $CaCO_3$~~(%)~~ and sodium content compared to control plot (Pune location).The data recorded on available nitrogen, phosphorus, potassium and micronutrient in soil was significantly reduced over control this is might be due to higher sodium in soil. Excess sodium on the soil exchange complex imparts structural instability to the soil giving poor physical properties.The infiltration rate of the soils is low and the soils have restricted internal drainage. For this reason, the surface soil layers remain nearly saturated for prolonged periods following irrigation or rain 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. A healthy soil allows for easy permeability of water, gases (oxygen and carbon dioxide) and solutes to and from the plant roots. Hard sodic soils occurring on the soil surface or close to the soil surface it can act as a root development barrier. This does not allow for water, gas and solute penetration into the deeper subsoil layers. This effect on plant growth is similar to symptoms caused by drought or saline conditions (Fitzpatrick, 2002). Soil structure plays an important role in determining the amount of salts percolating downward into the subsoil layers. In coarse textured soils, water will move downward faster, taking with it the salts that have accumulated on the soil surface.

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Petiole nutrient status

The data recorded on petiole nutrient status indicated that the sodic soilshave influencedthe uptake of cations (potassium, calcium, magnesium) which resulted in delay in cane maturity, flagging cell wall, reduced rate of photosynthesis which ultimately affected sugar accumulation, mummification and short berries in grapevines,respectively. Increasing soil sodicity always results in an increased uptake of sodium and decreased uptake of cations by plants. With an increase in exchangeablesodium percentageand the increase in sodium concentration of plants is usually much larger compared to the decrease in the cationsconcentration. For this reason, the plants often accumulate sodium to the level of toxic quantities before the cations become limiting for plant growth (Singh *et al*., 1979,1980, 1981; Chhabra *et al*.,1979). Several studies recommended that Na and Cl contents in petiole should not exceed 217 mmol.kg^{-1} sodium dry weight and 423 mmol.kg^{-1}chlorides dry weight as it will reduce pruning mass, shoot length, cane number, leaf and petiole mass with high saline conditions in the soil**(**Robinson and McCarthy, 1985).

Conclusions

From this investigate, it may be concluded that, the salt-affected soils have adverse effect on vegetative growth, yield and quality parameters and nutrient status of petiole and soil of vines grown under tropical conditions.

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 (mgg^{-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

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Table 2. Effect of sodic soil on yield and quality parameters in grapes 2018

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 during season 2018.

Plot No.	pH	EC_2 (dSm^{-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' season 2014-15

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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