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# Effect of water and salt stress on soil moisture status under nursery conditions

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**Abstract**

Soil is a natural body developed through pedogenic process, consisting of all necessary mineral and organic constituents who are require for plant growth and productivity. Therefore, any changes in the soil properties directly affect the plant growth status. In the present study, effect of artificially created abiotic stresses like drought, water logging, salinity, combined salinity + drought and salinity + water logging on the soil moisture of selected tropical forest tree species seedlings *viz: Tectona grandis, Gmelina arborea, Dalbergia latifolia* and *Pongamia pinnata* have been seen by performing pot culture experiment in factorial CRBD manner in TFRI nursery for one year duration. Transparent polythene bags were used filled with soil, sand and farm yard manure (FYM) in 2:1:1 ratio, keeping the weight of polybags fixed at 2 kg. The amount of water equal to the field capacity was given to each polybags. The moderate and severe drought conditions were created with the help of cumulative pan evaporation and permanent wilting point values. The artificial moderate and severe water logging conditions were created by perforating 8 periphery holes in the polybags below 6 cm and 3 cm from surface. 4dS/m, 8dS/m and 12dS/m sodium chloride salt dissolved water provided regularly for maintaining the salinity conditions. The salt doses combined with the illustrated drought and water logging way of treatments for generating combined salinity and drought & combined salinity and water logging conditions. The soil was analyses for general physicochemical characteristics so as to standardize the non-difference in the soil used along with the soil moisture by following gravimetric method. The soil moisture was measured initially on the start of experiment (August 2015) and then at six months intervals (February 2016 and August 2016). The data statistically analyses by using ANOVA table and CD values stated that there was the significant difference in the soil moisture readings of selected tree species. The maximum soil moisture was found in the severe waterlogged treatment, followed by moderate waterlogged, control and moderate drought and minimum in severe drought treatment irrespective of salt concentrations. Higher dose of salt concentration retains more moisture in the soil. The soil moisture holding capacity of different species remains unaffected under selected abiotic stresses.

**Keywords:** Nursery, drought, water logging, salinity, moisture

## Introduction

Soil is a dynamic natural body developed as a result of pedogenic processes during and after weathering of rocks, consisting of mineral and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having a variable depth over the surface of earth and providing a medium for plant growth for land plants (Tale, 2015) [28].

The soil is a reservoir of nutrients and moisture for the production of forages and plant species. Vegetation distribution and productivity is dependent on the physico-chemical properties of soil, which vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities and several other biotic and abiotic variables (Tale, 2015) [28]. Hence, it is very important to know the basic knowledge about the physico-chemical properties of soil (Tale, 2015) [28].

Influence of vegetation on the soil properties has been a subject of great interest in forestry. Vegetation has a pronounced effect on many soil properties. The nature and content of organic debris returned to the forest floor vary with vegetation and affects the physico-chemical properties of soil (Nath and Banerjee, 1992) [18].

The present study is dedicated to see the effect of water (drought and water logging), salinity and their combination on soil moisture of selected tropical forest tree species seedlings *viz: Tectona grandis, Gmelina arborea, Dalbergia latifolia* and *Pongamia pinnata* under nursery conditions. This will provide an understanding about the relationship among environment, plant species and soil moisture.

## Material and methods

The nursery (23°5'57.2" N latitude, 79°59'2" E longitude and 394 m altitude) of Tropical Forest Research Institute (TFRI), Jabalpur (M.P.) chosen for experimental site. The pot culture experiment was performed for one-year duration. *Tectona grandis, Gmelina arborea, Dalbergia latifolia* and *Pongamia pinnata* (Karanj) tropical tree species selected for the study. In order to avoid any difference due to genetic diversity, the seeds were collected from TFRI campus during March to May and then sown in the nursery beds in June, just before first shower of rainfall, which is favourable for normal and healthy germination process.

The sand was used as the sowing medium in the nursery mother beds (10 m x 1 m) for maintaining sterile conditions for germination of seeds. Pre-sowing treatment provided to *Tectona grandis* and *Gmelina arborea* seeds in a pit filled with water and cow dung for 1 week. The seedlings having 2-3 leaves were transferred to transparent polythene bags of standard size (15 cm x 23 cm) filled with soil, sand and farm yard manure (FYM) in 2:1:1 ratio. The polythene bags were initially placed under shade for one month to protect the seedlings from direct sunlight and then kept in open area for another one month in order to acclimatize them with the prevailing conditions.

Complete Randomized Block Design (CRBD) in a factorial manner was adopted to perform the experiment. Each treatment consisted of nine seedlings and each replication consisted of 20 treatments. The experiment was replicated thrice. During rainy season the entire pot culture experiment was protected by polythene sheets cover, allowing the sunlight penetration and circulation of wind normally.

S1W1 S2W1 S3W1 S4W1
S1W2 S2W2 S3W2 S4W2
S1W3 S2W3 S3W3 S4W3
S1W4 S2W4 S3W4 S4W4
S1W5 S2W5 S3W5 S4W5

Where,

| | Salt stress | | Water stress |
|---|---|---|---|
| $S_1$ | No salt | W1 | Control |
| $S_2$ | 4 dS/m | W2 | Moderate drought |
| $S_3$ | 8 dS/m | W3 | Severe drought |
| $S_4$ | 12 dS/m | W4 | Moderate waterlogged |
| | | W5 | Severe waterlogged |

The amount of soil moisture or water content held in the soil after excess water drained away is the field capacity which usually takes 2-3 days after rain or irrigation. The amount of water equal to the field capacity was given to each polybags i.e., to both control and treatment polybags equally. The field capacity value varies with the species (Table 1). The soil moisture at field capacity was calculated by following gravimetric method given by Tyree *et al*., (2002) [29] as: field capacity (%) = (WW-DW) x 100/DW, where, WW - Wet Weight of soil + plant (g) and DW - Dry Weight of soil + plant (g). Taking standard density of water as 1g/ml and water retained in polybags (WW-DW) after decantation, the volume of water required to irrigate the polybags was calculated by V (Volume) = M (WW-DW, Mass)/ D (Density).

The drought experiments were conducted by providing water equal to the field capacity at the interval of calculated Cumulative Pan Evaporation [CPE = Sum of evaporation values, adopted by Eliades, (1988) [7] & Savva and Frenken, (2002) [27], Table 2] values by Open Pan Evaporimeter. Soil moisture content measured at permanent wilting point [Soil moisture at permanent wilting point (%) = (WW-DW) x 100/DW, where, WW - Wet Weight of soil + plant (g) and DW - Dry Weight of soil + plant (g), adopted by Savva and Frenken, (2002)] [27] given at Table 1. Severe drought (SD) conditions were created with the help of time interval counted on the basis of CPE values calculated till the species-specific permanent wilting point (PWP) while Moderate drought (MD) conditions were created with half of the CPE values calculated for severe drought conditions. Watering frequency varied in different seasons, that is, high during summer and low during winter (Table 2).

**Table 1:** Species specific measurement of soil moisture content and volume of water required for irrigation of seedling.

| Species | Soil moisture content at PWP (%) | Soil moisture content at FC (%) | Amount of water calculated for irrigation (ml) |
|---|---|---|---|
| *Tectona grandis* | 6.42 | 36.76 | 735.20 |
| *Gmelina arborea* | 8.61 | 39.75 | 795.00 |
| *Dalbergia latifolia* | 10.89 | 43.23 | 864.60 |
| *Pongamia pinnata* | 3.41 | 24.86 | 497.20 |

**Table 2:** Calculation of time period for watering polybags for drought treatment.

| Species | Drought | Cumulative Pan Evaporation values (mm) | CPE attained in number of days | | Time period for watering in number of days | |
|---|---|---|---|---|---|---|
| | | | Summer | Winter | Summer | Winter |
| *Tectona grandis* | Severe | 120 | 24 | 50 | 23 | 49 |
| | Moderate | 60 | 13 | 25 | 12 | 24 |
| *Gmelina arborea* | Severe | 40 | 5 | 14 | 4 | 13 |
| | Moderate | 20 | 3 | 7 | 2 | 6 |
| *Dalbergia latifolia* | Severe | 60 | 8 | 20 | 7 | 19 |
| | Moderate | 30 | 4 | 11 | 3 | 10 |
| *Pongamia pinnata* | Severe | 80 | 15 | 31 | 14 | 30 |
| | Moderate | 40 | 7 | 15 | 6 | 14 |

Artificial water logging conditions generated by perforating 8 holes of size 6±0.5 mm in the periphery of the polybags below 3 cm and 6 cm from surface (Martin and Ogden, 2005) [15] and watering daily according to the field capacity (Gibberd *et al*., 2001; Dodd, *et al*., 2013) [8, 6]. Severe water logging was attained in polybags perforated at 3 cm and moderate water logging was attained in polybags perforated at 6 cm from the surface. In the control plants, the holes were made at the bottom of polybags and watered at the interval of 2-4 days (Handreck *et al*., 2002) [9].

Salinity was created through salt (NaCl) dissolved water, maintained to be 4dS/m, 8dS/m and 12dS/m after regularly measuring the electrical conductivity of the soil (Rhoades, 1993) [23].

The water was provided to polybags at fixed intervals according to calculated time interval for individual Moderate Drought (MD) and Severe Drought (SD) stress conditions with dissolved sodium chloride (NaCl) salt in order to create combined salinity and drought conditions. Similarly, combined salinity and waterlogging conditions were created by irrigating salt dissolved water equivalent to the calculated field capacity daily. The electrical conductivity was maintained at 4ds/m, 8ds/m and 12ds/m respectively.

The potting soil samples, filled in polythene bags, were collected and brought to the laboratory for analysis. The samples were oven dried at 40-600 C, grinded to powder form and passed through 2 mm sieve. The samples were analysed for their physicochemical characteristics (Table 4).

**PH and Electrical conductivity (EC)**

Soil pH and electrical conductivity were measured by weighing 20 g of soil sample and placed in 100 ml beaker. 50 ml of distilled water was added and the sample was kept for an hour at temperature of 240C.The readings were taken using Systronics-362 make Digital pH meter and Systronics-308 make EC meter (Jackson, 1965; Piper, 1950) [13, 20].

**Organic carbon**

For determination of organic carbon by wet oxidation method of Walkley and Black, the soil sample was grinded to pass a 0.5 mm screen and transferred to a 500 ml Erlenmeyer flask. Added 10 ml of 1N potassium dichromate, followed by 20 ml of concentrated sulphuric acid. Shaked by hand for one minute and left the flask to stand on asbestos sheet for about 30 minutes and added about 200 ml of water, 10 ml of phosphoric acid and 1 ml of diphenylamine indicator solution. Titrated by adding 0.5N ferrous ammonium sulphate solution from the burette until the solution is purple blue. Continuously added the 0.5N ferrous ammonium sulphate in small lots of about 0.5 ml, until the colour flashes to green. Then added 0.5 ml of 1N potassium dichromate to restore an excess of dichromate and completed the titration by adding ferrous ammonium sulphate drop by drop until the last trace of blue colour disappears.

**Available nitrogen**

10 g of soil sample is taken in a round bottle flask, add about 20 ml of distilled water and added 100 ml of 2.5% NaOH and 100 ml of 0.32% KMnO4. Kept this solution on a burner for about 25 minutes. Connected the round bottom flask with a condenser and react the condensed material with 10 ml of Boric acid until the color of red litmus paper changes from blue to red and titrated it with 0.1N H2SO4 till the blue colour turns to light peach colour (Chopra and Kanwar, 1976) [4]. Noted the reading of end point of burette (Piper, 1950) [20].

**Available phosphorous**

2.5 g of soil sample is taken and added 50 ml of sodium bicarbonate solution and a pinch of activated charcoal. Shake it for 1 hour and filter. Took 5 ml of filtrate in a 50 ml volumetric flask and add 2-3 drops of 2-4 dinitro-phenol indicator to appear yellow colour. Added 4N HCl drop by drop to adjust the pH of the solution until solution becomes colourless. Then added 10 ml of ammonium molybdate, 0.5 ml of stannous chloride and make up the volume to 50 ml with distilled water. Took readings of this solution with UV/VIS Spectrophotometer at 660 nm (Black, 1965) [3].

**Available potassium**

5 g of sample added with 25 ml of ammonium acetate was shaked well with the help of shaker for 10 to 15 minutes. After shaking, filtered the solution in 50 ml beaker and analysed with Flame Photometer (Black, 1965) [3]. For preparing 100 ppm stock solution of potassium, 0.1907 g KCl is dissolved in 1 litre of distilled water. Solution of different concentrations *viz.* 50, 40, 30, 20, and 10 ppm were prepared by dilution method and prepared a graph for estimation of this element.

**Exchangeable calcium**

Taken 5 g soil in 250 ml conical flask and added100 ml 1N ammonium acetate, kept it for overnight, then filtered it through Whatman filter paper. Taken 5 ml filtrate in the china clay dish, added about 20 ml of distilled water then add 10 drops of 1% NaCN + 10 drops of 5% Hydroxylamine hydrochloride, 1 - 2 drops of potassium ferricyanide. Yellow colour appears, then added sodium hydroxide solution till the solution becomes colourless. Added pinch of murexide indicator, reddish pink colour is obtained. Titrated the solution against 0.01N EDTA. At the end point purple colour is obtained (Jackson, 1956) [12].

**Exchangeable magnesium**

Taken 5 g soil in 250 ml conical flask, added 100 ml 1N ammonium acetate, kept it for overnight then filtered with What man filter paper No. 41. Took 5 ml filtrate in the china clay dish, added nearly 20 ml of distilled water + 10drops of 1% sodium cyanide + 10 drops of 5% Hydroxylamine hydrochloride + 1 - 2 drops of potassium ferricyanide. Yellow colour appeared, then decolourises with the addition of buffer solution. Then add 1 – 2 drops of EBT indicator solution. Titrated it with 0.01N EDTA, blue colour is obtained at the end point (Jackson, 1956) [12].

**Exchangeable potassium**

Take 5 gm soil sample to 250 ml conical flask, add 100 ml 1N ammonium acetate, keep it for overnight, then filter with Whatman filter paper No. 41. Take the readings of the extract with Flame Photometer. Before taking the readings, standardize the instrument by using 50 ppm, 40 ppm, 30 ppm, 20 ppm and 10 ppm standards of potassium (KCl) in descending order (Jackson, 1956) [12].

**Exchangeable sodium**

The similar method applied for estimation of exchangeable K is applied for the estimation of exchangeable sodium also, except standards of sodium (NaOH pellets) of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 ppm were prepared and graph is plotted (Jackson, 1956) [12].

**Soil texture**

20 g of soil sample was taken and 10-20 H2O2 ml added and was kept for 20-20 minutes on hot plate and the sample was allowed to cool. After cooling, 10 ml of H2O2 was again added and kept on the hot plate for 15-20 minutes. 10-15 ml of dispersing was reagents were added and sample stirred for 15-20 minutes with a Lab stirrer. After stirring, the solution was

added to a volume of 1 litter in 1000 ml of measuring cylinder (Jackson, 1973) [11].

The soil moisture was estimated thrice starting from August 2015 and then at the interval of six months (February 2016 and August 2016). Soil moisture was quantified for only those polybags, which had survived seedlings (Table 5). 10 g of fresh soil was taken in the aluminium boxes after 2 days of irrigation, so that the gravitational water is drained away and fresh soil weight (FSW) was measured. The empty weight of aluminium boxes was taken before taking FSW. The boxes were dried in hot air oven at 60-70$^0$C till the constant weight is achieved and dry soil weight (DSW) was measured (Hardisky *et al*., 1983) [10].

The data were statistically analyzed with the help of drawing ANOVA (Analysis of Variance) table and calculating CD (critical difference) among the selected treatments at 5% significance levels.

**Results and discussion**

The forest soil used to fill the polybags was analysed for physico-chemical properties (Table 4). pH is the most important factor which governs availability of nutrients in soil. The pH range of 6.5 to 7.5 is optimum for availability of most of the nutrient elements. EC denotes the soluble salt concentrations of soil and is the measurement that correlates with soil properties affecting crop productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity and sub-soil characteristics. Good water holding capacity shows the good physical condition of soil *viz*. sand holds little water, but gives it up to plants easily, whereas clay holds a lot of water but it can be held tightly within the clay structure and be more difficult for plants to extract, (Biswas and Mukherjee, 1994a) [2].

Organic carbon and other available nutrients range was analyzed according to standard values given in table 2, which showed organic carbon as in high range (>0.75%) and other available nutrients were found from low to high range. Available nitrogen and phosphorus falls in the category of low range. Organic carbon is an integrative property of soil and it is generally assumed that higher the level of organic carbon, higher the soil fertility. The organic carbon also influences the availability of nitrogen and phosphorus to the plants. Nitrogen is an essential constituent of metabolically active compounds like amino acids, proteins, enzymes and some non-proteinaceous compounds (Biswas and Mukherjee, 1994a) [2]. Jain and Singh (2014) estimated available nitrogen in the soil samples collected from Madhya Pradesh and found in the range of 172 ±2.1 to 193.3 kg ha$^{-1}$ for red and brown soils. Phosphorus plays an important role in energy transformations and metabolic processes in plants and stimulates root growth. It activates the enzyme in protein and carbohydrates metabolism and translocation of carbohydrates and impart resistance to plants against fungal and bacterial diseases (Biswas and Mukherjee, 1994a) [2]. According to Muhar *et al*. (1963) 25% samples were categorized as low $K_2O$ (< 125 kg ha$^{-1}$), 67.5% medium (125 to 300 kg ha$^{-1}$) and 2.5% high (>300 kg ha$^{-1}$). All the soil samples had available phosphorus values more than 10 mg/kg considered suitable for plant production (Tale, 2015) [28].

Exchangeable calcium is essential for the formation of cell walls, as calcium forms part of the middle layer of the cell wall which regulates the entry of only those nutrients which are not toxic to the plant. Magnesium is a constituent of chlorophyll and chromosomes and maintains the dark-green colour of leaves and regulates the uptake of other materials, particularly nitrogen and phosphorus. Excess exchangeable sodium has an adverse effect on the physical and nutritional properties of the soil with consequent reduction in crop growth. Potassium, after nitrogen and phosphorus, is the third most likely element to limit plant productivity. Only 1-2% of the total potassium in the soil is available as either exchangeable potassium adsorbed on soil colloidal surfaces (*i.e.* clay particles and organic colloids) and/or in soil solution (McKenzie *et al*., 2004) [16].

Soil texture is determined mainly by percent content of silt, clay and sand and influences physical and chemical properties of the soil. The result sandy clay loam soil have low tensile strength, improved hydrological properties and good roots and shoots (Biswas and Mukherjee, 1994a) [2].

**Table 3:** Standard values of soil parameters

| Nutrient | Low | Medium | High |
|---|---|---|---|
| Organic carbon (%) | < 0.50 | 0.50 - 0.75 | > 0.75 |
| Available N (kg/ha) | < 280 | 280 - 560 | >560 |
| Available $P_2O_5$ (kg/ha) | < 22.4 | 22.4 – 56.0 | > 56.0 |
| Available $K_2O$ (kg/ha) | <140 | 140-336 | >336 |

Biswas and Mukherjee (1994a) [2]

**Table 4:** Physico-chemical characteristics of soil (potting mixture) used in the experiment.

| Parameters | Values |
|---|---|
| pH | 7.88 |
| Electrical conductivity (ds/m) | 0.78 |
| Water holding capacity (%) | 25.77 |
| Organic Carbon (%) | 0.99 |
| Available Nitrogen (kg/ha) | 174.58 |
| Available Phosphorous (kg/ha) | 18.41 |
| Available Potassium (kg/ha) | 350.00 |
| Exchangeable Sodium (meq/100g) | 0.17 |
| Exchangeable Potassium (meq/100g) | 0.46 |
| Exchangeable Calcium (meq/100g) | 26.60 |
| Exchangeable Magnesium (meq/100g) | 7.68 |
| Soil texture | Sandy clay loam |
| Clay (%) | 24 |
| Silt (%) | 10 |
| Sand (%) | 66 |

The soil moisture was estimated for one year at the interval of six months, including initial observation at the time of setting up the experiment. Soil moisture was quantified for only those polybags, which had survived seedlings for one year duration (Table 5).

Significant ($P<0.05$) difference in moisture content was found among the selected twenty combinations of treatments. Maximum soil moisture content was found in severe waterlogged (W5) treatment, followed by moderate waterlogged (W4) (Sahu, 2014) [25], control (W1) and moderate drought (W2) and minimum in severe drought (W3) treatment (Sanchez *et al*., 2016) [26], irrespective of salt concentrations. With increase in salinity soil moisture increased in polybags, which could be due to less water available to plants and more water left in the soil under saline conditions (Rengasamy, 2006 and Oliveira *et al*., 2013) [22, 5].

Plants are frequently exposed to various environmental stresses in both natural and agricultural conditions. Decision-makers alert for potential flooding and severity of droughts through soil moisture monitoring (Rossato *et al*., 2017) [24]. The information of soil moisture is a key in drought monitoring, as the soil water content can drastically be depleted when there is a precipitation deficit. Hence, soil moisture provides direct evidence of areas suffering rain shortage (Sanchez *et al*., 2016) [26]. Water logging influences the soil properties of an area. The

Normalized Difference Moisture Index (NDMI) range indicates a good presence of soil moisture under prolonged waterlogged condition during the study of water-logged areas within Moyna basin, India (Sahu, 2014) [25]. As the effect of soil moisture, data reveal that the largest numbers of grainsper spike were obtained when the soil moisture content was 80% of capillary capacity (Rabie *et al*., 1985) [21].

The effect of soil moisture treatments in saline soils upon plant growth is of particular interest as it is possible that difference in soil moisture may either decrease or intensify the salt effect. When the plants use the water, the salts are left behind in the soil and eventually begin to accumulate which then creates osmotic stress caused by decrease in soil water potential and restriction of water uptake by roots (Oliveira *et al.* 2013) [5]. Increased additions of sodium chloride to the soil progressively reduced plant growth. Rengasamy (2006) [22] studied that without salt, plants are able to take up water until the soil dries to 5% water content; at 0.64dS/m soil salinity plants can take up water till 14% water content and at 1 dS/m plants cease to take up water at 18% water content. The absorption of nutrients depend on the moisture of the soil. Thus, soil processes specific to each type of salinity dictate the strategies for plant-based solutions to different forms of salinity (Rengasamy, 2006) [22]. The soil moisture for sandy clay loamy soil has been reported to be 1.3 – 1.8 mm/cm (Natural Resources SA Northern and Yorke, 2014) [19].

The relation of plant growth to variation in the available soil moisture is complicated which contain salts. As soil dries out, the concentration of salts in the soil solution increases. A plant might grow better in a saline soil which is irrigated when only part of the available moisture has been utilized than in a similar soil in which the soil moisture is allowed to approach the permanent wilting percentage before irrigation takes place. In the bean pot culture experiment, the pots with the same salt content, the growth was greatest in the pots irrigated most frequently and hence maintained at the lowest tension and was poorest in the pots receiving the fewest irrigations. The effect was also observed in the yield of bean fruits, showing higher reduction in those treatments in which the soil moisture tensions were greater at the time of irrigation (Ayers *et al*., 1943) [1].

The soil moisture holding capacity of the selected tree species remain unaffected under the effect of chosen abiotic stresses and obtained maximum soil moisture in *D. latifolia*, followed by *G. arborea, T. grandis* and *P. pinnata* under study.

**Table 5:** Soil moisture variation under different treatments of salt, drought and water logging at different time intervals.

| Treatment | *T. grandis* | | | *G. arborea* | | | *D. latifolia* | | | *P. pinnata* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug 15 | Feb 16 | Aug 16 | Aug 15 | Feb 16 | Aug 16 | Aug 15 | Feb 16 | Aug 16 | Aug 15 | Feb 16 | Aug 16 |
| S1W1 | 33.33 | 32.16 | 42.86 | 40.25 | 37.49 | 66.67 | 42.25 | 40.58 | 42.86 | 23.15 | 37.11 | 44.93 |
| S1W2 | 35.69 | 18.86 | 21.95 | 36.99 | 29.14 | - | 42.86 | 36.67 | - | 21.95 | 35.01 | 40.45 |
| S1W3 | 35.14 | 14.07 | 17.65 | 40.85 | 26.32 | - | 44.09 | 29.93 | - | 23.46 | 29.31 | - |
| S1W4 | 36.43 | 35.75 | 42.86 | 38.70 | 40.12 | 66.67 | 43.47 | 44.23 | 49.93 | 21.51 | 44.86 | 47.71 |
| S1W5 | 36.43 | 37.80 | 45.56 | 39.86 | 42.79 | 75.44 | 42.86 | 46.27 | 53.85 | 23.00 | 50.98 | 53.85 |
| S2W1 | 36.43 | 47.35 | 51.52 | 38.31 | 48.44 | - | 41.84 | 50.83 | - | 22.85 | 37.24 | 42.86 |
| S2W2 | 32.10 | 30.43 | 33.33 | 36.99 | 50.23 | - | 41.44 | 45.84 | - | 22.40 | 35.99 | - |
| S2W3 | 34.23 | 18.11 | 20.48 | 41.44 | 48.66 | - | 42.86 | 45.21 | - | 23.76 | 35.32 | - |
| S2W4 | 36.43 | 48.74 | - | 40.06 | 75.85 | - | 40.06 | 52.36 | - | 23.00 | 45.84 | 49.25 |
| S2W5 | 32.10 | 50.83 | - | 38.12 | 81.82 | - | 43.06 | 63.58 | - | 20.92 | 52.83 | 57.98 |
| S3W1 | 33.87 | 48.88 | - | 38.31 | 77.94 | - | 42.86 | 57.98 | - | 21.07 | 40.38 | - |
| S3W2 | 36.43 | 43.88 | - | 39.47 | 58.06 | - | 39.86 | 56.01 | - | 23.46 | 37.49 | - |
| S3W3 | 33.33 | 22.45 | - | 37.17 | 51.21 | - | 40.85 | 55.12 | - | 22.40 | 36.74 | - |
| S3W4 | 33.87 | 51.59 | - | 36.99 | 78.89 | - | 40.45 | 64.38 | - | 23.00 | 51.59 | 53.85 |
| S3W5 | 36.43 | 56.17 | - | 41.44 | 86.10 | - | 40.25 | 69.30 | - | 20.92 | 65.11 | 66.67 |
| S4W1 | 36.43 | 55.12 | - | 38.89 | 81.71 | - | 42.05 | 77.51 | - | 21.36 | 44.09 | - |
| S4W2 | 36.43 | 47.20 | - | 37.74 | 72.91 | - | 40.25 | 76.47 | - | 20.48 | 40.45 | - |
| S4W3 | 33.33 | 27.23 | - | 40.85 | 52.75 | - | 42.86 | 74.62 | - | 21.95 | 37.87 | - |
| S4W4 | 32.28 | 56.58 | - | 36.43 | 81.93 | - | 42.86 | 79.10 | - | 21.51 | 52.52 | - |
| S4W5 | 32.28 | 62.43 | - | 36.43 | 85.30 | - | 42.86 | 79.86 | - | 23.46 | 93.61 | - |
| $CD_{0.05}$<br>SE± | NS | 0.906<br>0.315 | 0.295<br>0.102 | NS | 0.848<br>0.295 | 0.264<br>0.092 | NS | 1.201<br>0.418 | 0.295<br>0.103 | NS | 0.876<br>0.305 | 0.319<br>0.111 |

NS – Non significant

## Conclusion

The identification of soil properties are very important to know the well-being of plant. The status of soil moisture is directly linked with the plant health which further decides the growth and productivity of plant. Any changes around the plant environment which affects the soil moisture status and other properties also affects the plant. Due to environmental stresses the water and nutrient relationship between soil and plant gets affected. The present study showed that due to variation in the soil moisture status as the effect of different abiotic stresses, the growth and survivability of selected tree species seedlings was affected. *T. grandis* was able to survive under minimum soil moisture tension and its combination with 4dS/m salt concentration. *G. arborea* and *D. latifolia* species showed that soil moisture status under waterlogging treatment was non-lethal for their growth and survivability. *P. pinnata* species was able to manage itself under the soil moisture tension arose due to moderate drought, waterlogging (moderate and severe), 4dS/m salinity, 4dS/m salinity + waterlogging (moderate and severe) and 8dS/m salinity + waterlogging (moderate and severe). The proper investigation of soil moisture status not only provides the valuable information about the area and vegetation but also suggests the arrangements of the vegetation for the area with same/similar soil moisture content, reducing the damaging effects of abiotic stresses.

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