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Performance of turfgrasses on a clay based simulated cricket pitch under varied levels of soil compaction and ABA

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ABSTRACT

The cricket pitch is most trafficked area in cricket ground. Growing grasses on this compacted clay based surface is most difficult. The present investigation was undertaken to study the behaviour of two Bermudagrass varieties 'Selection-1' and 'Tif-419'on a clay layer of 21 cm with varied levels of compactions. The shoot density per 100 cm^2 and NDVI values were reduced from lower compaction level of 1.2 g/cc to higher compaction level of 1.6 g/cc. Similarly, root dry weight and total root length in the top 21 cm clay layer reduced significantly from lower compaction level to higher compaction levels. The exogenous application of ABA (abscisic acid) @ 10μM significantly increased the root penetration of top 21 cm compacted clay layer. Among two grasses studied, Selection-1 gave higher root dry weight and total root length in top 21cm clay layer.

Key words: Compaction levels, Clay layer, Grasses, NDVI.

INTRODUCTION

Growing turfgrasses on compacted soils is prevalent on areas such as athletic fields, home lawns, and golf courses (Swartz and Kardos, 11). Particularly in cricket grounds, highly compacted clay based pitch is created to make an ideal playing surface and grass grown on these pitches mainly hold the clay soil without breaking. Maintenance of grass on the pitch is important because grass improves the stability and longevity of the pitch. It also has an effect on the pace and bounce of a pitch (Nawagamuwa *et al*., 6). Grass acts as a natural moisture remover from the deep layers of the pitch to create ideal surface for play, it provides the swing for fast bowlers and various other reasons. Soil compaction can limit root growth directly by physically restricting root penetration. Soil compaction can also limit turf growth indirectly by causing a stress condition that limits overall growth of roots or shoots.

Maintaining a good turf on the cricket pitch is a challenging job for pitch curators and a well maintained turf with a good root system provides the best playing surface for the game. Selecting a suitable variety which grows in these soil conditions and developing good root system is a prerequisite for making of a good cricket pitch. As suggested by many studies under highly compacted soil conditions plant's hormonal balance will change and start synthesizing more of ABA, especially at root tips (Tardieu *et al*., 12). Hartung *et al*. (4) observed similarity in root characters of plants grown in compacted soil and plants treated with ABA which are grown in normal soil conditions. This provided the evidence for the active role of ABA in root development of plants grown under compacted soil conditions. Although many studies were conducted on growth of crop plants under high soil compaction conditions and effect of exogenous application of ABA on root growth of especially in maize, wheat, barley and many other crop plants (1-2 References). While the studies on turfgrass behaviour under higher soil compaction conditions are limited. This paper describes, the growth behaviour of turfgrasses under varied compaction conditions of top 21cm of clay soil (as in cricket pitch) and the effect of foliar application of varied concentrations of ABA on Bermudagrass varieties, Selection-1 a widely used Bermudagrass cultivar in cricket grounds across India and Tif-419.

MATERIAL AND METHODS

The study was conducted in at the experimental farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi during September 2015. The experiment was laid out in double split fashion with two Bermuda grasses varieties (G_1-Tif-419 and Selection-1) taken as main plot, five levels of compactions B_1- 1.2, B_2-1.3, B_3- 1.4, B_4- 1.5 and B_5- 1.6 g/cm^3 in sub plot and Four concentrations of ABA C_1- 0μM, C_2- 1μM, C_3- 5μM and C_4- 10μM in sub-sub plot.

The study was conducted in PVC pipes of one meter length and 15cm in diameter. The whole column was divided into two portions the top 21 cm clay soil portion with varied compaction levels and the remaining portion were filled with normal loam soil.

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The clay was well dried and sieved in a 2mm sieve and bulk density of dried soil was (1.11g/cc). The volume of the clay to be placed in top 21 cm was determined by using the volume of the cylinder formula $2\pi r^2 h$ which is constant for all the treatments, only the amount of need to be place was varied. Whole quantity of clay soil was divided in to four lots. Method of filling each part of clay soil is explained here under.

PVC made cylindrical column was fixed upright on a wooden platform and one part of clay was put in, followed by a gentle pressing with a specially designed hammer to ensure that soil was packed within 5cm from the bottom (Fig. 1A). Second part of clay was filled above the first and allowed to settle till 10cm by preceding the same procedure with hammer (Fig. 1B). Similar method of filling and pressing was followed till it reaches 21 cm (Fig. 1C, Fig. 1D & Fig. 1E). The remaining volume (79 cm) was stuffed with pre weighed loam soil (Fig. F) and turned the column upside down such that clay was on the top (Fig. G). Bottom of the cylinder was covered with polyethylene sheet provided with holes to ensure proper drainage (Fig. H). Planting of grasses was done on the top clay layer (Fig. H). 20 two node cuttings of grass per column were planted. Four concentrations of ABA 0μM (C_1), 1μM (C_2), 5μM (C_3) and 10μM (C_4) was applied twice at one month after planting and two month after planting

The observations were recorded at three times (sampling date) i) Before spraying of ABA, ii) one month after spraying of ABA (1MAFS) and iii) one month after second spray (1MASS). The NDVI was recorded using Trimble Greenseeker™ and shoot density was measured by counting number of shoots in an area of 100 cm². The total shoot dry weight was calculated by adding the entire dry weight shoot collected three sampling dates and expressed in grams. Finally top clay layer and bottom layer was first separated from all the columns and washed by spraying water for separating roots. After extraction of roots from top clay layer were scanned to calculate total length (cm) using Whin-Rhizo root scanner. Later roots of respective top and bottom layers were oven dried at 75°C separately and dry weight expressed in grams. While total root dry weight was calculated by adding both top and bottom layer root dry weight

RESULTS AND DISCUSSION

The shoot density and NDVI values were decreased significantly from lower to higher compaction levels (Fig. 2) at all the three sampling dates. In the grass G_1 (var. Tif-419), the reduction in shoot density at B_5 soil compaction level (1.6 g/cc) was 28% at first sampling date (before ABA spray), 40.8% in the second sampling date (1MAFS) and 42.5% in the third sampling date (1MASS) as compared to B_1 soil compaction level (1.2 g/cc). Similarly in G_2 (var. Selection-1) at B_5 soil compaction level 3.23%, 16.54% and 15.35% reductions in shoot density were recorded in first, second and third sampling dates respectively

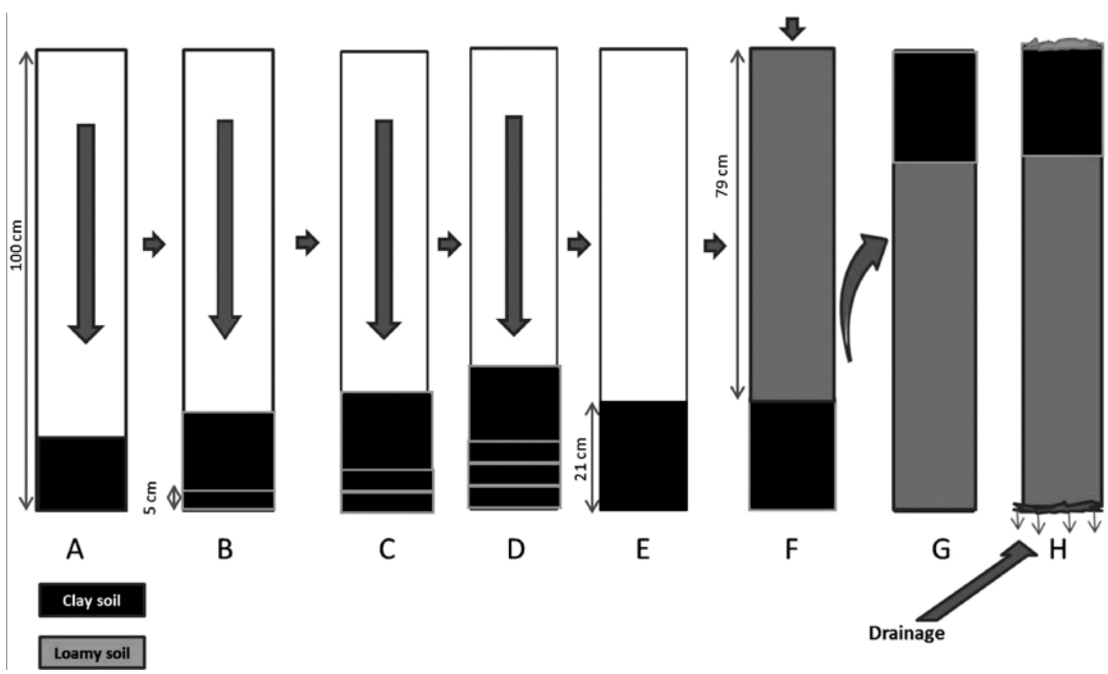

Fig. 1. Step wise flow chart of filling up of columns having top 21 cm clay layer and bottom loam soil.

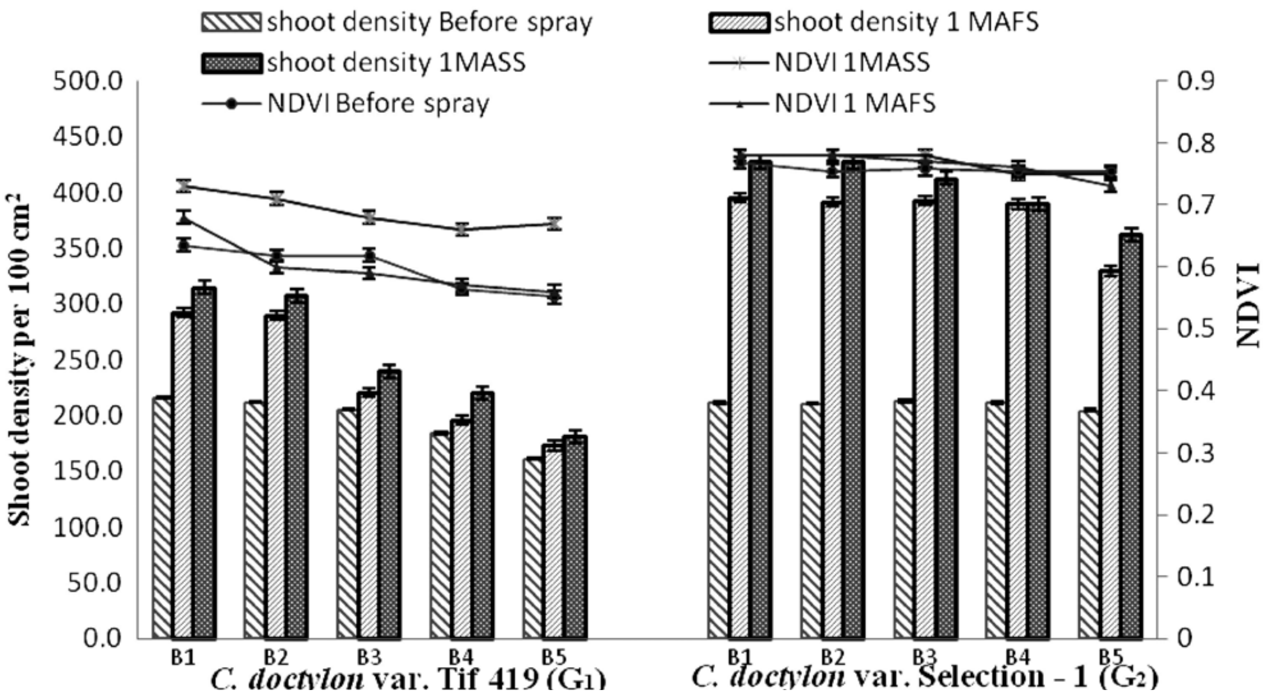

Fig. 2. Effect of varied levels of soil compaction (21 cm top clay layer) on Shoot density /100 cm^2 and NDVI of Cynodon dactylon var. Tif-419 and Cynodon dactylon var. Selection-1.

at B_1 soil compaction level. As the soil compaction increases the ability of plant root production decreases and this in turn reduces the shoot growth. This result is in conformity with O'Neil and Carrow (7) and Wallace (13) where they reported the reduction in shoot density and shoot dry weight in perennial rye grass and *Schizachyrium scoparium*, respectively. The reduction in shoot growth was attributed to the higher levels of ethylene production at higher soil compaction levels which in turn reduced the shoot biomass (Sarquis *et al.*, 10). With respect to NDVI values, the reduction in NDVI values from lower compaction level to higher compaction level was not as that of shoot density. In G_1, the reduction NDVI values were 13.19%, 17.65% and 8.22% from soil compaction level B_1 to B_5 during first, second and third sampling dates, respectively. Whereas, in G_2, we observed 1.79%, 6.41% and 3.85% reduction of NDVI values in B_5 compaction level at first, second and third sampling dates respectively, in comparison to B_1 soil compaction levels. The NDVI values were dependent on the shoot density and plant green biomass (Cabrera *et al.*, 1) as the shoot density decreased from lower to higher compaction levels the NDVI also decreased. Among two grasses, G_2 recorded more shoots per unit area and higher NDVI values in comparison to G_1 at levels of soil compaction levels. Application of ABA did not affect significantly the shoot density and NDVI values in both the grasses.

The root dry weight and total root length were reduced significantly from lower to higher soil compaction levels in the top 21cm clay layer (Fig. 3). The root dry weight was decreased by 23.8% and 13.2% in B_5 as compared to B_1 in G1 and G2, respectively, whereas root length was decreased by 18.1 and 25.7%. High compaction of soil reduces the penetrating ability of roots in plants grown in compacted clay soil (Hemsath *et al.*, 5). Similarly, Claudia *et al.* (3) also reported reduced root dry weight in Bermuda grass grown under compacted soil. The total root length was reduced from lower to higher compaction levels due to the consequence of higher soil compaction. Similar observations were made by Saoirse *et al.* (9) in tomato, where the plants gown in compacted soils recorded lower total root length. In compacted soil conditions, plant increases the production of ethylene which results in increase root diameter and reduced root length (Clark *et al.*, 2). Different levels of ABA application did not increase the root dry weight and total root length significantly at different soil compaction levels in both the grasses. Application of ABA @ 10μM increased root dry weight in the bottom layer (Fig. 4). This indicated that ABA significantly helped the roots to penetrate the upper compacted clay layer and enter into the second layer. The exogenous application of ABA might have reduced the production of ethylene which in turn

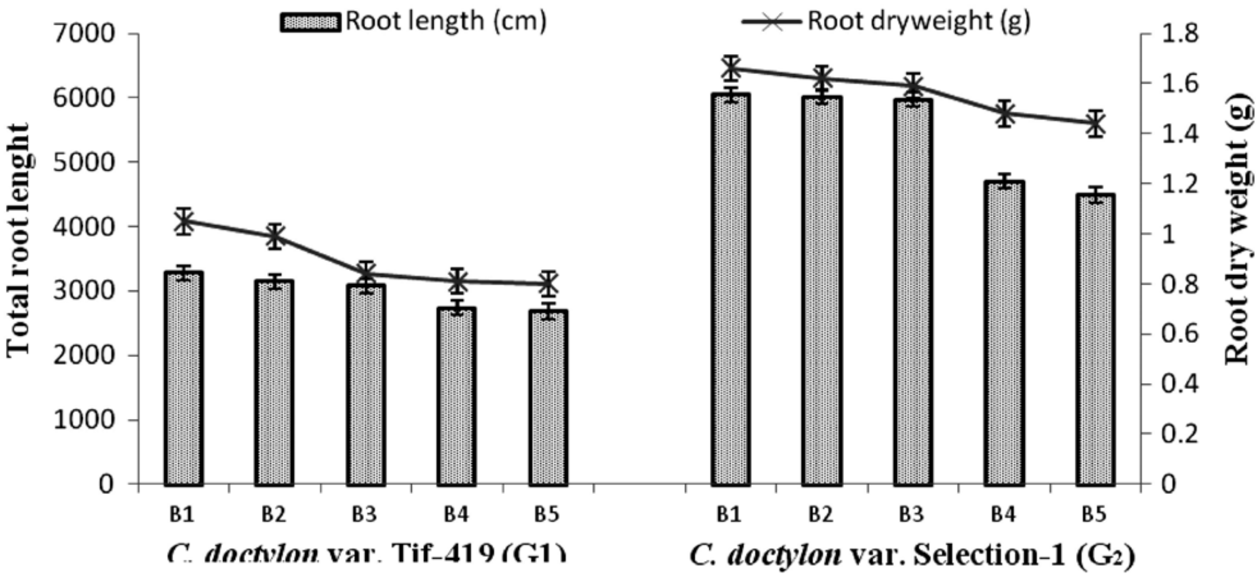

Fig. 3. Effect of varied levels of soil compaction (21cm top clay layer) on Total root length (cm) and root dry weight (g) of Cynodon dactylon var. Tif-419 and Cynodon dactylon var. Selection-1.

Note: Compaction levels (g/cc) (top 21cm clay layer): B_1 - 1.2, B_2 - 1.3, B_3 - 1.4, B_4 - 1.5 and B_5 - 1.6.

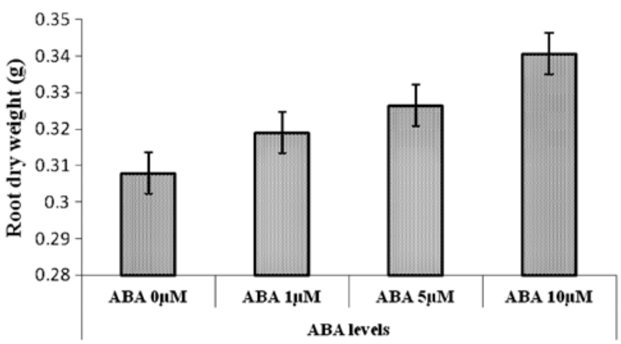

Fig. 4. Effect of Exogenous application of ABA (µM) on root dry weight turf grasses in bottom loamy soil.

helped the plants to overcome the stress condition of compacted soil as suggested by Robert and Mary (8). Among two grasses, G_2 produced more roots hence its root dry weight and total root length were high as compared to G_1.

The present study show that under the clay based top soil with increased compaction conditions, significantly reduces the shoot and root biomass production in grasses. Exogenous application of ABA @ 10µM increased the penetrating ability of grass roots under compacted situations. This study gave an insight to the behaviour of grasses under a clay based compacted soil conditions. Further, this investigation would provide information to other studies on identification of grasses for various clay, sand and silt combination of soil in varied companion conditions. As the cricket pitches are frequently rolled for matches, the future studies need to be conducted in real situations.

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