Trees for Shelter: The Implications in Agroforestry System

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TREES FOR SHELTER: THE IMPLICATIONS IN AGROFORESTRY SYSTEM

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ABSTRACT

The objective of this study was to determine the horizontal and vertical variations in soil penetration resistance (PR) observed at tree-scale in silvopastoral plots that were grazed by sheep with and without trees. Sycamore trees (Acer pseudoplatanus L) were planted in the spring of 1988 at 10 m x 10 m spacing (100 stems/ha) at Glensaugh NE of Scotland on plots replicated over three blocks in Randomized Complete Block design on a predominantly rye grass (*Lolium perenne* L) pasture. Included in the design were pasture plots without trees (Control). The experiment is grazed by sheep yearly from April to October. Soil PR was measured in Mega Pascals (MPa) around two randomly selected trees in each plot in 8 directions of the compass - N, NE, E, SE, S, SW, W and NW at 1 m intervals starting at 0.5 m from the tree base to mid point of the separation distance (4.5 m) between the trees. The soil PR data were measured at 3.5 cm soil depth intervals at points around the tree up to depth limit of 21.0 cm. This gave six depth intervals of d1 (3.5), d2 (7.0), d3 (10.5), d4 (14.0), d5 (17.5) and d6 (21.0). In the Control plots, soil PR was measured as in the Sycamore plots around two hypothetical tree positions chosen randomly in each plot. The soil PR was found to decrease significantly within the horizontal distance of 4.5 m from the tree and depth for up to d3 (10.5 cm) only in the grazed Sycamore plots. Soil penetrometer resistance was found to increase significantly within the vertical distance of 0-14 cm of the soil around the tree in grazed Sycamore and Control plots. Beyond this soil depth, soil PR was no longer significant in these treatments.

KEYWORDS

Trees, pasture, animals, silvopasture, shelter, grazing, penetrometer, soil resistance

INTRODUCTION

Grazing animals frequently seek shelter around trees in silvopastoral system plots (Sibbald *et al*, 1995). The hooves of animals carry the weight of the animals on a very small surface area and this results in surprisingly high downward pressures (Spedding, 1976). Mature cattle can exert a static ground pressure of approximately 1.7 kg/cm2 of hoof-bearing area (Bezkorowajnyj *et al*, 1993) and this may affect bulk density to depth of as much as one metre (Rhoades *et al*, 1964). Trampling of soil by animals was found to significantly increase the bulk density of a soil (Stewart and Cameron, 1992) and cause soil compaction (Bezkorowajnyj *et al*, 1993) which may reduce infiltration of water and impair tree and pasture root growth (Martino and Shaykewich, 1994). Plant growth is affected by soil compaction through its effects on the growth of impeded roots as well as non-impeded organs such as leaves (Masle and Passioura, 1987). Soil compaction also has been reported to adversely affect plant growth through its effect on soil nutrient transformation and uptake through changes in soil hydraulic, aeration and diffusive properties (Lipiec and Stepniewski, 1995). Among the methods used to measure soil compaction on soil, the most decisive was the determination of water infiltration and penetration resistance (Ferrero, 1991). The objective of this paper is to report the horizontal and vertical variations in soil penetration resistance observed at tree-scale in silvopastoral plots that were grazed by sheep with and without trees and the likely implications.

MATERIALS AND METHOD

Sycamore trees (*Acer pseudoplatanus* L) species were planted in the spring of 1988 in square lattice arrangements at 10 m x 10 m, spacing (SYC100) at Glensaugh NE of Scotland on plots replicated over three blocks in Randomized Complete Block design on a predominantly rye grass (*Lolium perenne* L) pasture. The silvopastoral experiment is grazed by sheep yearly from April to October. Included in the design were grazed pasture plots without trees (Control). Soil penetrometer resistance (PR) was measured in Killogram force (Kgf) around two randomly selected trees in each plot in 8 directions of the compass - N, NE, E, SE, S, SW, W and NW at 1 m interval starting at 0.5 m from the tree base to mid point of the separation distance between the trees. The soil PR data were collected at 3.5 cm soil depth intervals at points around the tree up to 21.0 cm depth limit. This gave six depth intervals of d1 (3.5 cm), d2 (7.0 cm), d3 (10.5 cm), d4 (14.0 cm), d5 (17.5 cm) and d6 (21.0 cm). In the Control plots, soil PR were measured as in the Sycamore plots around two hypothetical tree positions chosen randomly in each plot. The planned maximum soil depth for the soil PR assessment was 52.5 cm. This maximum depth was difficult to reach at certain points due to the presence of stones which resulted in a lot of missing data. Data use was therefore limited to 21.0 cm depth within which there were few missing soil PR values. The field data measured in Kgf were converted to ground pressure unit of Mega Pascals (MPa). The data were then analysed by cumulated Analysis of Variance test (ANOVA) which is a form of regression analysis because of the nonorthogonal nature of the data, using GENSTAT 5, (1990). Treatment means were separated by least significant difference (LSD) test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The soil PR was found to decrease significantly within a horizontal distance of 4.5 m from the tree and depth for up to d3 (10.5 cm) in the grazed SYC100 plots (Table 1). In the Control plots in which measurements were taken around hypothetical tree positions there was no significant effect of horizontal distance on soil penetrometer resistance (Table 1). Also, soil penetrometer resistance was found to increase significantly within the vertical distance of 0-14 cm of the soil around the trees in the Control and grazed SYC100 plots (Figs 1 and 2). Beyond the 14 cm soil depth, soil PR was no longer significant in these treatments (Figs 1 and 2). The extent to which soil trampling is dispersed or concentrated depends on the tendency of the animals to flock or herd (Spedding, 1976). That soil PR was found to be highest within 1 m radius around the tree and decreased significantly with horizontal distance from the tree, seems to suggest that these animals flock or herd close to the tree base. The downward pressure effects of the animals in the Control and sycamore plots seem to be the same. The most affected soil depth was 7.0-10.5 cm (d2-d3) and this may be due to cumulative effect (Kayombo and Lal, 1986) of high downward pressures (Spedding, 1976). Sands *et al* (1979) using a penetrometer found that penetration of radiata pine (Pinus radiata D. Don) roots in south-east of Australia were severely restricted above a critical penetration resistance of about 3 MPa. Jamieson *et al*. (1988) also found that a PR of between 1.1 and 2.3 MPa caused a considerable constraint on root growth of spring oats. The mean PR (MPa) measured in the plots used for this study (Table 1, Figs 1 and 2) were not above 3 MPa but a good percentage of them lie between 1.1 and 2.3 MPa. The implications of these for these grazed systems plots in the long-run may be decreased porosity as macropores are reduced and compressed resulting in lowered water infiltration (Ferrero, 1991; Ohu et al., 1993) impeded plant root system (Masle and Passioura, 1987; Martino and Shaykewich, 1994) and reduction in soil nutrient transformation and uptake (Lipiec and Stepniewski, 1995). These will have adverse effects on the growth of the trees and pasture in these plots.

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Table 1 Variation in mean soil PR (MPa)+ with horizontal distance from tree in Control and grazed Sycamore plots for soil depths d1-d3.

	Control (Grazed pasture without trees)			Grazed pasture with trees at 100 stems/ha (SYC100)		
Distance from tree (m)	d1	d2	d3	d1	d2	d3
0.5	0.68a*	0.99a	1.82a	0.68a	1.29a	1.98a
1.5	0.68a	1.06a	1.82a	0.53b	0.76c	1.67b
2.5	0.61a	0.93a	1.90a	0.46b	0.76c	1.67b
3.5	0.61a	0.99a	1.75a	0.46b	0.91b	1.67b
4.5	0.61a	1.06a	1.82a	0.46b	0.76c	1.52b

* different letters within each column indicate significant differences at P = 0.05

+ MPa = Mega pascals

Figure 1
Mean soil resistance (MPa) at tree-scale at depth intervals with standard error of the mean (SEM) in Control plots.

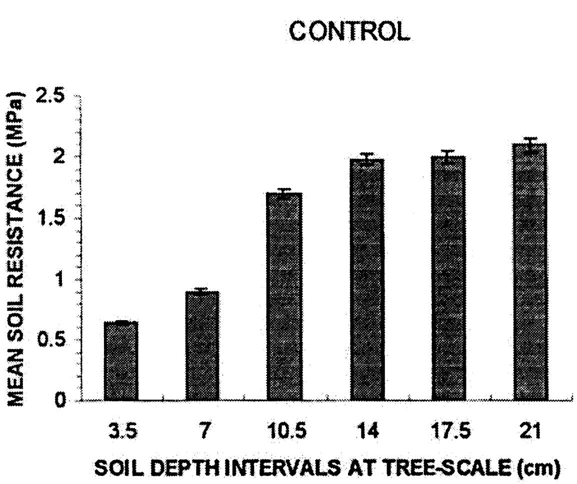

Figure 2
Mean soil resistance (MPa) at tree-scale at depth intervals with standard error of the mean (SEM) in SYC100 treatment plots.