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Research Article

Mulch Inoculation and Placement Influenced Barley (*Hordeum Vulgare*) Growth and Soil Nitrate Levels

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ABSTRACT

We investigated the effect of point of mulch placement and use of leaf mulches from plants inoculated with rhizobia on growth, nitrogen concentration and content of barley, and soil nitrate and pH changes. Mulches placed on soil surface enhanced barley heights and vegetative biomass in all leaf types used. However, nitrogen concentration was relatively higher in both barley vegetative plants and ears of barley grown in mixed mulches of both inoculated and uninoculated leaves. Mixing mulch types with soil caused a quick nitrate release within the first four weeks, which sharply dropped before week 6. Placing mulches on the soil surface resulted to a gradual nitrate release over the study period. Further, soil pH in all mulch treatments decreased within the first four weeks. Results from this study indicated that point of mulch placement was more effective than rhizobia inoculation of mulch on barley growth, nitrogen concentration and content, soil nitrate and pH changes. The results for nitrate levels revealed that it might be necessary for farmers to understand nitrogen requirements of crop so as to know where to place mulches. Results on pH revealed that care should be taken when mulching crops that are sensitive to small changes in pH.

INTRODUCTION

Many tropical soils are low in both total and plant-available nitrogen (N) and crop yields are often limited by N supply (Ladha *et al*., 1993). In agricultural systems crop yields are often increased by applying N fertilizers (Danso et al., 1993; Brady 1974; Simpson, 1986). However, scarcity of N fertilizers and their increased selling prices in developing countries have led to tremendous search for alternatives to N fertilizer sources for provision of N to crops (Araya and Stroosnijder, 2010; Broschat, 2007; Döring et al., 2005; Mafongoya and Nair, 1996).

Substantial leaf mulches can be obtained in alley cropping systems, where annual crops are grown between rows of trees and branches are pruned regularly to provide leaf mulch for the interplanted crops (Atta-Krah, 1990; Balasubramanian and Sekayange, 1991). Sometimes the legume leaves are ploughed into the soil (Catchpoole and Blait, 1990) to facilitate decay and release of nutrients to the soil for crops. Benefits of mulching include the reduction of erosion hazards, better infiltration of rain water and less evaporation, lower soil temperature, supply of organic matter and nutrients, higher soil biological activity, better root growth and suppression of weeds (Araya and Stroosnijder, 2010; Billeaud and Zajicek, 1989; Jodaugienė et al., 2006; Lal, 1974; Schroth et al., 1992).

Studies on mulching have been documented (Ahaiwe et al., 2010**;** Gutteridge, 1992; Mafongoya and Nair, 1996; Sinkevičienė et al., 2009; Yobterik et al., 1994). However, these studies were carried out using mulches from trees that had not been inoculated with rhizobia and all mulches were incorporated into the soil. Therefore the purpose of this study was to investigate the effect of leaf mulches from rhizobia-inoculated trees and their point of placement on barley early growth, nitrogen uptake and, soil nitrate and pH changes.

MATERIALS AND METHODS

Leaves of both rhizobia inoculated and uninoculated multipurpose *Leucaena leucocephala* and *Robinia pseudoacacia* shrubs were obtained from 7-month old plants. The leaves were either placed on the surface or mixed up with soil in 3 L pots at a rate of 4.835 g per pot (equivalent to 2.5 tones dry matter per hectare, pot surface area) (Gatteridge, 1992). Soils used in each pot weighed about 3 kg. Barley (*Hodeum vulgare*, variety ahadi, obtained from Kenya Seed Company, Kenya) was planted in all soil treatments (which had been watered slowly to eliminate differences due to soil moisture content and allowed to equilibriate for 24 hours). Enough pots were planted to allow for a destructive sampling of barley three times in four replicates. The pots were randomized in a greenhouse bench and kept moist by gentle watering. The greenhouse was maintained at temperatures between 19 and 24ºC and 16 hours of day light and 8 hours of night. Heights of the two tallest barley plants' highest leaf in each pot in all treatments were taken after every two days for five days starting from the third day after barley germinated (six days after planting). After two weeks barley was thinned to four plants per pot. The pots were randomized the bench twice every week. Barley straws were cut at the soil level and surface soil samples were taken at the upper 5 cm. This was a destructive sampling which was done at two, four and six weeks after barley germination. The barley straws were dried at 75ºC for 48 hours, weighed and ground to pass through an 810 µm, No. mesh sieve. The ground barley was analyzed for total N (%) using a Technicon^{TM} AutoAnalyzer^{TM} II. Soil pH in water, 1:5 (soil: water) was determined with pH meter (Cole-Permers). Soil nitreate was extracted using 2N potassium chloride (KCl) by shaking soil in a 250 ml conical flask for one hour, at a ratio of 1:10 (soil: KCl); nitrate concentration was determined as total N above, and then expressed on an oven dry basis (µg.100g^{-1} soil).

Statistical analysis

The data of barley growth, nitrogen concentration and content, soil nitrate and pH changes, was analyzed as a randomized complete block design using the Statistical Analysis System (SAS, 2008). Means were separated by least significant difference (LSD) and simple't' tests at $p<0.05$.

RESULTS

Barley heights recorded between days 6 and 14, after germination, showed that surface placed mulches of either *Leucaena* or *Robinia* relatively enhanced barley heights compared to mixed mulches (Figure 1and 2). On days 12 and 14 significant differences ($p<0.05$) in barley heights were noted in barley grown in surface placed mulches and that grown in mixed uninoculated *Leucaena* (Figure 1). In addition, heights of barley grown in surface placed mulches of *Robinia* had significantly ($p<0.05$) higher heights than barley grown in mixed mulches of *Robinai* on days 6, 8. 12 and 14 (Figure 2).

As observed in growth in heights, barley biomass was relatively higher in all mulches placed on soil surface for all leaf types (Figure 3 and 4). However, barley mulched in surface placed mulches of inoculated *Leucaena* resulted in significantly ($p<0.05$) higher biomass relative to other mulch types during week 6 (Figure 3). Further, during week 6, mulching barley with uninoculated *Robinia* leaves significantly ($p<0.05$) increased barley biomass relative to other mulch types (Figure 4).

Nitrogen concentration in barley straw decreased with the age of barley (Figure 5 and 6). However, significantly ($p<0.05$) higher nitrogen concentration in barley straw was recorded after

mulching with mixed leaves of uninoculated *Leucaena* relative to other *Leucaena* leaf treatments (Figure 5). Further, relatively lower straw N concentration was recorded when barley was mulched with surface placed inoculated *Leucaena* leaves (Figure 5). When *Robinia* mulches were used, relatively higher N concentration was recorded in barley mulched with mixed uninoculated *Robinia*. In addition, there was a significant difference between N concentrations of barley mulched with uninoculated mixed *Robinia* and barley mulched with surface placed inoculated *Robinia* mulch (Figure 6).

Mixing mulches with soil generally enhanced barley ear biomass (Table 1). In addition, ears of barley planted in all mixed mulches had generally higher nitrogen concentration and nitrogen content than those of barley planted in surface placed mulches (Table 1).

Generally nitrate released peaked in week four and drastically dropped in week 6 in all mixed mulch types (Figure 7 and 8). In addition, nitrate release in all surface placed mulches increased in week 4 through week 6 (Figure 7 and 8). In mixed *Leucaena* mulches, 1250 $mg.g^{-1}$ soil nitrate was released from uninoculated leaves in week four compared to only about 500 $mg.g^{-1}$ soil nitrate released from inoculated leaves during the same week (Figure 7). Further, during the same week surface placed inoculated leaves of *Leucaena* released1250 $mg.g^{-1}$ soil nitrate compared to 900 $mg.g^{-1}$ soil released by uninoculated surface placed *Leucaena* leaves (Figure 7).

As observed in *Leucaena* mulches, highest nitrate among the Robinia mixed mulches was released from mixed uninoculated *Robinia* leaves (1500 $mg.g^{-1}$ soil nitrate), and the lowest by mixed inoculated leaves (900 $mg.g^{-1}$ soil nitrate), during week 4. In addition, surface placed mulches of *Robinia* released lower nitrate levels compared to the mixed mulches, with surface placed uninoculated *Robinia* releasing lowest nitrate amounts (Figure 8). Soil pH generally dropped between weeks 2 and 4 and started rising during week 6. Generally, highest pH drops were observed in mixed uninoculated mulches of both *Leucaena* and *Robi*nia (Figures 9 and 10).

DISCUSSION

Relatively higher barley heights were recorded when leaf mulches were placed on the soil surface most probably because the presence of leaves on soil surface during barley germination might have increased cell elongation in barley plumule in response to limited light supply to the germinating barley. However, the effect of mulching on barley heights varied with tree species from which leaves were obtained and type of leaves used implying that point of mulch placement and mulch type could have determined barley heights.

Barley straw biomass were relatively higher in surface placed uninoculated leaves of both *Leucaena* and *Robinia* probably indicating a prolonged growth effect due to lack of light caused by placing leaf mulches in the soil surface during barley germination in these mulch treatments. However, highest biomass were noted in surface placed mulches of inoculated *Leucaena* and in surface placed mulches of uninoculated *Robinia*, which corresponds to soil pH of about 6 and soil nitrate levels of 1450 and 600 $mg.g^{-1}$, respectively. It was not clear whether the low nitrate levels in the uninoculated *Robinia* treatments were due to plant uptake or slow mulch decomposition. Gutteridge (1992) found out that *S. sesban* was effective in increasing maize stover when mixed with soil, whereas *L. leucocephala*, *C. callothyrsus* and *A. cunninghamii* resulted in higher maize (*Zea mays*) stover biomass when placed on surface. Further, Jakobsen and Jensen (1981) reported an 85% barley growth increase after mulching.

Barley ear results indicated that mulching with mixed leaves of *Leucaena* and *Robinia* enhanced ear total N and N content both of which indicated that these treatments may be necessary in increasing grain yield and grain N content. This observation may then imply that mixing mulches of *Leucaena* and *Robinia* with soil may be necessary to improve barley yield.

Barley straw nitrogen concentration decreased with time, probably due to allocation of N to growing parts from old leaves (Marschner, 1986) and therefore dilution of N in most old leaves of barley. However, N concentration varied with mulch type and point of mulch placement and implied that mixing mulches with soil enhanced barley nitrogen concentration in all mulch types. However, it was not clear why mixed mulches resulted to relatively higher nitrogen concentration in barley plants. It was hypothesized that high N concentration noted in the two week old barley plants might have been contributed by acquisition of N from seed endosperm but it was not very clear why barley from mixed mulch treatments had relatively higher N concentration over the study period.

Soil nitrate data indicated that mixed leaves were effective in releasing nitrate within a month after which nitrate supply drastically dropped as opposed to surface placed leaves which gradually released nitrate with time. Broschat (2007) found no effect of mulching on soil nitrate after samples were taken 6 weeks after mulching. The differences in results could probably be due to differences in mulch types, types of plants mulched, nitrate leaching and rates of mulches used. Based on ear total N and N content observations made after using mixed leaves of inoculated *Leucaena* and mixed leaves of uninoculated *Robinia*, it might be tempting to say that the time at which nitrate is supplied to the plant, leaf type, point of placement and species may commonly affect barley performance.

Soil pH decrease in week 4 coincided with high nitrate levels mostly in mixed leaves but increased at week 6. Brady (1974) suggested that during decomposition of organic matter carbonic acid is too weak to cause low pH often detected in most soils. So, he further suggested that inorganic acids such as sulphuric acid and nitric acids (from decomposing matter and sometimes from certain fertilizers such as

ammonium sulphate under microbial activity are potential suppliers of hydrogen ions in the soil). Studies have shown that soil pH decreases when organic mulches are used and that this decrease is proportional to the depth of these mulches (Billeaud and Zajicek, 1989). However, Broschat (2007) found no effect of mulch on soil pH. Soil pH in this study rose after week 4 probably due to reduced fresh organic matter in the soil, especially mixed treatments, which slowed mulch decomposition. Increase in soil pH after mulch application was reported by Ahaiwe et al. (2010), and Hue and Amien (1989) and was attributed to the release of organic chelates from decomposition products of green manure which formed complexes with Al (OH)3.

CONCLUSION

Results of this study indicated that placing mulches on the soil surface enhanced barley heights and biomass implying that it might be advisable to place mulches on the soil surface if the purpose of barley planting is biomass production. However, if the intention of barley planting is to produce seeds, which may relate to ear nitrogen content, it may be advisable to mix mulches with soil. To enhance ear nitrogen content it might be advisable to use mulch leaves from inoculated *Leucaena leucocephala* and leaves from uninoculated *Robinia pseudoacacia*.

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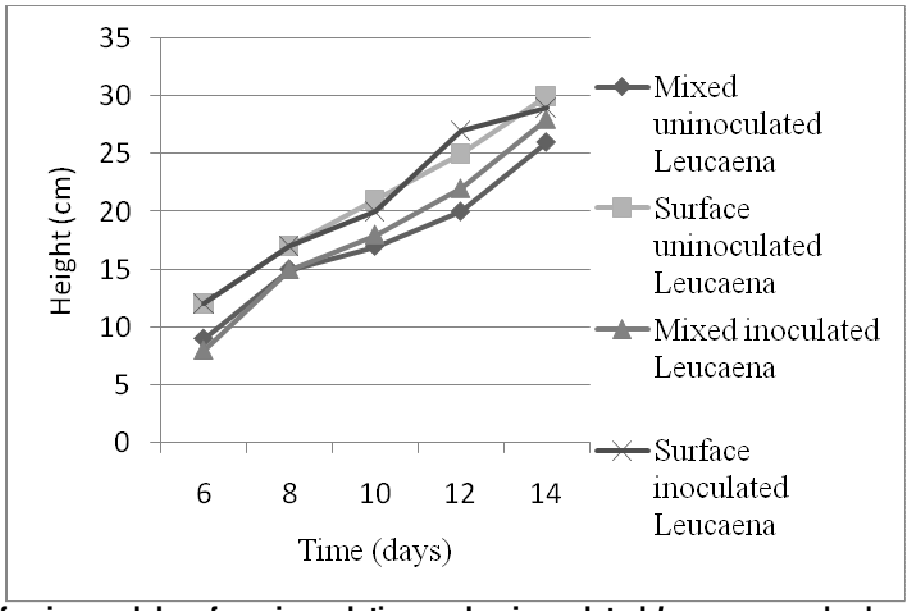

Figure 1: Effect of using mulches from inoculation and uninoculated *Leucaena* on barley height during the first fourteen days after barley germination

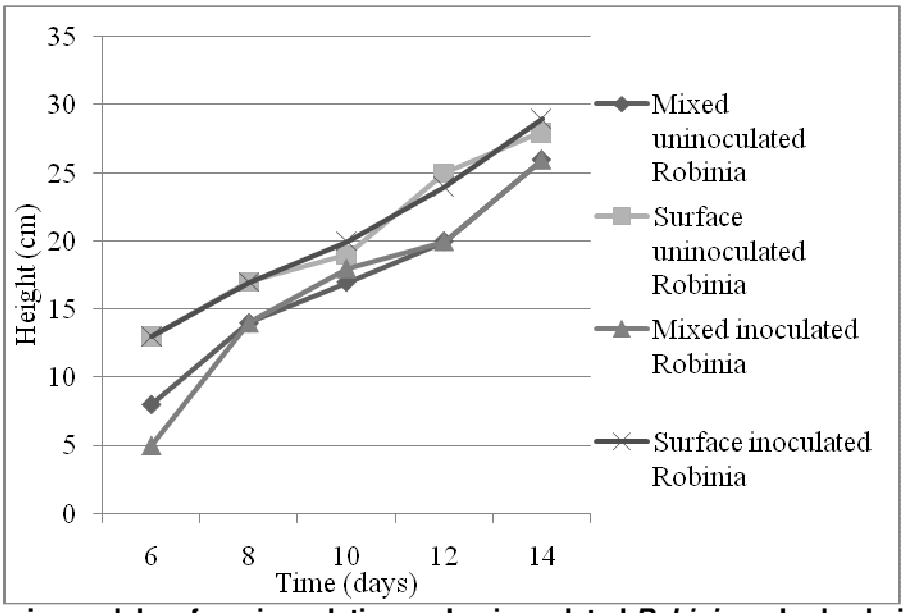

Figure 2: Effect of using mulches from inoculation and uninoculated *Robinia* on barley height during the first fourteen days after barley germination

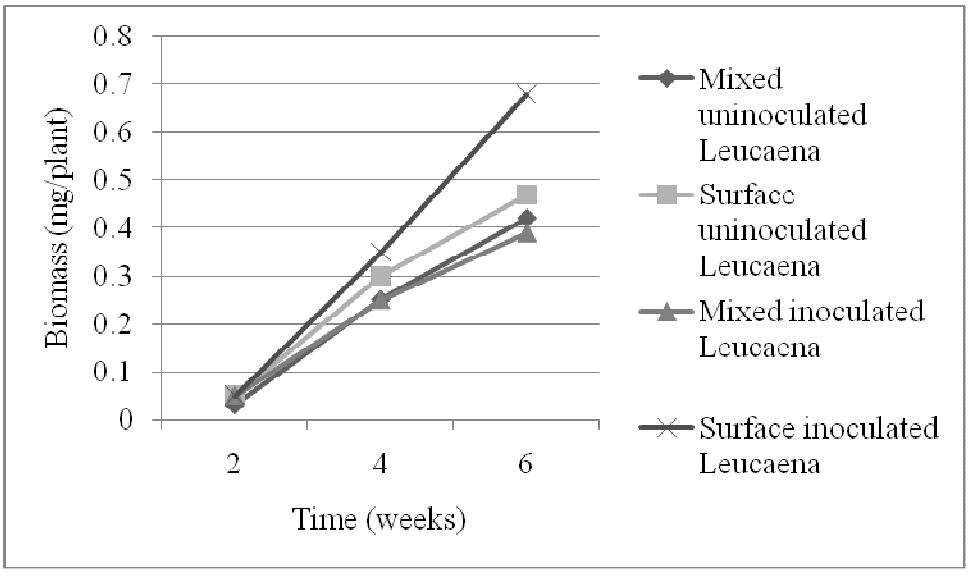

Figure 3: Effect of using mulches from inoculation and uninoculated *Leucaena* on barley biomass during the first six weeks after barley germination

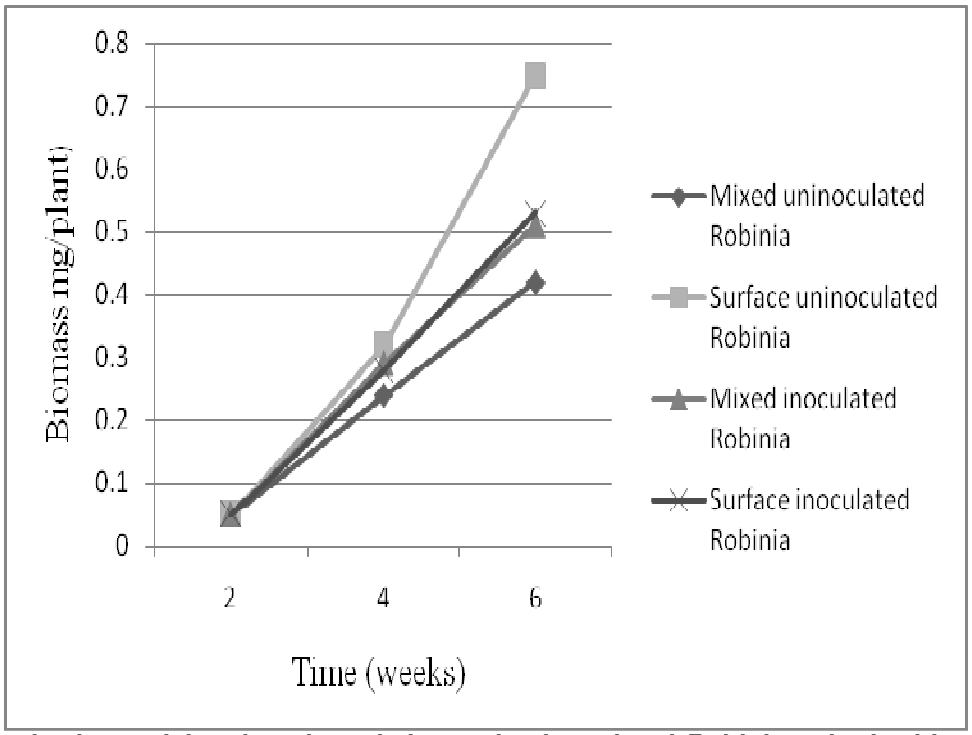

Figure 4: Effect of using mulches from inoculation and uninoculated *Robinia* on barley biomass during the first six weeks after barley germination

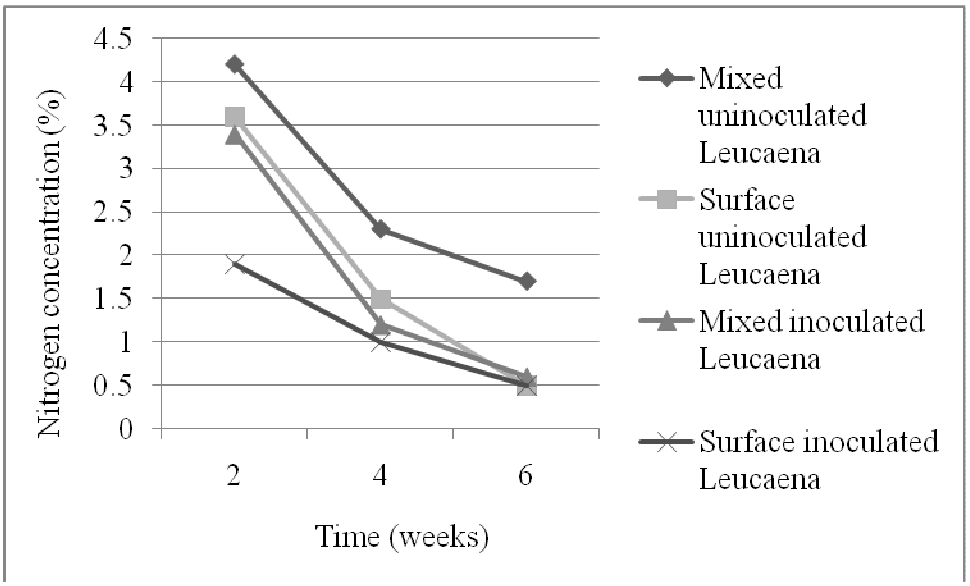

Figure 5: Effect of using mulches from inoculation and uninoculated *Leucaena* on barley nitrogen concentration (%) during the first six weeks after barley germination

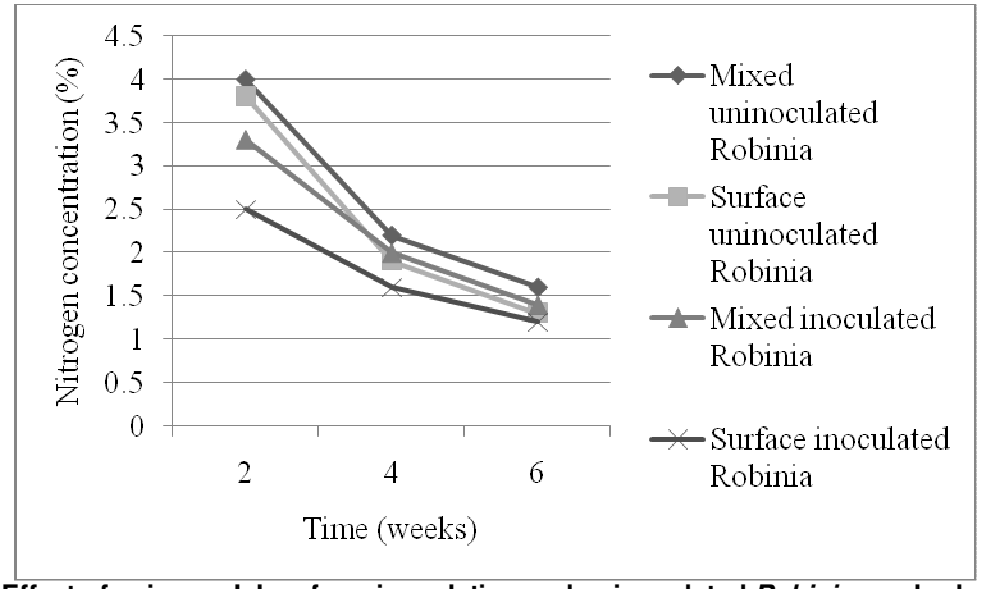

Figure 6: Effect of using mulches from inoculation and uninoculated *Robiniaa* on barley nitrogen concentration (%) during the first six weeks after barley germination

Table 1: Ear biomass (g.plant-1), total N (%) and N content (mg.plant-1) after barley was grown in soil mulched with mixed and surface placed leaves of both rhizobia inoculated and uninoculated leaves of *L. leucocephala* and *R. pseudoacacia*

	Barley ear biomass (mg.plant^{-1})		Barley ear nitrogen concentration (%)		Barley ear nitrogen content	
Species and inoculation	Mixed	Surface	Mixed	Surface	Mixed	Surface
Leucaena uninoculated	0.26	0.25	1.25^{a}	0.59^{b}	3.30^{a}	1.50^{b}
Leucaena inoculated	0.35^{a}	0.22^{b}	1.06^{a}	0.16^{b}	3.70^{a}	0.40^{b}
Robinia uninoculated	0.23^{b}	0.34^{a}	2.07^{a}	1.02^{b}	4.80	3.80
Robinia inoculated	0.28	0.23	1.03	1.23	2.90	2.80
Means	0.28	0.26	1.35	0.75	3.68	2.13

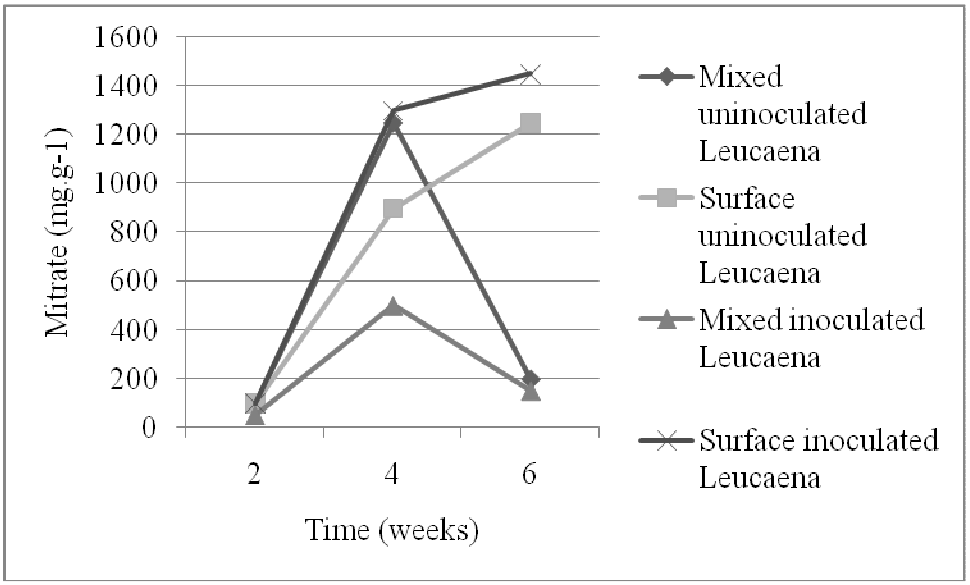

Figure 7: Effect of using mulches from inoculation and uninoculated *Leucaena* on soil nitrate (mg.g^{-1} soil) during the first six weeks after barley germination

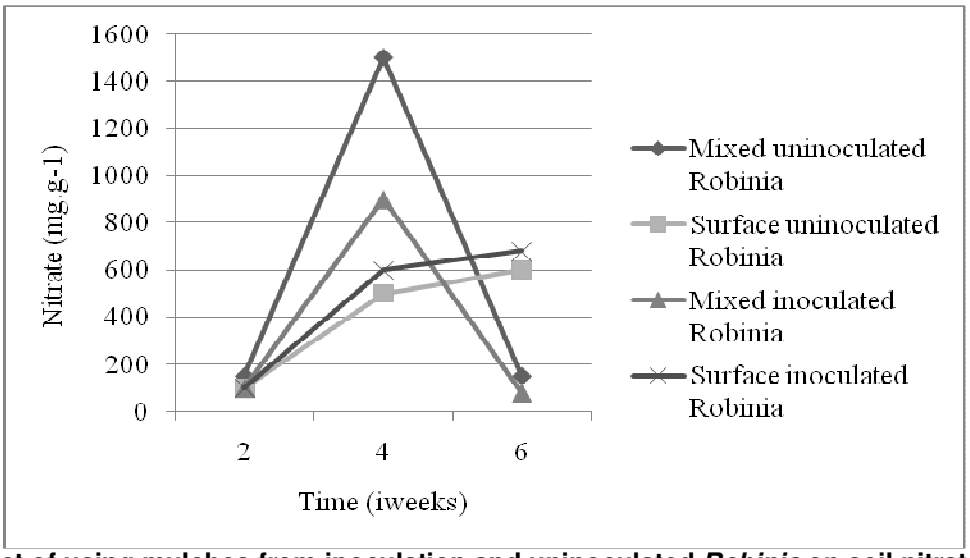

Figure 8: Effect of using mulches from inoculation and uninoculated *Robinia* on soil nitrate (mg.g^{-1} soil) during the first six weeks after barley germination

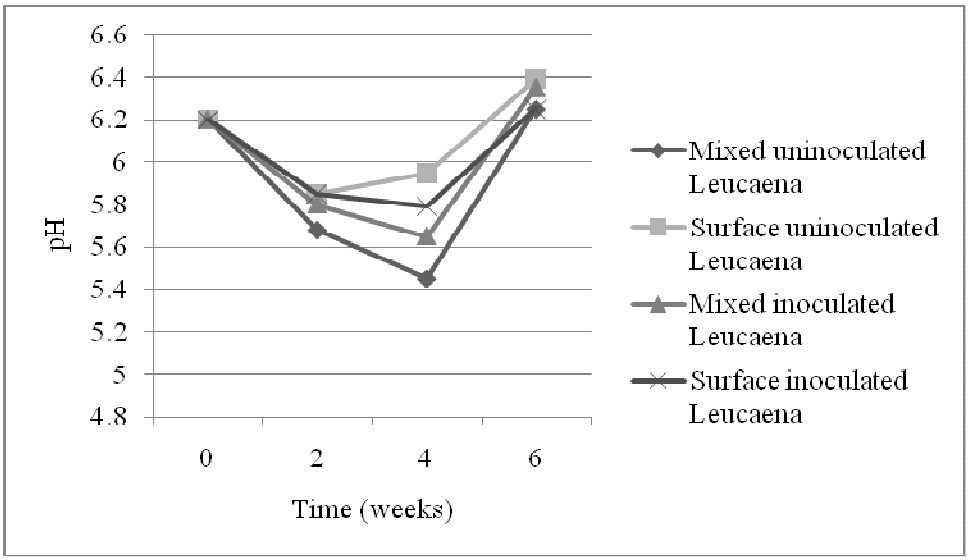

Figure 9: Effect of using mulches from inoculation and uninoculated *Leucaena* on soil pH during the first six weeks after barley germination

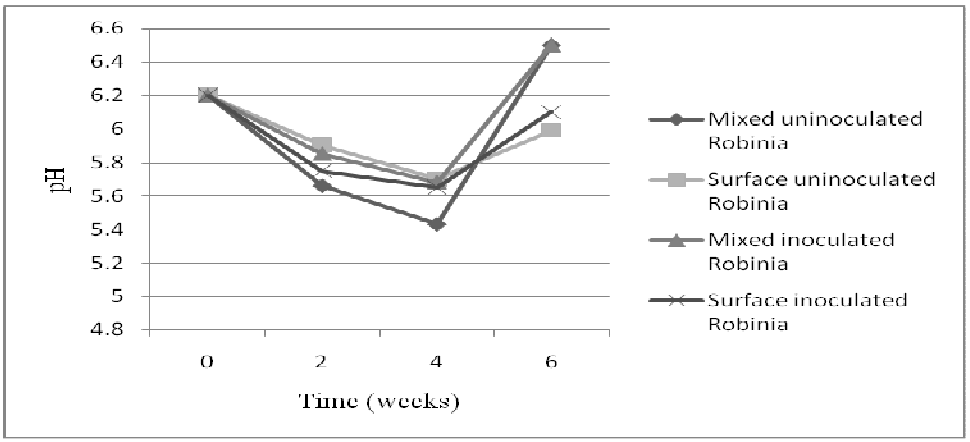

Figure 10: Effect of using mulches from inoculation and uninoculated *Leucaena* on soil pH during the first six weeks after barley germination

REFERENCES

Ahaiwe MO, Nwaigbo LC and Ano AO (2010). Influence of plant prunings on soil properties and yield of yam minisett. Journal of Agriculture and Social Research. 10(2): 172- 17.

Atta-Krah AN (1990). Alley farming with *Leucaena*: Effect of short-term grazed fallows on soil fertility and crop yields. Experimental Agriculture. 25: 1-10.

Araya A and Stroosnijder L (2010). Effects of tied ridges and mulch on barley (Hordeum vulgare) rainwater use efficiency and production in Northern Ethiopia. Agricultural Water Management. 97(6): 841-847.

Balasubramanian V and Sekayange L (1991). Effects of tree legumes in hedgerows on soil fertility changes and crop performance in semi-arid highlands of Rwanda. Biological Agriculture and Horticulture. 8: 17-32.

Billeaud LA and Zajicek JM (1989). Influence of mulches on weed control, soil pH, soil nitrogen content, and growth of Ligustrum japonicum. Jornal of Environvironment and Horticulture. 7*:* 155–157.

Brady NC (1974). The nature and properties of soils. 8th Edition. Macmillan Co., Inc. New York. Pp. 639.

Broschat TK (2007). Effects of Mulch Type and Fertilizer Placement on Weed Growth and Soil pH and Nutrient Content. Horticulture Technology. 17(2): 174-177.

Catchpoole DW and Blair GJ (1990). Forage tree legumes. III release of nitrogen from leaf, faeces and urine derived from *Leucaena* and *Gliricidia* leaf. Australian Journal of Agricultural Research. 41: 539-547.

Danso SKA, Hardarson G and Zapata F (1993). Misconceptions and practical problems in the use of ^{15}N soil enrichment techniques for estimating N_2 fixation. Plant and Soil. 152: 25-52.

Döring TF, Brandt M, Heß J, Finckh M and Saucke H (2005). Effects of straw mulch on yield, weed development, nitrate dynamics and soil erosion in organically grown potatoes. Field Crops Research. 94: 238-249.

Gutteridge RC (1992). Evaluation of the leaf of a range of tree legumes as a source of nitrogen for crop growth. Experimental Agriculture. 28:195-202.

Hue NV and Amien I (1989). Aluminium detoxification with green manure. Communication Soil Science and Plant Analysis. 20: 1499-1511.

Jodaugienė D, Pupalienė R, Urbonienė M, Pranckietis V and Pranckietienė I (2006). The impact of different types of organic mulches on weed emergence. Agronomy Research. 4: 197–200.

Jakobsen I and Jensen A (1981). Influence of vesicular-arbuscular mycorrhiza and straw mulch on growth of barley. Plant and Soil. 62(1): 157-161.

Ladha JK, Peoples MB, Garrity DP, Capuno VT and Dart PJ (1993). Estimating nitrogen fixation of hedgerow vwgetation using the nitrogen-15 natural abudance method. Soil Science Society Amican Journal. 57: 732-737.

Lal R (1974). Soil temperature, soil moisture and maize yield from mulched and unmulched tropical soils. Plant and Soil. 40(1): 129–143.

Mafongoya PL and Nair PKR (1996). Multipurpose tree prunings as a source of nitrogen to maize under semiarid conditions in Zimbabwe. Agroforestry Systems. 35: 31-46.

Marschner H (1986). Mineral nutrition of higher plants. Academic press, Harcourt Brace Javanovich, publisher. London. Pp. 674.

Statistical Analysis of System (SAS) (2008). SAS 9.2 release March 2008.

Schroth G, Zech W and Heimann G (1992). Mulch decomposition under Agroforestry conditions in sub-humid tropical savanna processes and influence of perinial plants. Plant and soil. 147:1-11.

Simpson K (1986). Fertilizers and manures. Longman, London. Pp. 254.

Sinkevičienė A, Jodaugienė D, Pupalienė R and Urbonienė M (2009). The influence of organic mulches on soil properties and crop yield. Agronomy Research 7(Special issue I): 485–491.

Yobterik AG, Timmer VR and Gordon AM (1994). Screening Agroforestry tree mulches for corn growth: a cmbined soil test, pot trial and plant anlaysis approach. Agrof. Systems. 25:1-14.

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