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Effect of Sole and Conjunctive Applications of Plant Residues and Inorganic Nitrogen on Profile Soil Water Content and Mineral Nitrogen in a Dryland Alfisol

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ABSTRACT: Field experiments were conducted on a red sandy loam (mixed isohyperthermic Typic Haplustalf) at Hayathnagar Research Farm of the Central Research Institute for Dryland Agriculture, Hyderabad, during *kharif* 1994 and 1995 to study the effect of sorghum straw and gliricidia loppings applied alone and in conjunction with inorganic N to sorghum, on profile soil water content and mineral N. Soil water in the 0-15 cm and 15-30 cm soil layers, and mineral N in the 0-15 cm soil layer were measured at regular intervals during crop growth. In both the years, soil water contents at different intervals were strongly influenced by rainfall events just preceding the time of measurement. Differences in soil water among treatments were relatively small and statistically insignificant. Soil water contents were relatively higher in plots that received 60 kg N through sorghum straw and 30 kg inorganic N + 30 kg N through sorghum straw. Mineral N in the soil was significantly influenced by treatments at all sampling intervals. At 33 days after sowing (DAS) in 1994, mineral N in the soil was highest with 60 kg inorganic N treatment followed by 30 kg inorganic N + 30 kg N through gliricidia treatment. In 1995, mineral N in the soil at 33 DAS was highest with 60 kg N through gliricidia treatment followed by 30 kg inorganic N + 30 kg N through gliricidia treatment. At 66 DAS in both the years, highest mineral N in the soil was observed with 60 kg N through gliricidia treatment. At the time of crop harvest in both the years, the highest mineral N in the soil was observed with 60 kg N through sorghum straw treatment. Findings of this study indicate that incorporated residues do not influence soil water content but affect mineral N levels in the soil significantly.

Keywords : Conjunctive use, nitrogen, inorganic, sorghum straw, gliricidia, profile soil water, mineral N

The value of plant residues in supplying nutrients to crops and for maintaining or improving soil fertility is well known. The utility of plant residues is best harnessed by applying them together with inorganic fertilizers (Palm *et al.*, 1997). Such a system of conjunctive use helps maintain adequate levels of nutrients in the soil, while at the same time contributing to long term soil fertility management through increase in soil organic matter content. Plant residues and inorganic fertilizers, applied alone or in conjunction can influence soil water content through their effect on soil physical properties such as infiltration rate, hydraulic conductivity, pore size distribution and aggregate stability (Kumar and Goh, 2000). Decomposing crop residues affect mineral nitrogen in the soil through mineralization/immobilization processes (Aggarwal *et al.*, 1997). This study evaluates the effect of sorghum straw and

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gliricidia loppings applied alone and in conjunction with inorganic N to sorghum grown on a dryland Alfisol, on soil water and mineral N content.

Materials and methods

Field experiments were conducted at Hayathnagar Research Farm (HRF) of the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, during *kharif* 1994 and 1995. The soil of the experimental site was a red sandy loam belonging to the family of mixed isohyperthermic Typic Haplustalfs. Some of the characteristics of the soil before the start of the experiment are given in Table 1. The experiment was conducted in a randomized completely blocked design consisting of seven treatments replicated thrice. The treatments were: T1 -Control, T2 - 30 kg inorganic N, T3 - 60 kg inorganic N, T4 - 30 kg inorganic N + 30 kg N through sorghum straw, T5 - 60 kg N through sorghum straw, T6 - 30 kg inorganic N + 30 kg N through gliricidia loppings, T7 - 60 kg N through gliricidia loppings. The plot size was 8m X 5m. Treatments were applied when the sorghum crop (cv. CSH-6) was 15 days old, by opening furrows between crop rows. Inorganic N was applied in the form of urea. Air dried sorghum straw and freshly lopped gliricidia were used for applying the residue and conjunctive treatments.

Table 1. Selected characteristics of the soil of the experimental site

Soil property	Measured value
Mechanical Analysis	
Sand (%)	80.5
Silt (%)	3.7
Clay (%)	15.8
Bulk density (Mg m^{-3})	1.64
Moisture retention (g kg^{-1})	
0.03 MPa	103.40
1.50MP8	64.10
Organic carbon (g kg^{-1})	5.39
Nitrogen fractions (mg kg^{-1})	
Ammonium N	4.27
Nitrate N	6.85
Fixed ammonium N	35.8
Total hydrolysable N	354.00
Acid insoluble N	161.00
Total N	560.00

Soil water and mineral N contents in the soil were measured at different intervals during crop growth.

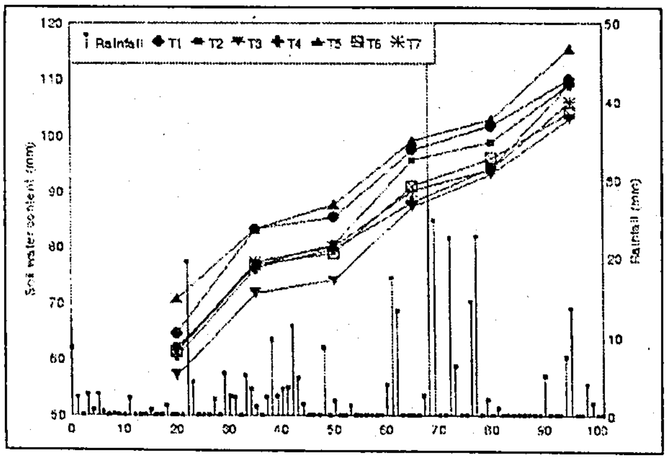
Soil water was measured at 15 day intervals starting from the 20 days after sowing (5 days after treatment imposition) till the harvest of the crop using the principle of neutron thermalization (Gardner, 1986). Aluminum access tubes measuring 60 cm in length were inserted to a depth of 40 cm leaving a 20 cm portion above the ground. Volumetric water contents in the 0-15 cm and 15-30 cm soil layers were determined by inserting a neutron probe (Depth Moisture Gauge, Troxler Electronic Laboratories, USA) to the required depths into the access tubes. The water contents in the 0-15 cm and 15-30 cm soil layers were summed to obtain the water content in the 0-30 cm soil layer, which is the effective depth for the soil of the experimental site.

Mineral N in the 0-15 cm soil layer was estimated at 33 DAS, 66 DAS and at harvest of the crop. Soil samples from the 0 - 15 cm layer were drawn using a tube auger. Samples were drawn from four locations in each plot, two between the crop rows and two within the crop rows close to the plants, to obtain one composite sample to represent the soil for each plot. Field moist soil samples equivalent to 20 g oven dry soil were extracted with 100 ml 2M KCl for one hour. The suspensions were then filtered with Whatman No. 42 filter paper into high density polyethylene reagent bottles. Mineral N in the extract was steam-distilled in the presence of magnesium oxide (MgO) and finely ground Devarda's alloy (Keeney and Nelson, 1982). Nitrogen in the distillate was determined by titration with 0.005N H_2SO_4.

Results and discussion

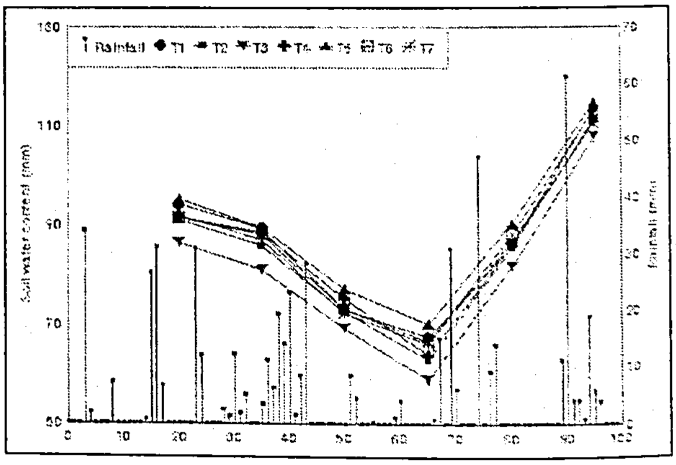
Effect of treatments on soil water content

Soil water contents at different intervals were strongly influenced by rainfall events just preceding the time of measurement (Figs 1 and 2). At individual intervals, the differences among treatments were relatively small and statistically insignificant. However, some treatments showed clear trends across the measurement intervals. Inorganic N alone treatments (T2 and T3) exhibited lower water contents compared to control. This could be due to better utilization of available moisture resulting from increased root growth in response to application of N. Other workers (Kmoch *et al.*, 1957; Brown, 1971) also reported improved root growth of plants fertilized with nitrogen. In both the years, soil water contents were higher with treatments involving sorghum straw (T4 and T5), especially so with 60 kg N through sorghum straw treatment (T5). Sharma and Srinivas (1997) also found higher soil water contents in plots that received sorghum straw, compared to those that received urea, gliricidia and urea + gliricidia treatments. Higher soil water in straw treated plots could be due to improved infiltration (Bellakki and Badanur, 1994) resulting from improved soil structure or due to an increase in water retention capacity of the soil resulting from increase in organic matter content (Bellakki and Badanur, 1994), but it is more likely that the higher profile water contents in straw treated plots were due to relatively poor crop growth and consequently, lower utilization of available soil water. Soil water contents were low with treatments involving gliricidia (T6 and T7) in spite of the large amounts of organic matter added. This could be due to the higher utilization of soil water resulting from better crop growth resulting from application of gliricidia loppings. Tian *et*



Days after sowing

Fig. 1. Effect of treatments on water content in the 0-30 cm soil layer - 1994



Days after sowing

Fig. 2. Effect of treatments on water content in the 0-30 cm soil layer - 1995

al. (1993) also reported increase in soil water content with the application of rice straw and maize straw, but not with gliricidia loppings. Thus, it is evident that profile water contents were influenced more by effect of treatments on crop growth than by their effects on soil physical properties.

Effect of treatments on mineral N in the soil

In 1994, soil mineral N in control (T1) plots showed a decrease as time progressed, up to 66 DAS (Table 2). Tian *et al.* (1993) also reported a steady decrease in soil mineral N in control plots in which maize was grown. This decrease was apparently caused by crop uptake of soil mineral N. After 66 DAS, there was a slight increase in soil mineral N, which could be due to cessation or partial reduction in active N uptake towards crop maturity. With inorganic N alone (T2 and T3), gliricidia N alone (T7) and inorganic N + gliricidia N (T6) treatments, there was an increase in mineral N up to 33 DAS followed by a rapid decline up to 66 DAS and a slow decline thereafter up to harvest. The increase up to 33 DAS might be attributed to release of mineral N from urea and mineralization of N from gliricidia. Tian *et al.* (1993) also reported higher levels of mineral N in soil following application of legume residues of gliricidia and leucaena in combination with inorganic N. With 60 kg N through sorghum straw treatment (T5), mineral N in the soil declined sharply up to 33 DAS but subsequently increased up to 66 DAS and further up to harvest. This could be due to active immobilization of N in the initial stages followed by remineralization of the immobilized N through turnover of microbial biomass. The bimodel release of mineral N can also be due to the nature of organic compounds like lingoproteins, which mineralize and release N only slowly.

Data on mineral N in the soil during 1994 (Table 2) shows that at 33 DAS, the level of mineral N was highest with 60 kg inorganic N treatment (T3). This suggests that inorganic N applied at 15 DAS remained largely unutilized up to 33 DAS. Sharma and Srinivas (1997) also reported high mineral N contents in soil at 32 days after sowing of sorghum in response to urea application. The mineral N contents were relatively high with 30 kg inorganic N (T2), 30 kg inorganic N + 30 kg N through gliricidia (T6) and 60 kg N through gliricidia (T7) treatments also. The mineral N contents were lower than control with 60 kg N through sorghum straw treatment (T5), indicating net immobilization of N due to the application of large quantity of sorghum straw, which has a wide C:N ratio. Sharma and Srinivas (1997) and Das *et al.* (1997) also reported low levels of mineral N in soil caused by immobilization resulting from application of sorghum straw to soil.

In 1995, mineral N levels at 33 DAS were higher with the two treatments involving gliricidia (T6 and T7) compared to 60 kg inorganic N treatment (T3). During this year, there were good rains prior to 33 DAS and this might have caused leaching of nitrate N from the 0-15 cm soil layer in case of inorganic N treatments. With gliricidia treatments, since N mineralization is spread over a relatively longer period of time, it is likely that leaching losses were less. By 66 DAS in both the years of study, most of the differences among treatments with respect to mineral N disappeared. This is due to the fact that major proportion of the N added through inorganic N, gliricidia, and inorganic N + gliricidia N treatments had already mineralized and was removed from the soil by plant uptake and/or various loss mechanisms. At 66 DAS in 1994, the amounts of mineral N with sorghum straw treatments (T4 and T5) were higher than with control. In 1995, however, mineral N with 60 kg N through sorghum straw (T 5) treatment remained lower than control indicating extended immobilization. In both the years, mineral N levels at harvest were distinctly higher with 30 kg inorganic N + 30 kg N through sorghum straw (T4) and 60 kg N through sorghum straw (T5) treatments compared to control and other treatments, indicating net positive mineralization of N in these two treatments. Differences in mineral N at harvest among treatments other than T4 and T5 were small in both the years, indicating that the effects of these treatments on soil mineral N did not last beyond 66 DAS.

Conclusion

Water content in the soil fluctuated with rainfall distribution and was generally not influenced by the treatments. However, plots that received sorghum straw showed marginally higher soil water contents than plots that received inorganic N or gliricidia loppings. The application of inorganic N resulted in an initial increase in mineral N levels, which did not last long. With treatments involving gliricidia, higher mineral N levels were maintained over a longer period of time compared to inorganic N treatments. Application of sorghum straw caused considerable reduction in mineral N in the soil in the initial and middle stages of crop growth but towards harvest, the mineral N levels increased. The results of this study indicate that while incorporated plant residues do not influence soil water, they have considerable effect on soil mineral N. Thus by appropriate management of plant residues, it is possible to manipulate the release of N in the soil in such a way as to benefit crop growth in different cropping systems.

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