MULCHES IN SMALLHOLDER MAIZE SYSTEMS IN THE LIMPOPO PROVINCE OF SOUTH AFRICA: UNTANGLING THE EFFECTS OF N THROUGH EXPERIMENTATION AND SIMULATION

By

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Declaration

NAME: Seshuhla Rebinah SASA PROGRAM: Master of Agricultural Science

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Abstract

In Limpopo Province of South Africa, poor soil fertility and low crop yields are serious problems facing resource poor smallholder farmers. A survey of over 60 farmers in 2 villages (Gabaza and GaKgoroshi) found that most of the smallholder farmers were women (68%), elderly (50% above 68 years of age) and had not attended school or only attended up to the primary level (80%). Very few farmers kept livestock (usually in small numbers) and most grew cereal and legume crops (on 1ha of land) for home consumption and livestock feed, with legumes being planted on 13% of the land. The study showed that 80% of farmers were not fully aware of the benefits of legumes in fixing nitrogen (N) and improving yield.

A field study at the survey village of Gabaza found that the application of fertiliser N and grass mulch combination and fertiliser N plus guarbean mulch significantly increased plant height and maize shoot growth at 4 and 8 weeks after planting. However, when grass mulch was without N fertiliser, there was no increase in maize growth relative to the control (0N).

A farming systems simulation model (Agricultural Production Systems sIMulator - APSIM) was used to simulate this field study as well as over the long-term (1971 to 2008). Simulation analysis showed poor average maize yield (<3000 kg ha^{-1}) with the application of grass residues even when used with 30 kg N fertiliser. However, the application of guarbean residues as mulch with or without N fertiliser and as green manure increased maize yields to >4000 kg ha^{-1}. Simulation showed that the grass mulch with or without the addition of N fertiliser reduced water stress and soil water evaporation but increased N stress during the reproductive phase of the crop in most seasons. When guarbean mulch was used as green manure by itself, or mulch plus N fertiliser, N stress was reduced but water stress and soil water evaporation were increased which could have been due to faster decomposition of legume mulch as compared to grass mulch. Addition of N fertiliser reduced N stress to maize but increased water stress and soil water evaporation similar to the guarbean mulch because of high soil evaporation.

APSIM analysis clearly showed the importance of N x soil water interactions in determining maize growth and yield at Gabaza. Therefore, two studies were undertaken in the laboratory in Australia to determine the dynamics of carbon (C) and N where residues of different qualities [canola (C:N 43), wheat (26), pea (9) and mucuna (14)] were applied

to clay loam (Tarlee) or sandy (Waikerie) soils. In experiment 1, where residues were incorporated into the two soils, the cumulative CO_2-C evolution for the wheat and canola treatments at the end of the incubation period were fairly similar but significantly higher than for pea, mucuna and the control. In general, the application of residues increased microbial biomass C more than the control, with highest increases up to 1.48 and 1.56 mg C g^{-1} soil for canola and wheat in Tarlee soil, respectively and 0.82 mg C g^{-1} soil for pea in Waikerie soil. Even though the Tarlee soil showed greater C release than Waikerie soil, the C turnover from the residues between the 2 soils was not significantly different except for pea residues. Canola and wheat residues were found to immobilise N whereas N content increased in both soils with the application of legumes (pea and mucuna).

In experiment 2, mucuna, pea and wheat residues were either incorporated or applied as surface mulches on Waikerie soil. Initially the CO_2-C release was higher for incorporated than mulched residues and CO_2-C released was higher for pea residues. However, at the end of the incubation more CO_2-C was released with the application of wheat residue indicating differences between residue types in the pattern of soil respiration. Microbial biomass C was higher for incorporated than mulched residue treatments; pea residue showed the highest biomass C for incorporated (0.78 mg C g^{-1} soil) whereas mucuna had the highest microbial biomass (0.11 mg C g^{-1} soil) treatments. The method of residue application resulted in a significant difference in C turnover between residues, with pea residue showing significant increase in C utilisation than mucuna and wheat. The pea residues, which had the lowest C:N, increased soil mineral N more than other treatments in both incorporated and mulched treatments. Lower mineralisation of N observed in residues of high C:N ratio compared to the control could be due to immobilisation of N. Therefore, understanding the nutrient dynamics of different crop residues could play an important role in the management of residues in different soil types. Based on these results it can be concluded that legume residues have the potential to improve soil fertility and crop yields in dryland farmers' fields in Limpopo. Extension programs aimed at increasing farmers' knowledge of the benefits of N fixation by legumes may increase their adoption and thereby improve soil fertility and maize yield.