Research Application Summary

An evaluation of the effect of hairy vetch (*Vicia villosa* Roth) on soil fertility of sandy soils in central Zimbabwe

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Abstract

Crop production in smallholder farming systems of Zimbabwe is limited by low inherent soil fertility, particularly N and P and available soil moisture. The use of efficient N fixing legumes is one way that can sustain soil fertility and conserve soil and moisture. Efforts to improve and manage soil fertility and soil and water conservation problems are hampered by the fact that the range of legume options available for use on depleted sandy soils, common in Zimbabwe smallholder farms and many other countries of Southern Africa, is narrow. In this study, the effect of hairy vetch (*Vicia villosa* Roth) on the fertility of sandy soils will be evaluated at three study sites and compared with Sunn hemp (*Crotalaria juncea* L.) and Cowpea (*Vigna unguiculata*). The effects will be assessed by determining the biomass production and fertility benefits of the three legumes to a succeeding maize crop and when planted as intercrops. Preliminary results have shown that sunnhemp has the greatest biomass yield followed by cowpea and hairy vetch has the lowest yield.

Key words: Hairy vetch, intercrops, N fixing, soil conservation, soil fertility

Résumé

La production agricole dans les systèmes des petits exploitants agricoles du Zimbabwe est limitée par la faible fertilité des sols inhérente, en particulier à N et P et l'humidité disponible dans le sol. L'utilisation de légumineuses efficaces fixatrices de N est un moyen qui peut maintenir la fertilité des sols et conserver les sols et l'humidité. Les efforts visant à améliorer et gérer la fertilité du sol et les problèmes de conservation de l'eau et des sols sont entravés par le fait que l'éventail des options des légumineuses disponibles pour une utilisation dans les sols sableux appauvris, communs dans les petites exploitations agricoles du Zimbabwe et de nombreux autres pays d'Afrique australe, est étroit. Dans cette étude, l'effet de la vesce velue

(*Vicia villosa* Roth) sur la fertilité des sols sableux sera évalué sur trois sites d'étude et rapport avec la crotalaire (*Crotalaria juncea* L.) et de niébé (*Vigna unguiculata*). Les effets seront évalués par la détermination de la production de biomasse et les bénéfices de la fertilité de trois légumineuses à une récolte de maïs réussie et quand ils sont plantés en cultures intercalaires. Les résultats préliminaires ont montré que la crotalaire a le plus grand rendement de biomasse suivi par le niébé et la vesce velue qui ont le plus faible rendement.

Mots clés: Vesce velue, intercalaires, fixation de N, conservation des sols, fertilité des sols

Background

Zimbabwean smallholder farming areas are situated in low rainfall areas, on sandy soils which constitute about two thirds of the country's soils (Cobo *et al.*, 2009). These soils are deficient in N and P and levels of soil organic matter (SOM) are very low which presents a major constraint to crop productivity. This is worsened where there is nutrient mining and little or no mineral fertiliser applications, usually common in smallholder farming areas.

The use of crops capable of symbiotic nitrogen (N_2) fixation and providing soil cover is important for agricultural sustainability (Vance *et al.*, 2000). Results from research in Zimbabwe show that lack of adequate soil moisture and nutrients and shortage of labour are major factors limiting crop productivity in smallholder farming systems (Zingore *et al.*, 2009; Mapfumo *et al.*, 2005) and farmers have limited opportunities for increasing availability of resources. Given this background the range of legume options available for use on depleted sandy soils, which are common in Zimbabwe and many other countries of Southern Africa, is narrow (Chikowo *et al.*, 2004).

Literature Summary

It is important for farmers to replenish and enhance nutrients N, P and K and conserve soil and water to ensure sustained productivity. The main sources of these nutrients are inorganic fertilizers and Biological Nitrogen Fixation (BNF) (Giller *et al.*, 1997). For smallholder farmers inorganic fertilizers tend to be very expensive (Sanchez, 2002) resulting in its limited use. The use of leguminous organic material (i.e., BNF) is an attractive alternative in view of the ever-increasing costs of inorganic fertilizers.

The inclusion of legumes affords greater yield stability in sub-optimal growth conditions such as poor soil fertility and low rainfall or droughts and benefits companion or the following non-leguminous crops (Sanginga, 2003). Legume inclusion in cereal based cropping systems is an efficient source of fixed N_2 through BNF, which plays an important role in land remediation (Hamdi, 2001). Yield increases of crops planted after harvesting of legumes are often equivalent to those expected from an application of 30 – 80kg of N ha^{-1} (Hamdi, 2001).

Pypers *et al.* (2007) suggested that a legume in a rotation system has other positive, possibly soil-microbiological effects which enhance maize growth and production. Other benefits of legumes, which should not be ignored, include reduced pest and weed occurrence, improved soil quality (Van Kessel and Hartley, 1999) and minimization of risk (Graham and Vance, 2000) and soil and water conservation.

Study Description

Field experiments are being conducted in Wedza (31°30', 18°46') and Chiota (31°05', 18°11') communal farming areas, and on-station at University of Zimbabwe (UZ) farm and at Grasslands Research Station in Marondera. At all sites rain follows a unimodal pattern with rains received between November and March. The soils at all sites are granite-derived sands to loamy sands except at the UZ farm where soils are red clays derived from dolerite.

The land was tilled using ox drawn implements and weeding done manually using hoes whenever necessary. Basal fertiliser was applied at a rate of 300kgha^{-1} Compound D fertiliser, providing the plants with 21 kg ha^{-1} N, 42 kg ha^{-1} P and 21 kg ha^{-1} K. Top dressing fertiliser was applied at a rate of 200 kg ha^{-1} ammonium nitrate to provide 85.5 kg ha^{-1} N. Top dressing fertiliser was applied twice (split applied) soon after emergence and when the maize plants had reached knee-height. Maize was planted with a spacing of 0.9m between rows and 0.45m within rows. Sole crop legumes were spaced at 0.3m between rows and 0.1m within rows and those sown as intercrops were spaced at 0.45m between rows and 0.1m within rows. For the intercrops two legume lines were between two maize lines.

The experiments are divided into 4 sub-experiments each being a completely randomised blocked design having 3 replicates/ blocks. The objective of experiment 1was to determine biomass production of sole legumes, and the soil physical properties: aggregate stability, porosity and infiltration rate and soil and nutrient loss through erosion using rainfall simulation. The treatments are hairy vetch, hairy vetch + compound D, Cowpea, Cowpea+ compound D, Sunhemp, Sunhemp+ compound D. Experiment 2 has the treatments maize + compound D + A.N. and maize only added to those of experiment 1 in order to determine the residual N contribution through BNF of the various legumes to a succeeding maize crop.

Experiment 3 seeks to determine the effect of the legume inter-crops through BNF on maize yield and has 10 treatments. The treatments are: Maize + Hairy vetch + Cmp D, Maize + Cowpea + Cmp D, Maize + Sunhemp + Cmp D, Maize + Hairy vetch, Maize + Cowpea, Maize + Sunn-hemp, Maize + Cmp D, Maize +Cmp D + A.N., Maize, Maize + A.N. For the field experiments soil, plant stover and grain samples collected are being analysed for N, P, K using standard procedures.

Experiment 4 will measure the decomposition and N, P mineralization of the legume residues in leaching tube incubations in a constant temperature room using two sandy soils from Wedza and Chiota communal areas. The treatments are hairy vetch residues + soil, cowpea residues + soil, sunn-hemp residues + soil, hairy vetch + maize residues + soil, cowpea + maize + soil, sunhemp + maize residues + soil, and unammended Soil (Control). The leachates are analysed for mineral-N (NH_4-N and NO_3-N) and P and net N and P release calculated.

Research Application

Biomass production of the various legumes was measured at 45, 60 and 75 days after planting (DAP) and maize stover and grain yield at the end of the season. For the 3 legumes planted, biomass production was greatest at 75 DAP. Figures 1 to 3 show biomass yields of the three legumes at the study sites. Sunnhemp exclusively had the greatest biomass yield at 3 sites followed by cowpea then hairy vetch. Soil samples are in the process of being analysed so as to assess the soil fertility benefits of the legumes. It is anticipated that the research will lead to enhancement of sustainable natural resource use, soil fertility improvement and management by smallholder farmers.

Acknowledgement

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References

Chikowo, R., Mapfumo, P., Nyamugafata, P. and Giller, K.E. 2004. Maize productivity and mineral N dynamics following

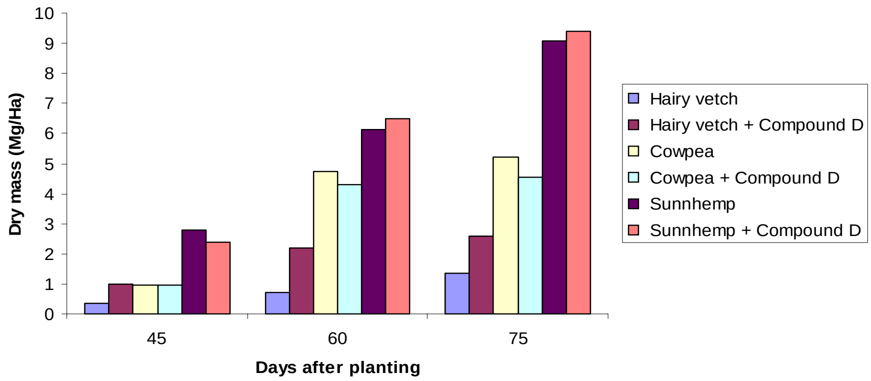

Figure 1. Legume biomass production at GRS, Marondera.

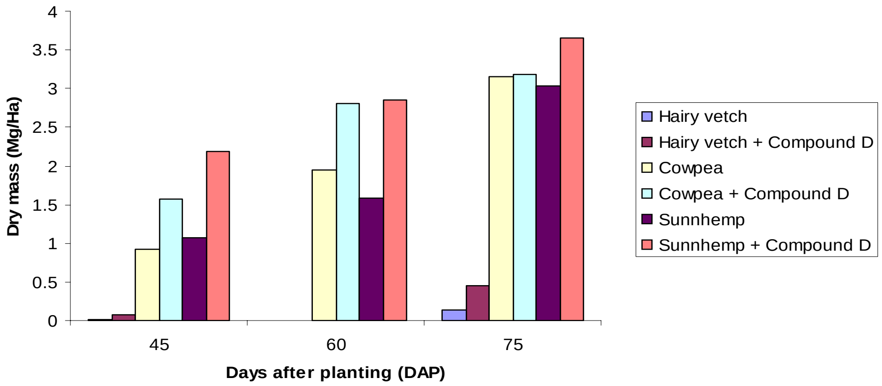

Figure 2. Legume biomass production in Chiota, (2009/10).

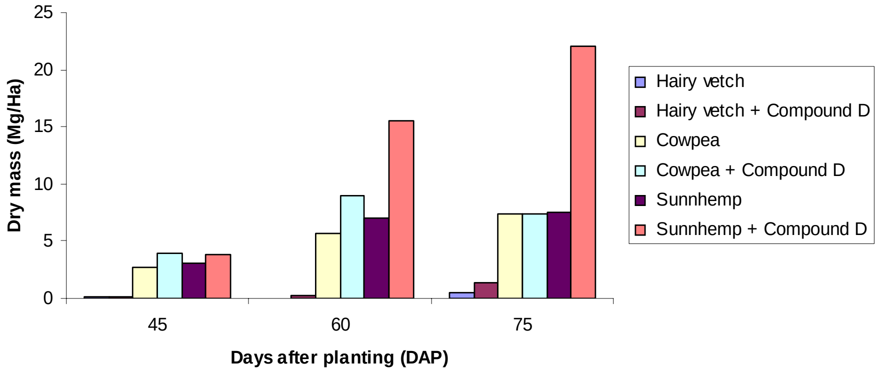

Figure 3. Legume biomass production in Wedza, (2009/10).

different soil fertility management practices on a depleted sandy soil in Zimbabwe. *Agriculture, Ecosystems and Environment* 102:119–131.

Cobo, J., Dercon, G., Monje, C., Mahembe, P., Gotosa, T., Nyamangara, J., Delve, R.J. and Cadisch, G. 2009. Cropping strategies, soil fertility investment and land management practices by smallholder farmers in communal and resettlement areas in Zimbabwe. Land Degradation & Development. DOI: 10.1002/ldr.927.

Giller, K.E., Cadisch, G., Ehakuitusm, C., Adams, E., Sakala, W.D. and Mafongoya, P. L. 1997. Building soil nitrogen capital in Africa. In: Buresh, R.J., Sanchez, P. A. and Calhoun, F. (Eds.). Replenishing Soil Fertility in Africa. SSSA Special Publication 51. SSSA, Madison, WI. pp. 151-192.

Graham, P.H. and Vance, C.P. 2000. Nitrogen fixation in perspective: an overview of research and extension needs. *Field Crops Research* 65:93 -106.

Hamdi, H.Z. 2001. Available at http://mmbr.asm.org/cgi/content/full.63/4/968?maxtoshow=&HITS=20&RESULTFORMAT=&titleabs tract=arid+or+aridity +or+ desert+or+dryland ++or+drought+o r+sahara+or+sahel+&searchid=1& FIRST INDEX=0&fdate=//&resourcetype=HWCIT. Accessed 05/10/2009.

Pypers, P., Michael, H., Diels, J., Abaidoo, R., Smolders, E. and Merckx, R. 2007. Does the enhanced P acquisition by maize following legumes in a rotation result from improved soil P availability? *Soil Biology and Biochemistry Journal* 39:2555- 2566.

Sanchez, P.A. 2002. Soil fertility and hunger in Africa. *Science* 295: 2019-2020.

Sanginga, N. 2003. Role of biological nitrogen fixation in legume based cropping systems; a case study of West Africa farming systems. In: Hardarson, G. and Broughton, W.J. (Eds.). Maximising the use of biological nitrogen fixation in Agriculture. F.A.O. and Kluwer Academic Publishers. pp. 25 -39.

Van Kessel, C.and Hartley, C. 1999. Agricultural management of grain legumes: has it lead to an increase in nitrogen fixation? *Field Crops Research* 65:165 -181

Vance, C.P., Graham, P.H. and Allan, D.L. 2000. Biological nitrogen fixation: phosphorus - a critical future need? In: Pedrosa, F.O. (Ed.). Nitrogen fixation: From molecules to crop productivity. pp. 509-514.

Zingore, S., González-Estrada, E., Delve, R.J., Herrero, M., Dimes, J.P. and Giller, K.E. 2009. An integrated evaluation of strategies for enhancing productivity and profitability of resource-constrained smallholder farms in Zimbabwe. *Agricultural Systems* 101:57-68.