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Research Application Summary

Potential of hairy vetch (*Vicia villosa* Roth) to improve soil physical properties of sandy soils in central Zimbabwe

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Abstract

Most farmers in the smallholder areas practice conventional tillage which results in soil loss of between 10-34 t ha^{-1} yr^{-1}. Tillage also results in breakdown of macroaggregates into smaller aggregates as well as primary particles. Close packing of these will increase the bulk density and decrease porosity, aeration and root development gradually over the years. These damaged and depleted soils need to be rebuilt in order to sustain agriculture and one way of rebuilding these sols is through the use of legumes such as hairy vetch. Hairy vetch (*Vicia Villosa* Roth) has been found to improve soil structure leading to better soil and water conservation. In this study soil aggregate stability, hydraulic conductivity and soil porosity, which all influence soil moisture retention, will be measured on soils planted with hairy vetch and maize intercrop. Soil and nutrient loss will be measured using rainfall simulation. In order to make comparisons cowpea (*Vigna unguiculata*) and sunhemp (*Crotalaria juncea*) will also be included as sole crops and as intercrops with maize. Preliminary results have so far shown that sunhemp has the highest biomass production and hairy vetch the lowest.

Key words: Aggregate stability, hairy vetch, soil structure, tillage

Résumé

La plupart des agriculteurs dans les petites exploitations pratiquent le labour traditionnel qui entraine la perte de sol comprise entre 10 à 34 t ha^{-1} yr^{-1}. Le labour du sol entraine également à la dépression des macroagrégats en petits agrégats, ainsi que les particules primaires. Fermer l'emballage de ceux-ci va augmenter la densité apparente et diminuer la porosité, l'aération et le développement des racines peu à peu au fil des années. Ces sols endommagés et appauvris doivent être reconstruits afin de soutenir l'agriculture et un moyen de reconstruction de ces sols est l'utilisation de légumineuses comme la vesce velue. La vesce velue (*Vicia Villosa* Roth) a été trouvée pour améliorer la structure du sol permettant une meilleure conservation des sols et de l'eau. Dans cette étude, la stabilité des agrégats de sol, la conductivité hydraulique et la porosité du sol, qui toutes influencent la rétention de l'humidité du sol, seront mesurées sur les sols plantés de vesce velue et de maïs intercalés. La perte de sol et de nutriments sera mesurée à l'aide de simulation de pluie. Afin de faire des comparaisons, le niébé (*Vigna unguiculata*) et la crotalaire (*Crotalaria juncea*) seront également inclus en tant que cultures pures et comme cultures intercalaires de maïs. Les résultats préliminaires ont montré jusqu'à présent que la crotalaire a la plus forte production de biomasse et la vesce velue la plus basse.

Mots clés: Stabilité des agrégats, vesce velue, structure du sol, labour

Background

Soil degradation is a major environmental problem worldwide and there is strong evidence that the soil degradation processes present an immediate threat to both biomass and economic yields, as well as a long-term hazard to future crop yields. In Zimbabwe, a widespread problem in smallholder farming areas is soil and water loss which has been blamed for reduced yields (Vogel, 1992). Soil and water losses can reach dramatic levels and compromise future agricultural production. The smallholder areas in Zimbabwe occupy 42 % of the total land area (Anderson and Ingram,1993) and experience frequent droughts. As a result, increased food production in the country is limited and could be improved using leguminous crops, such as hairy vetch. Hairy vetch (*Vicia villosa* Roth) can be used as a winter annual legume and can grow from 0.6 m to 1.2 m high. It is widely adapted and its high N production, vigorous growth, tolerance of diverse soil conditions, low fertility needs and diverse climatic conditions (Iragavarapu *et al*., 1995) makes it a high potential cover crop on infertile granitic sandy soils in Zimbabwe. Kamprath *et al.* (1958) found that the use of hairy vetch as a winter legume cover crop on Norfold soils in North Carolina increased maize yields from 26 to 57 t ha^{-1}, an increase comparable to that produced by the application of 84 to 106 kg N ha^{-1}. Some researchers have also observed that hairy vetch provides yield improvements beyond those attributable to N alone which may be due to mulching effects and soil structure improvements leading to better moisture retention (Varco, 1986; Doran *et al.*, 1987).

Literature Summary

The integration of legumes in cropping systems has long been recognized as a cost effective alternative to industrially manufactured N-fertilizers (Giller, 1998). In addition the potential benefits of cover crops include protection of soil from water and wind erosion, addition of organic matter, improvement of soil structure and water penetration, suppression of weed growth and also attraction and sustenance of beneficial insects, spiders and mites.

Peoples *et al.* (2008) reported that the inclusion of legume cover crops in a cropping sequence generally improves the productivity of following crops. While some rotational effects may be associated with improvements in availability of N in soils, factors unrelated to N also play an important role. Chalk (1998) compared yield responses to increasing rates of applied N fertilizer for 26 wheat-wheat and lupin-wheat rotations in Australia. He concluded that in over 60% of the experiments (16 out of 26 comparisons) non-N effects derived from the lupin either dominated the rotational effect or were important contributing factors in the subsequent yield improvement by wheat.

In another study in Japan, Sato *et al.* (2007) evaluated the effect of hairy vetch planting on changes in soil physical properties and soybean early growth in a heavy clayey soil field. Hairy vetch grew vigorously and its roots elongated into the subsoil (about 40 cm in depth). In the surface layer, the soil aggregate structure was developed by hairy vetch root growth compared with the control. There were large soil cracks from the surface to deep layer (until 50 cm in depth) where the hairy vetch root elongated along with the soil cracks. However, the problem with most Zimbabwean soils is that they are sandy soils with little amounts of organic carbon and poorly developed structure (macro and micro). Hairy vetch's potential to improve aggregate stability in sandy soils needs to be assessed in erosion prone smallholder farming areas in Zimbabwean. Soil aggregate stability seems the most appropriate indicator with regard to protection of soils from erosion and shallow mass movements as it is critical to both plant growth and soil erodibility (Barthes and Roose, 2002; Canton *et al*., 2009).

Study Description

The research is being carried out at two farmer managed sites (Wedza: 31^{o}30', 18^{o}46' and Chiota: 31^{o}05', 18^{o}11') and at one researcher managed site (University of Zimbabwe farm in Mazowe) over two agricultural seasons (November 2009/April 2010 and November 2010/April 2011). Chihota and Wedza are in agro-ecological Region IIb and III (Rainfall 650-800 mm/

year) respectively and University of Zimbabwe Farm is in agro-ecological region IIb (Rainfall 750 – 1000 mm/year). Trials were set up in a randomized complete block design with slope as the blocking factor. The treatments are hairy vetch, hairy vetch + compound D, Cowpea, Cowpea+ compound D, Sunhemp, Sunhemp+ compound D, all spaced at 0.3m between rows and 0.1m within rows (Fig. 1). The same treatments within the same plots will be repeated in the following season.

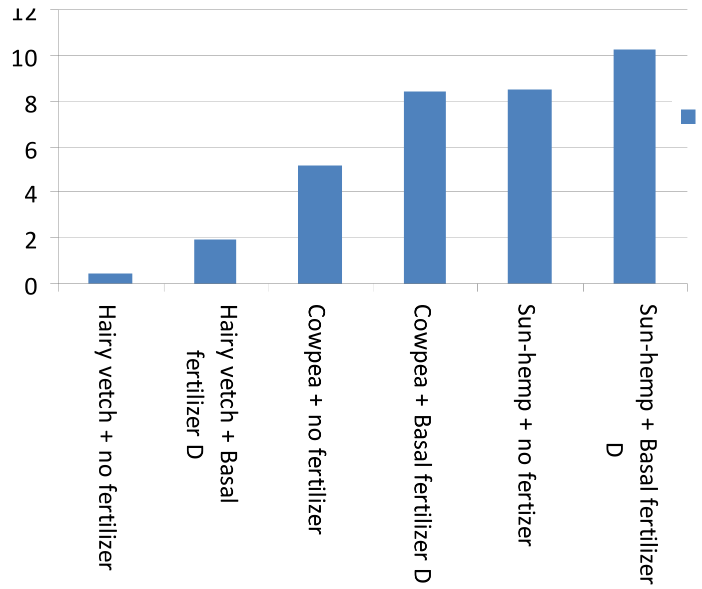

Figure 1. Biomass (t/ha) of hairy vetch, cowpea and sun-hemp at University of Zimbabwe farm.

Soil and nutrient (N, K and C) loss will be determined through rainfall simulations. Rainfall simulation will be conducted at a rainfall intensity of 35 mm hr^{-1} (modal for the rainfall received in most parts of Zimbabwe) on 1 m^2 sub-plots in each field until steady state. The test area will be demarcated and hydrologically confined using aluminium sheets installed on all sides leaving 7cm of the sheets above the ground. A metal flume will be anchored at the outlet, leading into a small trench to collect runoff. The amount of soil in the runoff will be determined and the amounts of nitrogen (using the macro-Kjeldahl method), phosphorous (using Olsen's method), potassium (using ammonium acetate for the soil and Atomic absorption spectrophotometer) and organic carbon (using Walkely Black method) will be determined. Undisturbed soil cores will be taken from the 30 cm depth in all the plots and pressure plates will be used to measure soil water retention. Undisturbed soil samples will be collected using cores from 0-30 cm depth of each experimental plot prior to rainfall, air dried, then sieved using a

2-mm sieve and water-stability of macroaggregates (>0.2 mm) will be determined by the Barthes test (Barthès *et al*., 1996). Porosity will be derived from the soil's bulk density.

Above ground biomass in 30 x 30 cm quadrant at 45 days, 60 days (flowering stage) and 75 days (physiological maturity) after planting will be measured.

Research Application

The preliminary results obtained to date show that sun-hemp had the highest biomass production, followed by cowpea, with Hairy vetch having the lowest biomass production. Measurement of soil physical properties are however in progress. This research is expected to increase knowledge on the non-N benefits of hairy vetch in comparison to cowpea and sunhemp. This knowledge will help in giving recommendations to farmers on how they can improve their soil's physical properties and ultimately increase crop yields in a sustainable way.

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