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Improving the productivity and resilience of smallholder farmers with maize-legume and legume-legume systems in Malawi

Ngwira Amos[1] (A.Ngwira@cgiar.org), Nelson William[2], Snapp Sieglinde[3], Chikowo Regis[3], Rao Karuturi[4], Whitbread Anthony[4]

[1] ICRISAT, Lilongwe, Malawi; [2] TROPAGS, Georg-August-Universitaet, Goettingen, Germany; [3] Plant, Soil and Microbial Sciences, Michigan State University, Michigan, United States; [4] ICRISAT, Hyderabad, India

Introduction

Smallholder farmers in southern Africa must cope with declining soil fertility and production risks associated with frequent droughts (Jayne et al., 2014). Legume integration through rotations or intercropping in maize-based farming systems are promoted to increase crop diversification and soil fertility. A novel strategy, doubled up legumes, could help develop production systems that fulfil sustainable intensification (SI) indicators. It is however crucial to understand resource competition in mixed cropping systems under variable soil and climate conditions.

Materials and Methods

We used agronomic data from participatory farmer trials to parameterise the Agricultural Production systems SIMulator (APSIM) and evaluate its performance simulating observed treatments at three locations from 1986-2019 in central Malawi. The calibrated model was used to simulate groundnut-pigeonpea intercropping, maize-pigeonpea intercropping and maize-groundnut rotation, soybean-maize rotation and continuous maize under a range of N fertiliser inputs.

Results and Discussion

Simulated maize and legume grain yields were generally in-line with observed yields from seasons 2012/2013 to 2017/2018 (RMSE = 1317 and 274 kg/ha for maize and groundnut), confirming observations that APSIM is able to predict maize yield response to fertility inputs, rotations and intercrops (Carberry et al., 1989; Robertson et al., 2005). Maize yields declined by around 30% in intercrops with pigeonpea compared with sole maize. Low maize yields were compensated for by pigeonpea yields. Averaged across sites, maize after sole groundnut gave similar yields to maize receiving the full fertiliser rate. Hence, the nutrient gap for maize across sites was largely filled by legume rotation treatments receiving 50% of the fertiliser rate - a huge saving in fertiliser costs for maize production - setting aside opportunity costs of forgone maize in the preceding season (Kiwia et al., 2019). The coefficient of variation for all systems tested was around 10%, in contrast to earlier, similar reports that showed stable maize yields in rotations with grain legumes (Chimonyo et al., 2019).

The integration of legumes into the maize systems slightly reduced the magnitude of the decrease in soil organic C (witnessed in sole maize rotations), especially when pigeonpea was added to the system. This highlights the importance of grain legumes in sequestering soil C and the sustainability of such cropping systems. This result is in-line with Smith et al. (2016) that reported higher total C and N levels in doubled up legume systems compared with sole maize.

Conclusions

Maize-legume rotations or intercrops can assist farmers in southern Africa to achieve similar maize yields with moderate N fertiliser inputs. In addition, integrating pigeonpea in maize systems increased total soil C compared with continuous sole maize. These systems therefore have the potential to improve soils and reduce chemical fertiliser input.

Practical experimentation is required to determine site-specific suitability for resource-limited farmers, which should be part of a strategy to build soil fertility and provide immediate household needs.

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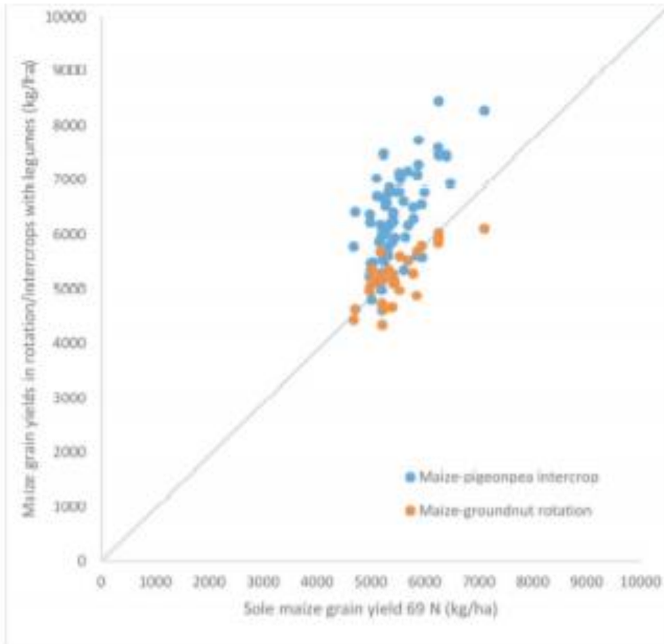

Figure 1. Maize grain yield (kg/ha) comparison between sole and intercrop/ rotations systems simulated under farmer's conditions in Malawi (1986-2019). Dots represent maize-pigeonpea intercrop (blue), and maize-groundnut (orange). Maize-pigeonpea intercrop and maize-groundnut received 35 kg N/ha (12 at sowing, 23 as a top dressing, 21 days after sowing) and sole maize received 69 kg N/ha (23 at sowing and 46 as a top dressing, 21 days after sowing).

Keywords: APSIM, Sustainable Intensification, Climate Variability, Legume Rotation, Intercropping

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