Developing Sustainable Subsistence Smallholder Conservation Agriculture Systems in Southern Africa

Neal Eash[1], Forbes Walker[1], Dayton Lambert[1], Michael Wilcox[1], Makoala Marake[2], Patrick Wall[3], and August Basson[4]
[1]University of Tennessee Institute of Agriculture – Knoxville [2]Soil Science, National University of Lesotho, Roma, Lesotho [3]CIMMYT, Mexico, Mexico [4]Growing Nations, Maphutseng, Lesotho

Background

Recent efforts by the Government of Lesotho, non-government organizations (NGOs), and international attention have focused on developing conservation agriculture (CA) practices adapted to the cultural, economic, and agro-ecological conditions characterizing Lesotho's crop agriculture. In particular, understanding the influence of the introduction of CA technologies on soil erosion, yields, labor allocation and gender roles are of critical importance for developing sustainable agriculture technologies. This research is a collaborative effort between The National University of Lesotho, The University of Tennessee, USAID, and other NGO's based in Lesotho.

Plowing on highly erosive areas create "Dongas", which lead to soil loss and lower agricultural production.

Research objectives

1. Integrate cover crops into CA systems to protect soil from erosion, provide N, provide weed suppression or control, including crop rotations that provide forages for livestock, decrease risk and vulnerability to drought.
2. Determine the agronomic and economic fertilizer rates for maize planted using the pothole method ("Likoti", picture below) with two seeds per hole compared with no-till machine planted.
3. Characterize the composition and contribution of N and C from legume/grass cover crops and determine the best species for maintaining soil residue cover until after maize crop harvest.
4. Determine the impacts of CA systems on gender equity in terms of household income and economic impact and to involve women in decisions that impact their welfare.
5. Evaluate ways and means to improve fertilizer adoption rates among smallholder farmers, the degree to which market structure influences fertilizer use, and determine welfare implications based on price margins.

Figure 1. Cost of Agricultural Practices

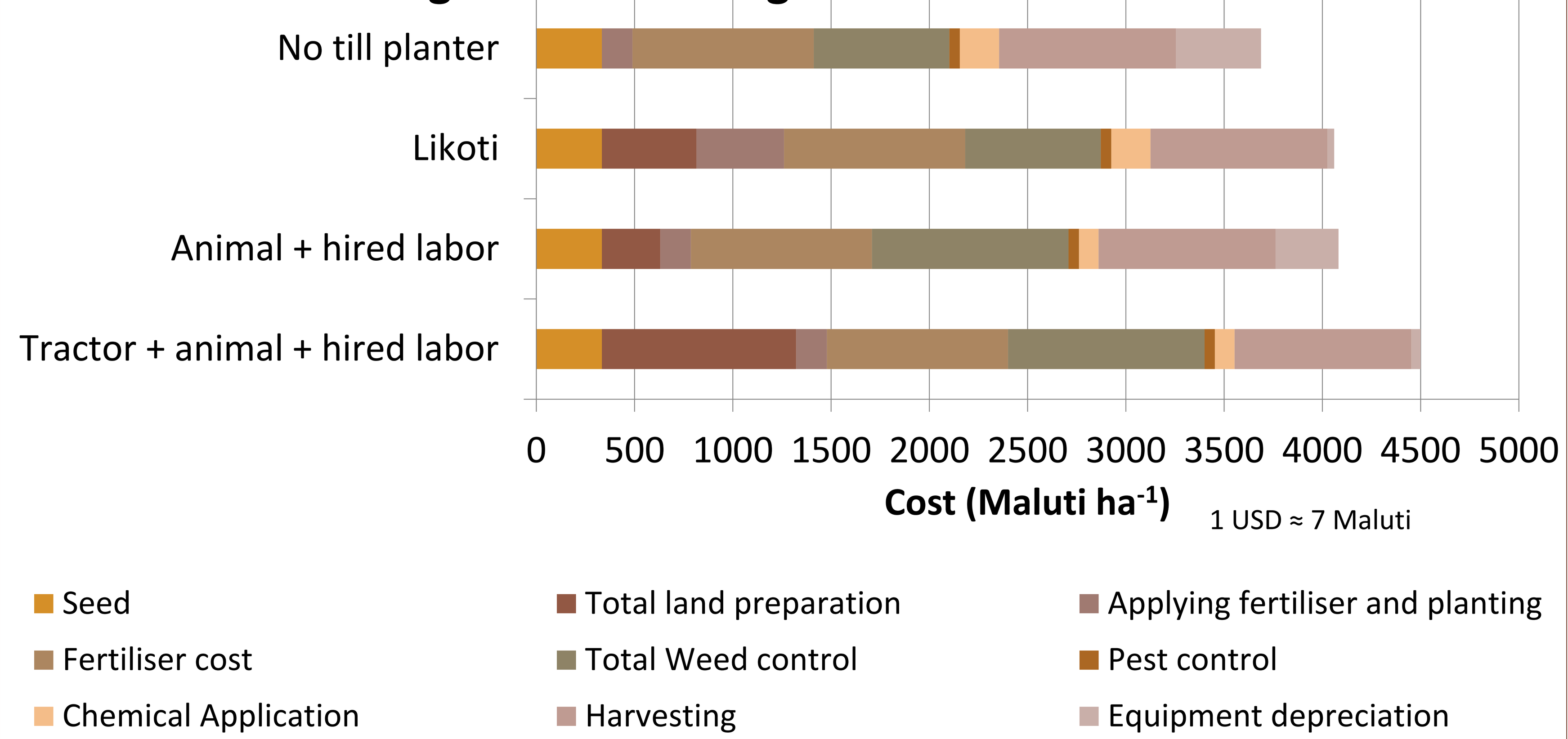
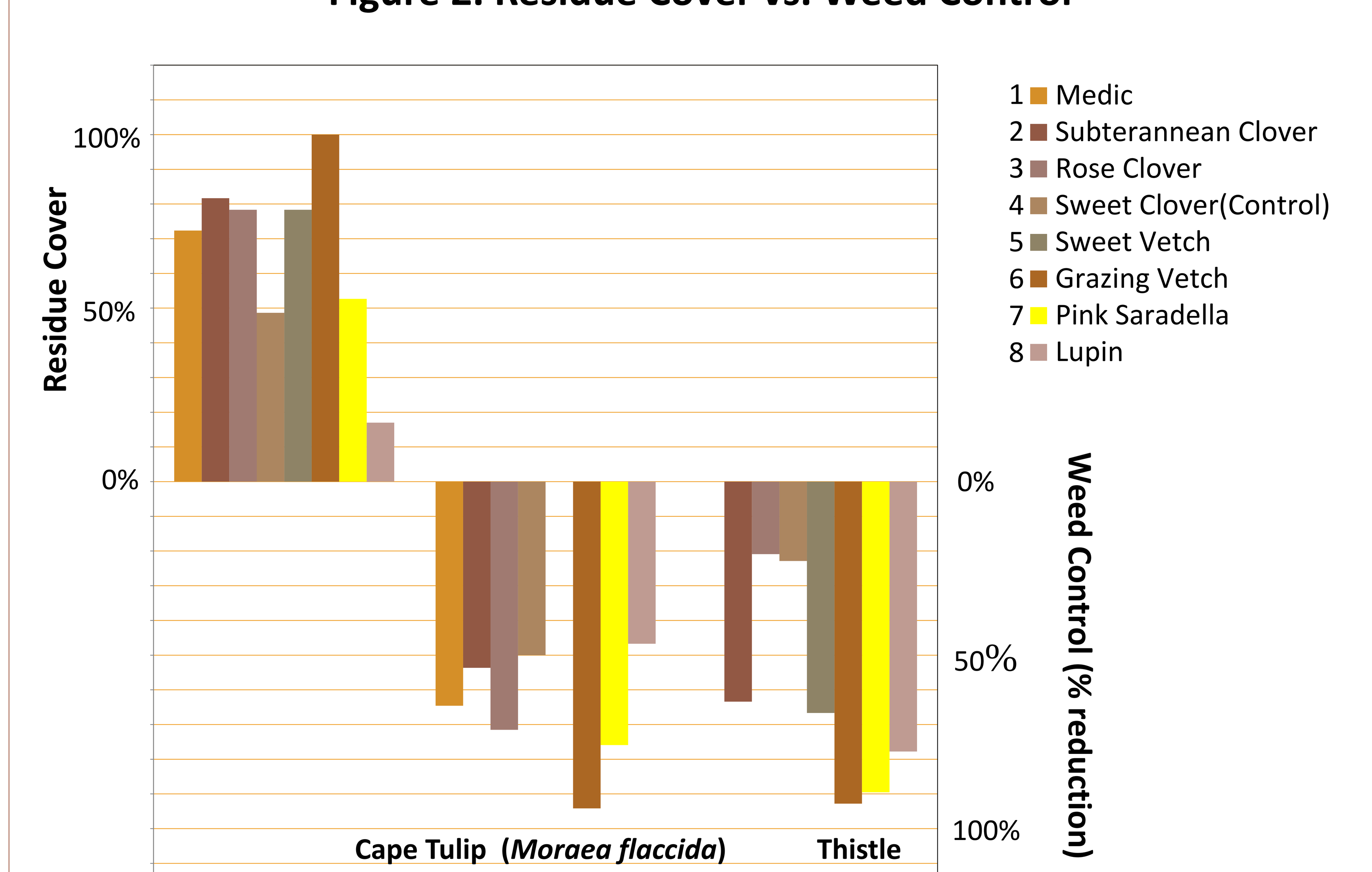


Table 1. Comparison of tillage technologies, break-even yields, and labor cost share.

Tillage technology	Break even yield ($Mg\ ha^{-1}$)	Labor cost as % of total cost
Likoti ("pothole" method)		
Hired labor herbicide + hand weed	2.32	62
Hired labor	2.76	71
Family labor	0.80	0
Conventional		
Tractor + animal + hired labor	2.57	48
Animal + hired labor	2.33	60
Animal + family labor	0.93	0
No till planter		
Hired labor herbicide plus hand weed	2.11	48

Figure 2. Residue Cover vs. Weed Control



1. *Medicago monantha* 2. *Trifolium subterranean* 3. *Trifolium hirtum* 4. *Melilotus ofiicinalis* 5. *Hedysarum L.* 6. *Vicia sativa* 7. *Ornithopus sativus* 8. *Lupinus L.*

Figure 3. Maize Yields by Planting Date and Weed Treatment

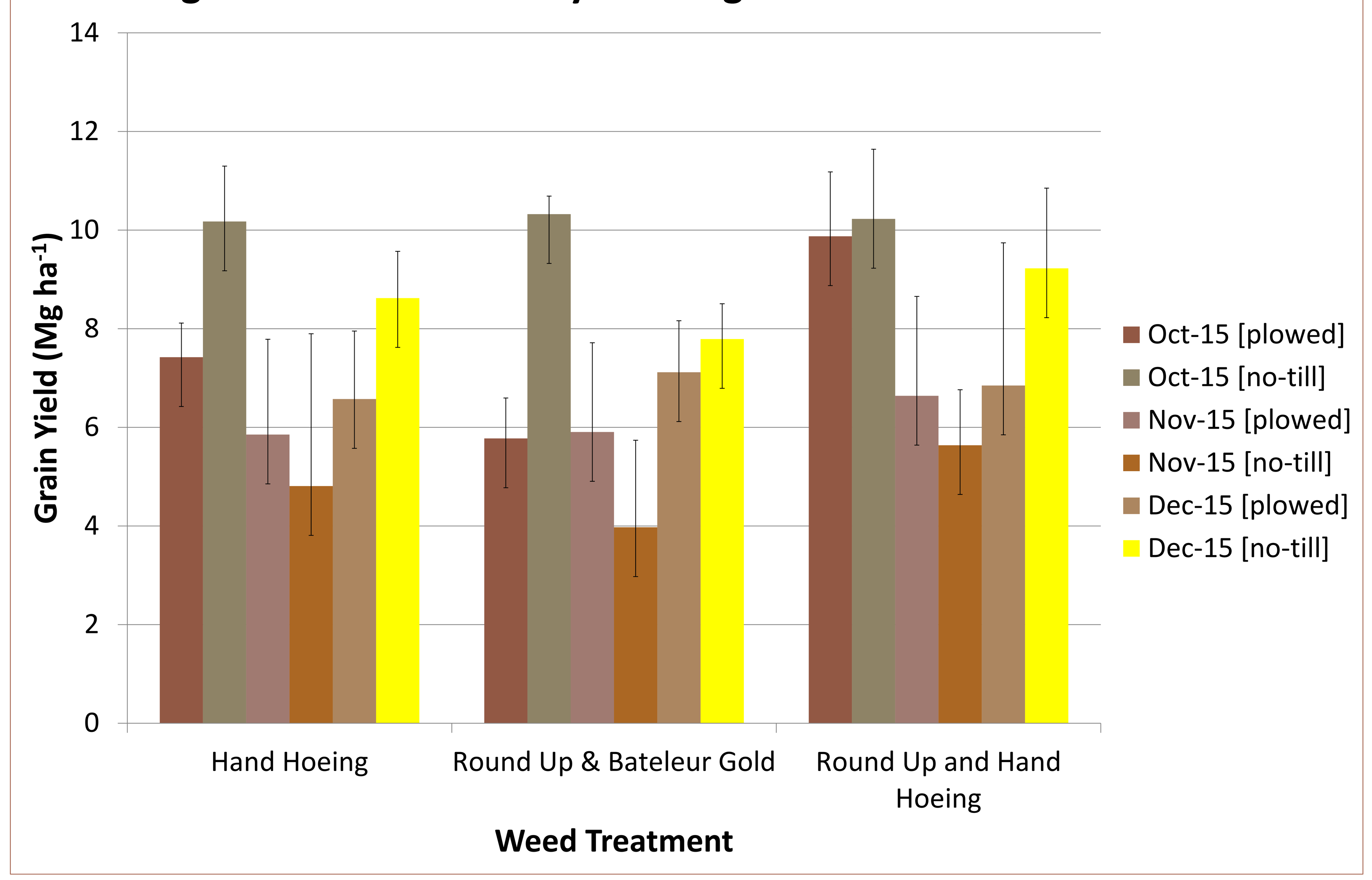
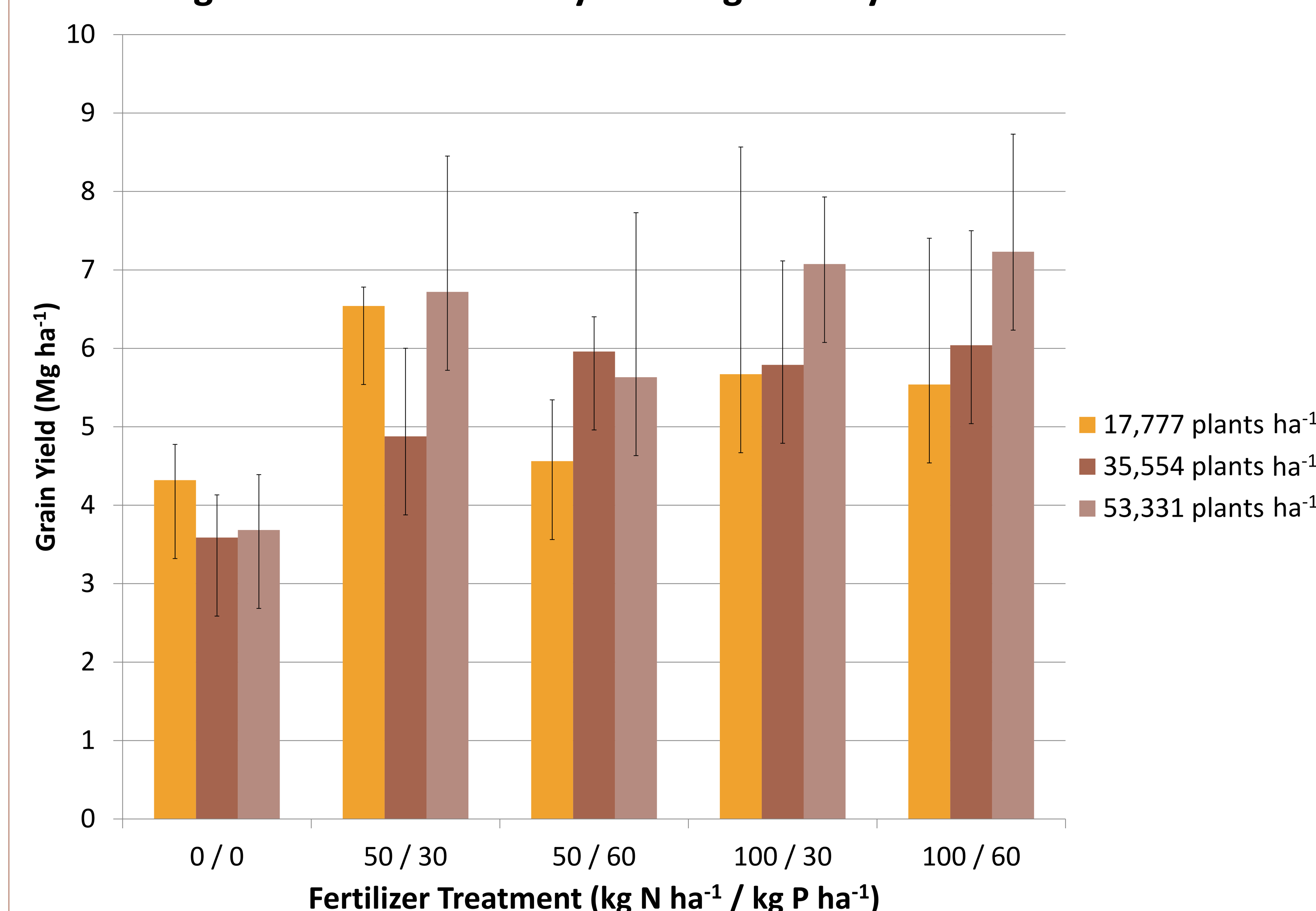


Figure 4. Maize Yields by Planting Density and Fertilization



Conclusions and future directions

Progress continues on understanding the costs of adopting CA technologies in Lesotho. At the conclusion of year one of the five-year project, we have gained a better understanding of the expected costs of CA technologies compared to conventional cultivation practices. Scale economies could play a role in the adoption of various CA methods and concomitantly the total land area at risk of erosion. More work is needed regarding the socioeconomic effects of CA; especially how it pertains to labor demand, household income, and how gender roles may be affected at the household and community levels. In addition, establishing and maintaining a passion for disseminating information remains a challenge for Extension agents, local influential persons, and the farm population. The success of CA depends upon the capacity building within the local extension system to develop successful outreach and extension programs.

Preliminary results

A baseline partial budget analysis compared the costs of four cultivation practices. The first – "Likoti" – is method where potholes are dug by hand and then planted following the first rains. Producers are encouraged to leave residue on the plots (typically about 0.5 ha). The second method used a no-till planter to seed fields. The "Likoti" method is generally more labor intensive, while the no-till planter is tractor- or oxen-drawn. These CA methods were compared to conventional tillage methods that used animal traction or hired labor, and a combination of animal traction and hired labor. These conventional technology sets are typical for the region studied, but "Likoti" and no-till methods are relatively novel. Break-even yields were calculated for each technology based on prevailing input and maize prices.

At present, weeding, inputs (herbicide, insecticide, fertilizer and labor) and application of chemicals differentiate the total costs borne by each cultivation method. Per hectare costs appear to be lowest for the no-till operation (Fig. 1). However, it should be noted that this result is largely driven by assumption of scale economies. For relatively larger operations, the costs of the no-till planter can be spread over a larger area. Assuming small-holder operations (e.g., plots of 0.5 ha), the breakeven yield for "Likoti" where family members are completely engaged in management of the system is lowest (0.80 Mg/ha), followed closely by the conventional tillage operation that uses only family labor (0.93 Mg/ha). Break-even yield was 2.11 Mg/ha for the no-till system (Table 1). Thus, preliminary results suggest that scale effects should be taken into consideration when designing a policy targeting region-wide erosion problems as opposed to a "one size fits all" solution.

Results from the past winter cover crop trials suggest that winter annual weeds can be controlled/suppressed effectively with cover crops. Grazing vetch had the best establishment as evidenced by nearly 100% ground cover and nearly 100% effectiveness in controlling tulips and thistles. In contrast, lupin establishment was weak, with less than 20% ground cover, yet was effective in reducing 80% of the thistle population (Fig. 2).

Early planting under no-till and plowed treatments gave the greatest yields regardless of weed control except for the Round Up/Bateleur Gold treatment which was probably due to effective soil moisture differences between planting date (Fig. 3).

Results from the first year of N-P fertilizer trials with the three plant populations suggests that rates need to be increased for next year as do the target plant populations. Contrary to our working hypothesis that 35,554 plants/ha would be the optimal population, higher populations need to be investigated in conjunction with N and P rates (Fig. 4). However, rainfall in 2010 was near extraordinary so it is unclear how the higher populations will fare under intense drought stress common most years.