Mobilizing Greater Crop and Land Potentials with Conservation Agriculture

Gottlieb Basch (Institute of Mediterranean Agricultural and Environmental Sciences, Universidade de Évora, 7002-554 Évora, Portugal, gb@uevora.pt)
Amir Kassam (University of Reading, UK)

Background

In the coming decades, crop yields must increase substantially to cope with the growing demand for food driven by continued population growth and increasing incomes resulting in rising consumption of livestock products, but also due to the expansion of biofuel production. All this will dramatically increase the pressure on global agriculture and require boosting production per unit of land cropped, unless farming is expanded considerably into forest areas and natural habitats with the well-known consequences on wildlife biodiversity and carbon sequestration capacity. Thus, to produce more from the land already under cultivation means the intensification of crop production and narrowing the yield gaps between potential yields (Yp) or water-limited yields under rainfed conditions (Yw) and the actual average farm yields (Ya) (Ittersum et al., 2013). The question is how best to reduce this exploitable yield gap.

Current rates of improvement in both potential (Yp) and water-limited yields (Yw) in many of the world's important cereal producing regions appear to be well below the 1.16-1.31% per year rates necessary to meet the projected demand in 2050 (Hall and Richards, 2013), which calls for a 70% increase in global food production. According to Ray et al. (2013), the projected need is even to double global production by 2050, which would require a 2.4% increase per year. In any case, this is far beyond the current growth rates of 1.6%, 1.0%, 0.9% and 1.3% of the production of maize, rice, wheat and soybean, respectively. For many regions worldwide there are reports and concerns on yield stagnation or even declines (Lin and Huybers, 2012, Ray et al., 2012, Finger, 2010, Brisson et al., 2010, Hafner, 2003). Also, the dominant production methods based on intensive tillage and excessive agro-chemicals is now generally considered to be environmentally and economically unsustainable, particularly in the face of widespread degradation of agricultural lands, rising costs of energy and production inputs and climate change.

Exploring and improving the genetic yield potential of major staple crops is widely recognized as an important contribution to guaranteeing food security over the coming decades. Unexploited opportunities for further genetic improvement following several novel approaches could enhance current relative yield growth rates. However, the time-scales necessary between progress and widespread adoption are known to be considerable (Hall and Richards, 2013).

The role of Conservation Agriculture in harnessing the fuller potentials of crops and land

Given that the rate of increase in yield potential is much less than the rate of increase in expected demand and that the exploitable gap between genetic yield potential and average farm yields is becoming smaller, additional efforts have to be undertaken to find improved production system solutions towards global food security without further putting at risk the main natural resource base, the soil and its agronomic crop and land potential. Soil degradation in tillage-based production systems, in fact, is the major threat to future food security that must be addressed as an integral part of the task of coping with the need to maintain the yield gains already made and further improve actual crop yields in many of the important cropping areas worldwide. To halt and reverse this tendency of stagnating yield growth and increasing degradation, the principal resource base, the soil, has to be sustained and its productivity improved through its sustainable management.

According Lal (2013), strategies aiming to close crop yield gaps must comprise soil-based management approaches for site/crop-specific situations optimizing soil conditions for enhanced crop growth and yields. Thus soil quality management plays a key role in harnessing the full potential of crops and land. It is not by chance that despite the adoption of improved varieties, crop yields especially in Sub-Saharan

Africa showed very small increases over the last decades. Soil degradation and nutrient depletion are the most likely cause for the tremendous yield gap there. On the contrary, in countries like Brazil, where the grain cropping area between 1991 and 2004 increased approximately by 10%, total grain yields more than doubled (Cooplantio/Conab 2005, cited by Derpsch, 2005). In the same period the area under Conservation Agriculture (CA) raised from 1 million to over 20 million hectares. In addition, the crop yield increases observed in many situations of long-term CA practice are accompanied by reduced inputs, especially the amount of mineral fertilizers, fuel and labour (Derpsch 2005, Carvalho et al., 2012).

Concluding remarks

Based on worldwide empirical and scientific evidence, it appears generally evident that CA can play a major role in accelerating production output growth to meet future global food needs. The evidence also suggests that it can do so while arresting soil degradation and improving factor productivity (efficiency of input use) and profit margins, as well as add the much needed resilience to cropping systems and ecosystem services. There is growing evidence to show that CA through improved soil quality enables better phenotypic performance from any adapted genotype, traditional or improved. This is because CA enables agricultural soil and landscape to be treated as living biological entities in which soil biota and their symbiotic relationships with root systems are encouraged while maintaining improved and efficient soil-plant-moisture-nutrient relationships (Jat et al., 2014).

References

Brisson, N., Gate, P., Gouache, D., Charmet, G., Oury, F.X. and Huard, F. 2010. Why are wheat yields stagnating in Europe? A comprehensive data analysis for France. *Field Crops Research* 119 (1):201-212.

Carvalho, M., Basch, G., Calado, J.M.G. and Barros, J.F.C. 2012. Long term effect of tillage system and crop residue management on soil carbon content of a Luvisol under rainfed Mediterranean conditions. *Agrociencia*, (Special Issue), 183-187

Derpsch, R. 2005. The extent of Conservation Agriculture adoption worldwide: Implications and impact. Proceedings of the III World Congress on Conservation Agriculture, 3 – 7 October 2005, Nairobi, Kenya.

Finger, R. 2010. Evidence of slowing yield growth - The example of Swiss cereal yields. *Food Policy* 35 (2):175-182.

Hafner, S. 2003. Trends in maize, rice, and wheat yields for 188 nations over the past 40 years: a prevalence of linear growth. *Agriculture Ecosystems & Environment* 97 (1-3):275-283.

Hall, A.J., and Richards, R.A. 2013. Prognosis for genetic improvement of yield potential and water-limited yield of major grain crops. *Field Crops Research* 143:18-33.

Ittersum, M.K., Cassman, K.G., Grassini, P., Wolf, J., Tittonell, P. and Hochman, Z. 2013. Yield gap analysis with local to global relevance-A review. *Field Crops Research* 143:4-17.

Jat, R., Saharawat, K., Kassam, A.H. 2014. Conservation Agriculture: Global prospects and challenges. CABI, Wallingford.

Lal, R. 2013. Principles of Soil Management. In: Lal, R & Stewart, B. A. (Eds). Principles of Sustainable Soil Management in Agroecosystems, Advances in Soil Science. 2-18. CRC Press.

Lin, M., and P. Huybers. 2012. Reckoning wheat yield trends. *Environmental Research Letters* 7 (2).

Ray, D.K., Mueller, N.D, West, P.C. and Foley, J.A. 2013. Yield Trends Are Insufficient to Double Global Crop Production by 2050. *Plos One* 8 (6).

Ray, D.K., Ramankutty, N., Mueller, N.D., West, P.C. and Foley, J.A. 2012. Recent patterns of crop yield growth and stagnation. *Nature Communications* 3.