Should tillage be an evaluation factor in the breeding program for major cereal and legume crops ?

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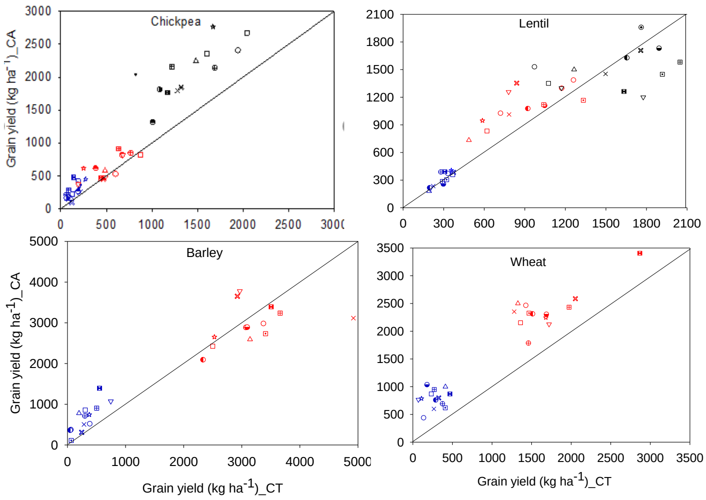
Introduction

Crop yield in the rainfed Mediterranean environment, the hot spot for climate change, is highly affected by rainfall variability, temperature extremes, and low soil organic matter. Conservation agriculture (CA) practices are more than ever needed in rainfed areas due to their potential to minimize climatic risk, reduce soil erosion, and improve soil quality and water availability. Due to minimum soil disturbance and crop residue retention, the soil environment for crop growth and development can differ between CA and conventional tillage practice (CT). However, breeding targets for improving yield performance in conservation agriculture systems remain poorly explored. The objective of this study was to assess the performance of elite genotypes of barley, chickpea, lentil, and bread wheat grown under CA, in the Mediterranean rainfed conditions in Morocco.

Lentil and wheat genotypes under CA

Figure 1. Chickpea, lentil, barley, and wheat genotypes yield under conservation (CA) and conventional (CT) system. On the solid yield is the same in CA and CT. Colors represent years: blue, 2016; red, 2017; and black, 2018. Symbols denote genotypes of respective crop species.



Methodology

The experiment was conducted at the ICARDA research farm in Merchouch (33°36′41′′N, 6°42′45′′W, 390 m a.s.l.), Morocco during the crop growing seasons (December to June) of 2015/2016 to 2017/2018 for four different crops, i.e., **chickpea lentil, barley and bread wheat** in a cereal–legume rotation. The experimental treatment included two tillage methods (no-tillage vs. conventional tillage) and thirteen genotypes of each crop species developed by ICARDA breeding programs and that we selected based on **yield potential and early vigor**. In CT, the land was prepared according to the farmers' practice (3-4 tillage passes before seeding) while in CA, seeds were directly drilled into the undisturbed soil using a zero-till planter. Zero-till seeder (Wintersteiger Plotseed XXL) was used for seeding and basal fertilizer application in both CA and CT plots each year. All crops were seeded on the row spacing of 25 cm with a seeding density of 300 seeds m^{-2} for wheat and barley; 150 seeds m^{-2} for lentil; and 50 seeds m^{-2} for chickpea. All crops were seeded between 15 to 30 December depending on occurrence of rainfall. Cereal received 100 kg N, 22 P and 42 kg K and legume received 30 kg N, 13 kg P and 25 kg K per hectare. Weeds during the growing season were controlled by applying selective pre- and post-emergence herbicide and occasional hand weeding. In CA plots, weeds were killed by the application of 1 L ha^{-1} glyphosate 10- 12 days before sowing.

Results and discussion

The effect of tillage methods and genotype on yield performance of barley, chickpea, lentil, and wheat varies with **rainfall amount and distributions**. Chickpea and wheat produced significantly higher yields under CA (+43% in chickpea and + 62% in wheat), but lentil and barley performed equally under both CA and CT (Fig. 1). Tillage (T) × genotype (G) interaction was more frequent for chickpea and wheat than for lentil and barley. In the dry year of 2016 and 2017, there was significant effect of G × T in chickpea, where top five yielding genotypes produced significantly higher yield under CA than in CT. There was no significant T × G effect for barley suggesting that a **specific breeding focus for tillage may not be efficient for barley**. In wheat, in both years (dry years) all the tested genotypes produced higher yields under CA than CT. The difference in the performance of chickpea genotypes under CT and CA in both dry and wet years, which is also true in wheat, suggested the need to identify genotypes according to tillage methods. Although there were few significant T × G effects for chickpea and lentil their importance might be small as tillage main effects were not significant. Also, the **major cause of variation in grain yield (> 80 % of total variation) was rainfall amount** and distribution and **contribution of tillage x genotype was minimal**. The overall result indicated that a **specific breeding program for CA in lentil, chickpea, wheat, and barley may not be efficient**. Few tillage × genotype interaction, especially in dry years, indicated that with breeding target on increasing tolerance to drought (high yield in dry years) and potential yield (high yield in wet year) can help to improve yield performance of chickpea, lentil, and wheat genotypes in CA system. The growing conditions under on-station experiments are often different from the reality of farmers' fields and their management practices. Hence, it is important to ensure that this breeding process produces genotypes with high yield potential in the wet years and high stability across years, both in CT and CA, to make them attractive to dryland farmers coping against unpredictable variable rainfall.

Conclusión

The major cause of variation in grain yield (> 80 % of total variance), was rainfall amount and distribution and contribution of tillage x genotype was minimal. The overall result indicated that a specific breeding program for CA in lentil, chickpea, wheat, and barley may not be efficient. Existence of trade-offs between high yield on good years and risk of yield reduction in dry years in both tillage systems suggest that a breeding effort for the development of drought-tolerant and high-yielding genotypes is needed. **Integrating trade-off analysis between yield potential and stability in a rainfall gradient in both CT and CA in the national certification scheme of varieties may be more efficient than developing breeding programs for each type of tillage system**.

For detail: Devkota, M., S. B. Patil, Shiv Kumar, Z. Kehel and J. Wery. 2021. Performance of elite genotypes of barley, chickpea, lentil, and wheat under conservation agriculture in Mediterranean rainfed conditions. Experimental Agriculture, 1-18.

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Online Congress Bern, Switzerland
June 21st-23th, 2021