Root distribution pattern of some lentil and chickpea genotypes under conventional and no-tillage systems in a Moroccan dryland region

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Introduction

Conservation agriculture (CA), comprising a minimum and no tillage systems (NT), occupies 9% of the global arable land (Kassam et al., 2012). It was introduced as a promising water-conserving technology in drylands regions characterized by water scarcity and drought hazards (Mrabet, 2007).

Shifting to NT system involves several changes in the plant environment; these changes affect the plant-soil continuum. Mainly plant root distribution pattern, the primary driver and sensor of soil physical state (Fiorini et al., 2018). The contribution of root traits (stem length, taproot length and the number of lateral roots…) to water and nutrient uptake is more essential in water-limited environments (Gaur et al., 2008; Idrissi et al., 2015 Priya et al., 2021).

Lentil (*Lens culinaris Medik*.) and chickpea (*Cicer aeritinum L*.) are two food legumes that play an important role in rotations and improving soil quality (Kumar et al., 2011; Van Kessel and Hartley, 2000). Over 90% of crop legume roots are distributed in 0-60 cm of soil profile. The most significant percentage occurs in the top 20 cm soil (Bandyopadhyay, 2014). In addition, adopting NT system with suitable genotypes can be more resilient in variable rainfed conditions (Devkota et al., 2021). This strategy however needs much more knowledge about responses of plants to the tillage system and genotype interaction. This knowledge will provide opportunities for crop selection and breeding program for NT. To evaluate this, the current study aims to assess the effect of NT and CT systems on different root properties under some lentil and chickpea genotypes.

Methodology

Site description

The experiment was carried out in the 2020-2021 season. The experiment site is located at the Sidi El Aidi experimental station of the National Institute of Agricultural Research, Settat-Morocco (N: 33.167 and W: 7.4). The region's climate is semi-arid, with an average annual rainfall of 297 mm and min and max temperature of 0 and 33°C, respectively.

Crop management

Sowing was carried out on 25 November, 2020. Four lentil genotypes (L24, "Nilou" Gara, Bakria, and LNYT19) and two winter chickpea genotypes (Local Chaouia and Moubarak) were tested under two tillage systems, conventional (CT) and no-tillage (NT).

Crop measurements

Six plants from each treatment were randomly selected. The assessed root properties are the maximum depth reached by the roots (RL), the total dry weight of root (RB), root-to-shoot ratio (RSR), and specific root length (SRL). The statistical analysis was done by GENSTAT 15th edition (VSN International, Hemel Hempstead, UK (2011)).

Results and discussion

Variance analysis

Variance analysis of results of lentil crop showed significant effect of tillage system on RL, significant effect of genotype on all root traits studied, and significant interaction for RB trait.

For chickpea crop, Variance analysis of NT/CT cropping system showed no-significant effect of tillage system, genotype and their interaction on all traits.

	RB	RL	SRL	RSR
Source of variation	Lentil (p_{value})			
Tillage (T)	0.339 ns	0.007 **	0.109 ns	0.042 *
Genotype (G)	< 0.001 ***	< 0.001 ***	0.017 **	< 0.001 ***
Interaction (T x G)	0.043 *	0.179 ns	0.581 ns	0.292 ns
Source of variation	Chickpea (p_{value})			
Tillage (T)	0.291 ns	0.962 ns	0.744 ns	0.177 ns
Genotype (G)	0.626 ns	0.418 ns	0.486 ns	0.129 ns
Interaction (T x G)	0.056 ns	0.371 ns	0.161 ns	0.964 ns

ns: not significant; *: significant at p<0.05; **: highly significant at p<0.01; ***: very highly significant at p<0.001.

Tillage system effect on root properties of different lentil genotypes

Lentil L24 genotype produced more RB and RL compared to other genotypes. Likewise, some genotypes modified significantly their root traits in response to tillage system. For instance, RB was increased by 25%, 3% and 35%, for "Nilou" Gara, Bakria and LNYT19 genotypes, respectively, under NT compared to CT. And 6%, 28% and 23% of increase was recorded also for RL of the same genotypes. While, 25% and 32% of SRL increase was recorded for L24 and Bakria genotypes. In addition, the three genotypes L24, Gara and Bakria have increased their RSR in response de no-tillage system.

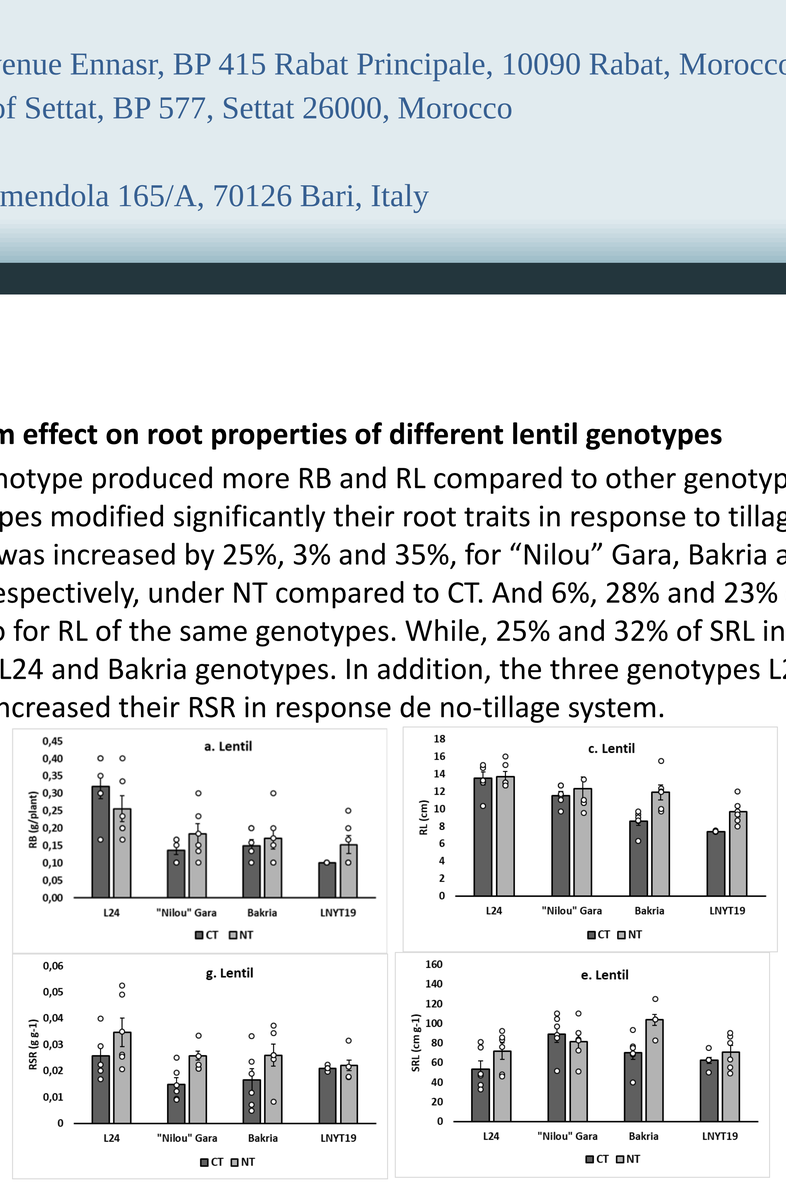

Figure 1. Root traits (RB, RL, SRL, RSR) of lentil genotypes (a, c, g and e) under conventional (CT) and no-tillage (NT) systems

Tillage system effect on root properties of different chickpea genotypes

For chickpea crop, some genotypes improved some root traits in response to no-tillage system. For instance, Local Chaouia increased SRL by 19% and RSR by14%, under NT compared to CT. And Moubarak genotype increased RB by 18%, RL by 2% and RSR by 21%.

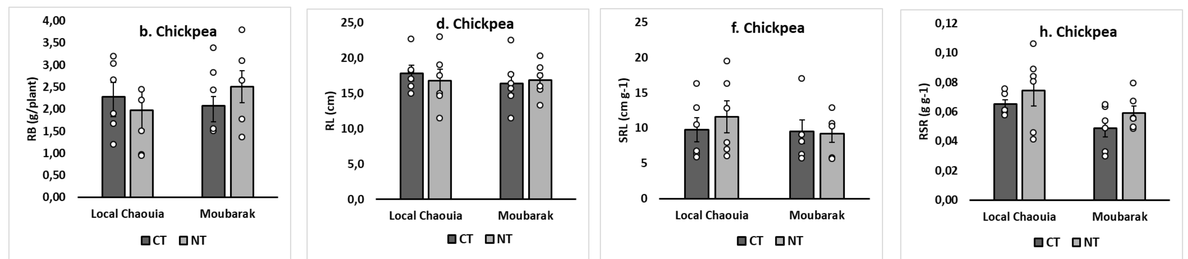

Figure 2. Root traits (RB, RL, SRL, RSR) of chickpea genotypes (b, d, f and h) under conventional (CT) and no-tillage (NT) systems

Conclusion

- Importance of significant interaction effect between tillage system and genotype
  - Importance of incorporating significant root traits in breeding programs
    - Importance of developing breeding programs for each tillage system
      - The economic utility of exploring the genetic diversity in root traits
        - Developing high productive cultivars
          - Adaptation to current and future variable climatic conditions

✓ **Ensuring Global food demand**

References

Bandyopadhyay, P. K. Root distribution pattern of pulses in response to water availability. *Resource conservation technology in pulses,* ***2014***, p. 483-493.

Devkota, M.; Patil, S. B.; Kumar, S.; Kehel, Z.; Wery, J. Performance of elite genotypes of barley, chickpea, lentil, and wheat under conservation agriculture in Mediterranean rainfed conditions. *Experimental Agriculture,* ***2021***, vol. 57, no 2, p. 126-143. https://doi.org/10.1017/S0014479721000107

Fiorini, A., Boselli, R., Amaducci, S., & Tabaglio, V. Effects of no-till on root architecture and root-soil interactions in a three-year crop rotation. *European Journal of Agronomy,* ***2018***, vol. 99, p. 156-166. https://doi.org/10.1016/j.eja.2018.07.009

Gaur, P. M.; Krishnamurthy, L.; Kashiwagi, J. Improving drought-avoidance root traits in chickpea (Cicer arietinum L.)-current status of research at ICRISAT. *Plant Production Science,* ***2008***, vol. 11, no 1, p. 3-11. https://doi.org/10.1626/pps.11.3

Idrissi, O.; Houasli, C.; Udupa, S. M.; De Keyser, E.; Van Damme, P.; De Riek, J. Genetic variability for root and shoot traits in a lentil (Lens culinaris Medik.) recombinant inbred line population and their association with drought tolerance. *Euphytica,* ***2015***, vol. 204, p. 693-709. https://doi.org/10.1007/978-90-481-3709-113

Kassam, A. H.; Friedrich, T.; Derpsch, R.; Lahmar, R.; Mrabet, R.; Basch, G.; González-Sánchez, E. J.; Serraj. R. Conservation agriculture in the dry Mediterranean climate. *Field Crops Research,* ***2012***, vol. 132, p. 7-17. https://doi.org/10.1016/j.fcr.2012.02.023

Mrabet, R. Conservation agriculture in Morocco: a research review. In : The Proceedings of the International Workshop on Conservation Agriculture for Sustainable Land Management to Improve the Livelihood of People in Dry Areas. ***2007***. p. 183-208.

Priya, S.; Bansal, R.; Kumar, G.; Dikshit, H. K.; Kumari, J.; Pandey, R.; ... & Kumar, A. Root trait variation in lentil (Lens culinaris Medikus) germplasm under drought stress. *Plants,* ***2021***, vol. 10, no 11, p. 2410. https://doi.org/10.3390/plants10112410

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