THE ROLE OF GREEN MANURE-BASED CROP ROTATION SYSTEMS IN ENHANCING WATERMELON PRODUCTIVITY IN RAINFED AGRICULTURAL AREAS

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Abstract

This study evaluated the influence of crop rotation systems involving cereal, legume, green manure, and melon crops on productivity under rainfed conditions. The yields of winter wheat, chickpea, and watermelon cultivated after different green manure crops were analyzed. The results showed that green manure treatments significantly increased watermelon yield compared with the conventional fallow treatment. The highest yield (192.1 centners ha^{-1}) was obtained after a mixture of forage pea and triticale used as green manure, exceeding the control treatment by 11.9 centners ha^{-1}. The forage pea + barley mixture and forage pea alone produced average yields of 186.4 and 181.6 centners ha^{-1}, respectively. The positive effect of green manure crops was associated with improved soil fertility, enhanced biological nitrogen accumulation, increased organic matter content, better soil structure, and improved soil moisture conservation. The findings indicate that integrating legume–cereal green manure mixtures into crop rotation systems is an effective agroecological practice for improving soil productivity and increasing watermelon yield in rainfed farming areas.

Keywords

Rainfed agriculture, crop rotation, green manure crops, forage pea, triticale, barley, chickpea, winter wheat, watermelon, yield, soil fertility, biological nitrogen, organic matter, moisture conservation, agroecological efficiency.

Introduction: Rainfed agriculture plays a crucial role in ensuring food security in arid and semi-arid regions where irrigation water is limited or unavailable. In such environments, crop productivity is highly dependent on precipitation patterns, soil moisture retention capacity, and inherent soil fertility. Therefore, improving soil quality and optimizing agronomic practices, particularly crop rotation systems, is essential for achieving stable and sustainable yields (FAO, 2017).

Recent studies have demonstrated that crop rotation is an effective strategy for enhancing soil physical, chemical, and biological properties. Leguminous crops contribute to soil fertility through biological nitrogen fixation, while cereal crops improve soil structure and organic matter dynamics, thereby creating a more favorable agro-ecological environment for subsequent crops (Lal, 2015; Giller et al., 2016). These combined effects result in improved nutrient availability and increased crop productivity over time.

Green manure crops have gained increasing attention as an environmentally sustainable practice for improving soil fertility and structure. Their incorporation into crop rotation systems enhances soil organic matter content, stimulates microbial activity, and improves soil water-holding capacity (Drinkwater & Snapp, 2007). In particular, leguminous green manures such as forage pea (*Pisum sativum*) enrich the soil with biologically fixed nitrogen, while cereal-based green manures such as barley (*Hordeum vulgare*) and triticale (× *Triticosecale*) contribute to soil structural improvement and erosion reduction (Khan et al., 2018).

Several studies have reported that integrating green manure crops into cropping systems not only improves soil fertility but also enhances water-use efficiency, which is especially important in rainfed agricultural systems (FAO, 2020). Under moisture-limited conditions, improved soil water retention directly contributes to better crop establishment, growth, and yield stability.

Watermelon (*Citrullus lanatus*) is a widely cultivated melon crop that is moderately drought-tolerant; however, its yield is strongly influenced by soil fertility and moisture availability. Research indicates that watermelon grown in soils enriched with organic matter and biologically active residues exhibits improved vegetative growth, fruit set, and yield performance (Maynard & Hochmuth, 2007). Therefore, soil improvement practices are particularly important for optimizing watermelon production in rainfed systems.

Although previous studies have confirmed the benefits of crop rotation and green manure application, limited research has focused on the combined effect of legume–cereal green manure mixtures under rainfed conditions, particularly in relation to watermelon productivity. The comparative effectiveness of forage pea, barley, and triticale as single and mixed green manure systems also requires further investigation under local agro-climatic conditions.

In this context, the aim of this study is to evaluate the impact of green manure-based crop rotation systems on soil fertility and watermelon yield under rainfed agricultural conditions, with particular emphasis on identifying the most effective green manure combinations for sustainable production.

Results and discussion: The results of the experiment demonstrated that crop rotation systems in rainfed areas have a significant impact on crop productivity. The obtained data revealed clear differences in watermelon yield depending on whether the

preceding crops were cereals, legumes, or green manure crops. In particular, higher yield values were recorded in treatments where green manure crops were applied, which can be explained by improved soil fertility and enhanced soil moisture retention capacity.

In the first treatment, winter wheat yield ranged from 12.1 to 12.2 centners per hectare across replications, with an average of 12.2 c/ha. The minimal variation between replications indicates a high level of experimental reliability. Although wheat showed relatively stable performance under rainfed conditions, its yield was highly dependent on precipitation and the available soil moisture reserves.

In the second treatment, chickpea yield varied between 7.2 and 10.4 c/ha, with an average of 8.9 c/ha. The noticeable variation in yield among replications reflects the high sensitivity of leguminous crops to moisture availability under rainfed conditions. However, chickpea plays an important agronomic role due to its ability to fix atmospheric nitrogen, thereby improving soil fertility for subsequent crops. In addition, its root system enhances soil biological activity and increases organic residue content.

In the next treatment, watermelon grown after deep cross-plowing at a depth of 30 cm in fallow soil produced yields ranging from 174.3 to 186.7 c/ha, with an average yield of 180.2 c/ha. Although this treatment was based on conventional agronomic practices, relatively higher yields were achieved due to improved soil water infiltration and moisture retention resulting from deep tillage. Deep plowing helped to loosen compact soil layers and created favorable conditions for deeper root development.

Watermelon grown after a green manure mixture of forage pea and barley produced an average yield of 186.4 c/ha. This yield was 6.2 c/ha higher than that of the fourth treatment, demonstrating the positive effect of green manure crops on soil fertility improvement. Forage pea enriched the soil with biologically fixed nitrogen, while barley root residues improved soil structure. As a result, the content of organic matter increased

and soil moisture retention capacity improved, which in turn accelerated both vegetative and generative development of watermelon plants, leading to higher yields.

The highest yield was observed in the sixth treatment, where watermelon was grown after a green manure mixture of forage pea and triticale. In this treatment, yield ranged from 187.7 to 194.6 c/ha, with an average of 192.1 c/ha. This result was 11.9 c/ha higher than that of the fourth treatment and 5.7 c/ha higher than that of the fifth treatment. The deep and well-developed root system of triticale improved the physical properties of the soil, while forage pea enriched the soil with biologically fixed nitrogen, enhancing the nutrient availability for the subsequent crop. Furthermore, the incorporation of green manure biomass into the soil stimulated microbial activity and improved overall soil fertility.

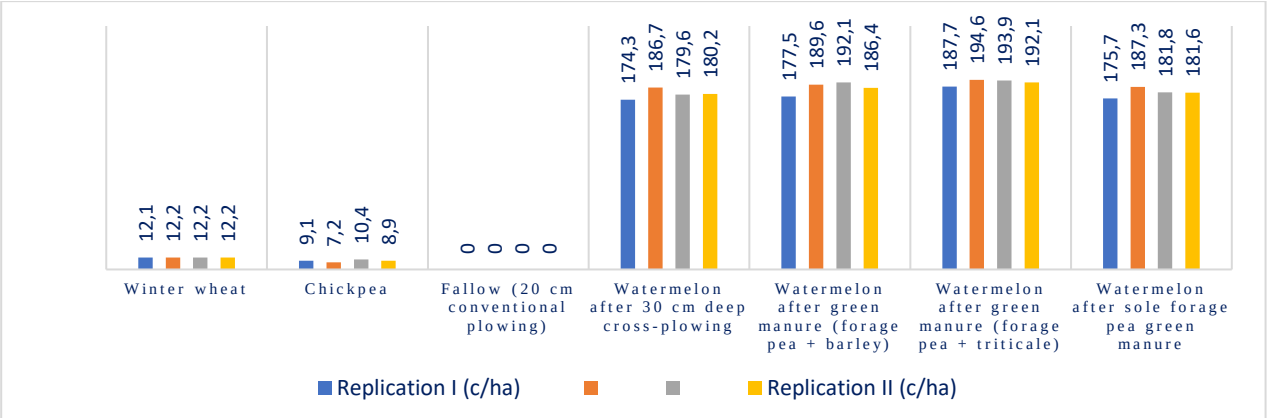
Watermelon grown after sole forage pea green manure produced an average yield of 181.6 c/ha. Although this treatment showed results close to the fourth treatment, it was lower than those of the fifth and sixth treatments. This indicates that mixed green manure systems are more effective than single-species green manure applications. In particular, the combination of leguminous and cereal green manure crops plays a crucial role in improving both soil nutrient status and physical properties.

Figure – Watermelon after green manure (forage pea + triticale)

The results clearly indicate that all treatments involving green manure crops resulted in higher watermelon yields compared to the control and conventional treatments. This improvement can be attributed to increased soil organic matter content, enhanced soil moisture retention, and improved nutrient cycling. In rainfed areas, where water scarcity is the main limiting factor, agro-technologies that improve soil water-holding capacity are of critical importance.

The relatively small differences in yield among replications confirm the reliability of the experiment. Statistically, the observed yield differences highlight the significant role of green manure crops in crop rotation systems. In particular, the forage pea and triticale mixture proved to be the most effective green manure treatment under rainfed conditions.

Effect of Crop Rotation System on Yield of Cereals, Legumes, Green Manure and Watermelon Crops in Rainfed Areas



Overall, the results of this study demonstrate that the inclusion of green manure crops in crop rotation systems is an effective agro-technological approach for improving soil fertility, optimizing moisture utilization, and increasing watermelon yield in rainfed agricultural areas. In particular, the use of a forage pea and triticale mixture is recommended as an environmentally and economically efficient practice.

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