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Dissertation for obtaining a doctorate degree in the field of crop ecology

Title

Effect of tillage systems combined with residue management and planting pattern on prodution, energy budgeting and emergy based indices of sesame (*Sesamum indicum* L.)

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Abstract
The use of conservation tillage and crop residue retention in soil can have a significant impact on the production and yield of crops. Proper tillage practices and crop residue retention are among the essential components of sustainable agriculture systems that play a crucial role in the sustainability of agricultural production systems. The planting pattern represents the geometric position of plants on rows, which can be modified by changing the row spacing, plant spacing, and arrangement of plants on the planting rows. To investigate the effect of tillage system on sesame production under the influence of crop residue and planting pattern, a split-factorial experiment was conducted in a randomized complete block design with three replications for two cropping seasons (2019-2020 and 2020-2021) in the farm of Jiroft Agricultural Research Center and Natural Resources. The main factor in this study was tillage system with three levels: no-till, reduced tillage, and conventional tillage. The sub-factor was wheat straw residue incorporation with three levels (5, 30, and 60%) and planting pattern with two levels (conventional and zigzag). Wheat straw residues in the second year were the same as the remaining residues in the first year. The studied characteristics were number of capsules per plant, number of seeds per capsule, thousand seed weight, biological yield, harvest index, chlorophyll a and b, total chlorophyll, carotenoids, and oil percentage and yield. Oil percentage was measured using the solvent extraction method and Soxhlet apparatus. Chlorophyll a, b, and carotenoids were measured before flowering from the green surface using the Arnon method (1967). The collected data were analyzed using the SAS statistical software (version 9.1). Duncan's multiple range test was used to compare the means of the data at the 5% probability level. The effect of planting pattern on chlorophyll a was significant, with the highest chlorophyll a obtained from the zigzag planting pattern. The interaction of year × tillage × residue percentage × planting pattern was significant for number of capsules per plant, number of seeds per capsule, thousand seed weight, biological yield, harvest index, chlorophyll b, total chlorophyll, carotenoids, and oil percentage. The results showed that the highest seed yield (1629.92 kg/ha), biological yield (6137.3 kg/ha), thousand seed weight (71.5 g), and number of seeds per capsule (75.85) were observed in the second year under conventional tillage with 60% residue application and zigzag planting pattern, and the lowest were observed under no-till with 5% residue application and conventional planting pattern. Under reduced tillage, total chlorophyll increased with the application of 30 and 60% residues and zigzag planting pattern. The increase in oil percentage was observed under conventional tillage with 60% residue application and conventional planting pattern. Based on the results, it can be concluded that the use of conservation tillage systems with 30-60% residue retention and zigzag planting pattern, in addition to reducing environmental pollution, can play an effective role as an appropriate method for obtaining higher sesame yield in the study area. The results of the energy analysis demonstrated that the no-tillage cultivation method generally exhibited superior energy efficiency compared to the other two methods. However, all cultivation systems investigated were highly dependent on non-renewable energy sources, which imposes considerable environmental pressure. The analysis of energy indicators revealed that the highest energy consumption was attributed to the fuel used by agricultural machinery, while the lowest energy consumption was associated with seed input. Additionally, the no-tillage system recorded the lowest total energy consumption, whereas conventional tillage methods exhibited the highest energy demand. Energy efficiency indices also indicated that no-tillage was the most energy-efficient cultivation method. In the emergy analysis section, the results indicated that reduced tillage generally achieved the highest environmental performance compared to both no-tillage and conventional tillage systems. Nevertheless, all systems displayed a significant reliance on non-renewable resources, particularly groundwater and soil organic matter. Overall, the findings underscore the necessity for more sustainable water management practices, strategies aimed at improving soil health, and a holistic approach to sesame cultivation that incorporates both environmental sustainability and economic viability.

Keywords: Conservation agriculture, reduced tillage, seed yield, zigzag planting