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Article title	Foliage-sprayed nano-chitosan-loaded nitrogen boosts yield potentials, competitive ability, and profitability of intercropped maize-soybean
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Abstract

The progressive reduction of synthetic agrochemical fertilizers is one of the key factors in the shift from conventional agriculture to sustainable farming. Nitrogen (N) is the ruling element in the development of agricultural production, but its use in the mineral form or its excessive use causes several environmental issues. Since the release of N nanocomposites coincides with their uptake by crops, N loss reduces while enhancing plant uptake due to nano fertilizers application. Additionally, an intercropping legume with cereal as an eco-friendly pattern could improve and rationalize the nitrogenous inputs. Therefore, a two-year field trial was conducted to determine the efficacy of nano-chitosan-loaded N (CS-NNPs) for saving mineral N amounts applied in maize-based on maize-soybean intercropping and enhancing land productivity. In a randomized split-plot design in three replicates, three intercropping patterns, in addition to the sole crops, and three N levels were implemented. Intercropping involved three intercrop configurations [planting maize rows (M) alternated with soybean rows (S) in patterns of 4M:2S, 2M:4S, and 3M:3S)], in addition to planting sole maize crop (SMC) and sole soybean crop (SSC). N fertilization treatments included adding 288 kg N ha^{-1} (MN100%) and two levels of CS-NNPs composite involving 216 kg N ha^{-1} + 2 foliar sprays of CS-NNPs (MN75%+2CS-NNPs), and 144 kg N ha^{-1} + 3 foliar sprays of CS-NNPs composite (MN50%+3CS-NNPs). Under the tested treatments, the agronomic traits, intercropping indices, and economic benefits were estimated. Findings revealed that the application of SMC × MN75%+2CS-NNPs, followed by 4M:2S × MN75%+2CS-NNPs showed the highest growth, biological yield, and grain yield of maize. The interaction of SSC × MN75%+2CS-NNPs, followed by 2M:4S × MN75%+2CS-NNPs resulted in the highest seed yield components, biological yield, straw yield, and seed yield of soybean. Application of 2M:4S × MN100%, 2M:4S × MN50%+3NNPs, and 3M:3S × MN100% recorded the maximum total land equivalent ratio. While applications of 2M:4S × MN100%, 2M:4S × MN75%+2CS-NNPs, and 3M:3S × MN100% achieved the highest land equivalent coefficient, land-use efficiency, area time equivalent ratio, and percent yield difference. Likewise, both interactions of 2M:4S × MN75%+2CS-NNPs and 3M:3S × MN100% recorded the highest system productivity index. Better yield advantage of maize-soybean intercrop compared with the monocrop since total actual yield loss values were positive and higher than zero in all interactions of intercropping pattern × N fertilization. Fertilizing maize with MN50%+3CS NNPs grown under the 2M:4S pattern had the highest positive aggressivity values. The productivity shortfall accompanying the 25% N reduction was compensated by the application of CS-NNPs. Thus, N applied to the maize intercropped with soybeans can be rationalized. This undoubtedly has a good economic payoff for the maize growers with the conservation of the agricultural environment. In maize production systems, it is advisable to fertilize the plants using 216 kg instead of 288 kg nitrogen ha^{-1} when nano chitosan-loaded nitrogen composite twice (0.48 kg nitrogen ha^{-1}) applied.