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SYNERGISTIC EFFECTS OF NANO-EMULSION BIOFERTILIZER AND ORGANIC MANURES ON AGRONOMIC TRAITS OF CHICKPEA

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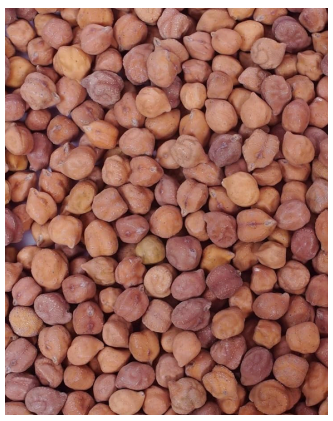
INTRODUCTION



Sustainable intensification of agriculture has become essential to meet rising food demand while conserving natural resources. Improving nutrient management strategies that enhance crop productivity, optimize resource use efficiency, enrich soil organic carbon, and maintain ecological balance is fundamental to achieving long-term sustainability. Pulses, particularly chickpea (*Cicer arietinum* L.), play a critical role in sustainable cropping systems due to their high protein content, nitrogen-fixing ability, and contribution to soil fertility.

To counter nutrient depletion and maximize crop response, integrated nutrient approaches combining organic manures, chemical fertilizers, and innovative nano-based foliar inputs are gaining attention. Nano fertilizers and nano-bioformulations offer precise nutrient delivery, improved absorption, and reduced losses. Against this backdrop, the present study was conducted to identify nutrient management combinations that enhance chickpea growth, physiological performance, and yield under semi-arid conditions of western ghats of Tamil Nadu, India.

METHODOLOGY

The field experiment was conducted during the *Rabi* 2023–2024 season in the western ghats region of Tamil Nadu, India, characterized by a semi-arid tropical climate. The study was laid out in a factorial randomized block design with two factors comprising soil nutrient treatments and foliar nutrient sprays.

Soil nutrient treatments

S_1 – 100% recommended dose of fertilizer
S_2 – 75% recommended dose of fertilizer + farm yard manure at 10 t ha^{-1}
S_3 – 75% recommended dose of fertilizer + vermicompost at 5 t ha^{-1},
S_4 – 50% recommended dose of fertilizer + farm yard manure at 10 t ha^{-1}
S_5 – 50% recommended dose of fertilizer + vermicompost at 5 t ha^{-1}

Foliar treatments

F_1 – nano di-ammonium Phosphate (two sprays at 2% at 30 and 45 days after sowing)
F_2 – nano urea (two sprays at 2% at 30 and 45 days after sowing)
F_3 – nano emulsion biofertilizer (two sprays at 10 ml L^{-1} at 30 and 45 days after sowing).

Standard agronomic practices were followed, and data were recorded on growth parameters, physiological traits, yield attributes, grain yield, and stover yield across different crop growth stages.

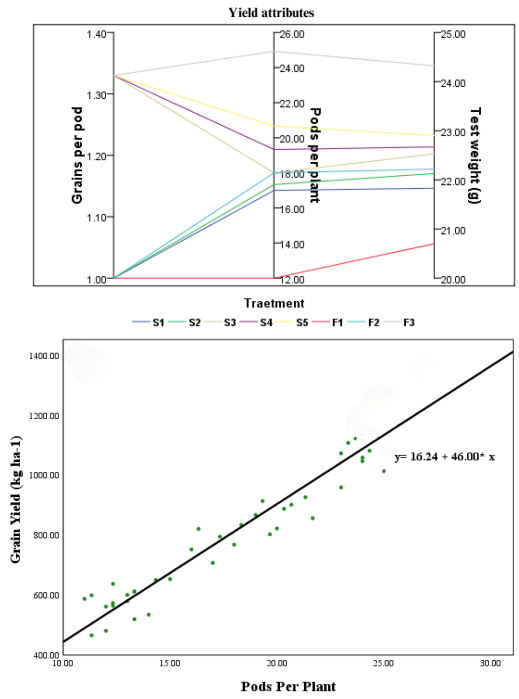
RESULTS

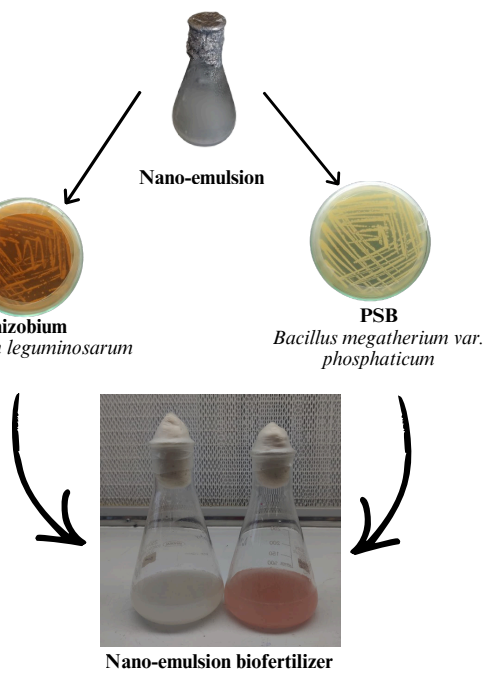
The findings revealed that soil application of 50% RDF in combination with vermicompost at 5 t ha^{-1} (S_5), together with foliar application with nano emulsion biofertilizer (F_3) at 30, 45, and 60 days after sowing and at harvest, exerted a significant positive effect on growth parameters, physiological traits, and yield components.

There is a significant increase in soil application (S_5), 50% RDF + vermicompost at 5 t ha^{-1}, resulting in a grain yield of 705.38 kg ha^{-1} and 1279.66 kg ha^{-1}.

Similarly, the foliar application (F_3) of nano-emulsion biofertilizer resulted in grain yields of 913.72 kg ha^{-1} and 1736.00 kg ha^{-1}.

Across the interactions, the highest productivity was achieved with the combined application of 50% RDF and vermicompost at 5 t ha^{-1}, along with Nano-emulsion biofertilizer (S_5F_3), which recorded a grain yield of 1111.60 kg ha^{-1} and a stover yield of 2501.10 kg ha^{-1}.





DISCUSSION

The soil application of RDF with vermicompost provides both inorganic and organic nutrient sources, leading to synergistic effects on chickpea growth and yield. RDF supplies sufficient available N, P, and K, meeting the crop's critical nutrient demand. Vermicompost enhances soil physical properties (structure, porosity, and moisture retention) and improves microbial activity. Together, this combination ensures balanced nutrition, stronger root development, improved vegetative growth, and higher yield attributes, making it an effective strategy for sustainable chickpea production.

Nano Emulsion Biofertilizer application boosted chickpea grain yield by 111% when compared to un-inoculated, yielding a maximum of 1.73 tons ha^{-1}. This can be explained by the fact that inoculations of Nano Emulsion Biofertilizer enhance symbiotic Nitrogen fixation and N nutrition, which in turn improve assimilate production, thereby promoting growth, which can then be re-translocated for the formation of yield components, such as increasing the number of seeds per pod.

The combined application of soil and foliar treatments enhanced chickpea growth, with soil application improving root development, microbial activity, and nutrient availability, while foliar spray boosted nutrient translocation, chlorophyll synthesis, and metabolic efficiency. This integrated approach accelerated vegetative growth, promoted pod and seed development, and significantly increased grain yield.

CONCLUSION

The study demonstrated that integrating organic manures with reduced doses of chemical fertilizers and supplementing them with nano-based foliar sprays significantly enhances chickpea growth, physiological performance, and yield.
The treatment combination of 50% RDF + vermicompost at 5 t ha^{-1} with nano-emulsion biofertilizer proved to be the most effective, achieving the highest grain and stover yields under the conditions of western ghats of Tamil Nadu, India.

These findings confirm that nutrient-use efficiency and productivity can be improved through sustainable nutrient management strategies that combine soil organic amendments and advanced nano-formulated foliar inputs. This integrated approach not only supports high yield potential but also contributes to long-term soil health and environmental sustainability.

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