Original Research Article

Effect of integrated nutrient management practices on growth and yield of chickpea under different chickpea-based cropping systems in western Rajasthan

Comment [Mu1]: Please change the title to "**Impact of integrated nutrition management techniques on chickpea yield and growth in various systems of chickpea-based farming in western Rajasthan"**

Abstract

A field experiment was carried out during rabi season of 2020-21 in Pearl millet – Chickpea, Clusterbean + Sesamum (6:2) - Chickpea system to study the effect of nutrient management practices ((1.) Recommended fertilizers (100% RDF) (2.) 75% RDF + 5 t FYM (3.) 75% RDF + 5 t FYM + Biofertilizers (4.) 50% RDF + 5 t FYM + Biofertlizers + Crop residue) on crop growth, yield attributes and yield of chickpea.The results of the study revealed that the integration of 75% of the Recommended Dose of Fertilizers (RDF) with farmyard manure (FYM) and biofertilizers (BF) significantly enhanced chickpea growth and yield. This improved plant height, dry matter accumulation, branch number, and pod count, reflecting the synergistic effect of combining organic and inorganic inputs. This approach not only boosted the seed yield by 22.11% compared to the 75% RDF + 5t FYM but also matched the performance of the 100% RDF, offering a more sustainable cultivation strategy. These findings underscore the importance of adopting integrated nutrient management practices in chickpea cultivation, particularly in the arid region of western Rajasthan. Such practices have the potential to improve crop performance, increase yields, and promote sustainable agriculture in the area.

Keywords: Cropping system, biofertilizers, FYM, western arid zone and chickpea

Introduction

Chickpea (*Cicer arietinum* L.) is a vital pulse crop in India that is renowned for its significant contribution to nutrition and food security.It is a key source of protein, particularly in vegetarian diets, and is rich in essential vitamins and minerals (Wallace *et al.*, 2016).Chickpeas are versatile in culinary uses and form an integral part of various traditional Indian dishes. In the 2021-22 agricultural year, India had an extensive cultivation area of 10.74 million hectares, resulting in a total production of 13.54 million tons and a national average productivity of 1261 kilograms per hectare. Rajasthan, a state in India, also played a role in these agricultural achievements, with a cultivation area of 2.3 million hectares, producing 2.68 million tons, with a productivity of 1167 kilograms per hectare (www.indiastat.com 2021-22).

The Western part contributes to a significant area of chickpeas in Rajasthan state.The region has a unique set of geographical and climatic conditions. The semi-arid climate, characterized by low rainfall and high temperature variations, coupled with predominantly loamy sand to sandy soils, presents a challenging environment for crop production (Bhati *et. al.*, 2017). These conditions require specific agricultural practices to ensure successful cultivation.

Chickpea cultivation in Western Rajasthan is confronted with several distinct challenges that impede its sustainable production. One of the primary issues is water scarcity, which is a consequence of the region's semi-arid climate and erratic rainfall patterns (Naorem*et. al.*, 2023).Therefore, soil fertility is a significant challenge. The loamy sand and sandy soils prevalent in Western Rajasthan are often low in essential nutrients and organic matter (Sehgal and Sohan, 1992). This lack of fertility can lead to reduced crop yields and inferior quality of produce.Additionally, these soils have a poor water retention capacity, further exacerbating the effects of water scarcity.

Comment [Mu2]: Soil rather, please.

Therefore, nutrient management is crucial in these regions where soils often lack essential nutrients. Effective nutrient management strategies can significantly enhance chickpea yield and quality in these areas. This involves the judicious use of fertilizers, organic amendments, and other soil health-improving practices tailored to the specific needs of the crop and local soil conditions. By optimizing nutrient availability, farmers can not only improve crop yields but also contribute to the sustainability of agricultural practices in these challenging environments.Biofertilizers, such as rhizobium and phosphate solubilizing bacteria (PSB), assume countless importance on account of their dynamic role in N_2-fixation and P solubilization.The use of rhizobium and PSB has been shown to improve chickpea growth and yield parameters (Rudresh *et al*. 2005). The FYM material has excellent structure, porosity, aeration, drainage, and moisture-holding capacity (Ismail 2005).FYM plays a vital role in dictating biochemical cycles, as it supports the growth and activity of soil microflora. It enhances the colonization of Mycorrhizae, Rhizobium, Azotobacter and Azospirillum which in turn improve the nitrogen (N) as well as phosphorus (P_2O_5) supply and other micronutrients (Zn, Fe, Cu, Mn) besides imparting the resistance to plant against various soil borne diseases and insect pest attack which ultimately improves the grain yield. Vasanthi and Subramanian (2004) observed that the highest grain yield and crude protein N, P, and K concentrations and uptake were recorded with the application of vermicompost at 2 t ha^{-1} along with 100 percent recommended levels of N, P, and K. Maheteleet *al.* (2011) reported that the addition of FYM at 10 t ha^{-1} to soil improved the supply of plant-available nutrients and brought about a favorable soil environment, which ultimately increased the nutrient and water holding capacity of the soil for a longer period and improved the plant dry matter.Similarly, Dhegavathet *al.* (2021) reported that all growth parameters, that is, plant population, plant height, dry matter production, total number of pods, test weight, seed yield, stover yield, and harvest index, were significantly higher under soybean residue incorporation with the treatment that received 100% RDF. However, it was found on par to treatment of 75% RD of N plus biofertilizers and 75% RD of P plus biofertilizers along with 50% RD of N plus biofertilizers and 75% RD of P plus biofertilizers.

Despite extensive research, gaps remain, particularly regarding integrated nutrient management (INM) in the loamy sand soils of Western Rajasthan. Most studies have focused on generic nutrient management practices without tailoring them to the unique soil and climatic conditions of this region.There is a need for more localized research examining the effectiveness of INM in enhancing chickpea yield under semi-arid conditions.

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Materials and Methods

A field experiment was conducted during Rabi 2020-21 at ICAR-Indian. Institute of Pulses Research, Regional Research Centre, Bikaner (Rajasthan).The soil of the experimental field was loamy sand in texture, low in organic C (0.10 %) and nitrogen (88 kg ha^{-1}), and medium in available phosphorus (15.03 kg ha^{-1}) and potassium (195 kg ha^{-1}). The soil was low with respect to available Fe (3.15 ppm) and available Mn (1.78 ppm), and available Zn (0.32 ppm) whereas it was high available Cu (0.20 ppm). The soil was alkaline (8.10 pH).The experiment was laid out in a split-plot design with three replicates.There were eight treatment combinations comprising two cropping systems:Pearl millet – Chickpea, Clusterbean + Sesamum (6:2) - Chickpea system and four treatments of nutrient management practices ((1.) Recommended fertilizers (100% RDF) (2.) 75% RDF + 5 t FYM (3.) 75% RDF + 5 t FYM + Biofertilizers (4.) 50% RDF + 5 t FYM + Biofertlizers+ Crop residue).Pure chickpea GNG-2144 seeds were used in the experiment.Sowing was performed manually in line in the previously opened furrows 30 cm apart using a seed rate of 80 kg ha^{-1}.Minor gap filling of chickpeas was carried out 10 days after sowing to maintain a full plant population, and thinning was carried out 20 days after sowing, keeping healthy plants.Fertilizer was applied as per the treatments.Periodic data on plant height and dry matter accumulation were recorded at different growth stages, whereas data related to yield attributes were recorded at the physiological maturity stage.Grain yields were recorded on a plot basis and converted into q ha^{-1}.

Comment [Mu4]: "Biofertilizers", please

The collected data were statistically analyzed according to the analysis of variance procedures appropriate for a split-plot design.Means werecompared using the least significant difference(LSD) test at $P \leq 0.05$, based on a significant F-test (Gomez and Gomez, 1984).

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Result and Discussion

Growth parameters

Data related to chickpea plant height at various intervals are presented in Table 1.Plant height was found to be identical at 30 and 60 DAS for chickpea grown after the pearl millet and cluster bean +sesamum treatments.The Clusterbean+sesamum-chickpea system had the highest plant height at both 90 DAS (41.52 cm) and harvest (46.14 cm), indicating that this combination might be better for plant growth.

Plants treated with a 100% recommended dose of fertilizers (RDF) showed good growth, but not the best.Adding farm yard manure (FYM) with 75% RDF did not enhance plant height compared to 100% RDF alone. The combination of 75% RDF with FYM and Biofertilizers (BF) resulted in thesignificantly highest plant heights at 30, 60, and 90 DAS and at harvest, which were 10.27 cm, 22.14 cm,42.13 cm and 46.95 cm, respectively, suggesting that a combination of organic and inorganic inputs could be beneficial but it was at par with 75% RDF + 5 t FYM. The 75% RDF with FYM treatment showed the lowest plant height, which may indicate that reducing chemical fertilizers below a certain threshold and relying on organic inputs alone may not be sufficient for optimal growth.

Table 1. Effect of chickpea-based cropping system and nutrient management practices on plant height of chickpea

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Cropping systems				
Pearl millet-chickpea	9.95	19.85	38.14	43.01
Clusterbean+seasamum-chickpea	10.12	21.42	41.52	46.14
LSD	NS	NS	3.32	2.06
Nutrient management aspects				
100%RDF	10.17	21.58	40.79	45.41
75%RDF+5t FYM	9.83	19.24	37.69	42.13
75%RDF+5t FYM+BF	10.27	22.14	42.13	46.95
50%RDF+5t FYM+BF+crop residue	9.85	19.4	38.7	43.78
LSD	0.92	1.88	3.2	3.15

The data pertaining to dry matter accumulation are presented in Table 2.Chickpea dry matter accumulation was higher in the Clusterbean+sesame – chickpea cropping system.This cropping system yielded significantly higher dry matter accumulation at harvest than the pearl millet-chickpea sequence.Starting at 0.50 g at 30 DAS and increasing to 1.08 g at 60 DAS, the growth rate accelerated to 3.31 g at 90 DAS, culminating in the highest dry matter accumulation of 13.16 g at harvest.

The different nutrient management practices significantly influenced dry matter accumulation per chickpea plant.The application of 75% RDF + 5t FYM + BF (biofertilizers) resulted in the accumulation of higher dry matter across crop growth intervals.This combination showed the highest dry matter accumulation at 30 DAS (0.53 g), 60 DAS (1.23 g), 90 DAS (3.768 g), and harvest (13.67 g), and remained on par with 100% RDF, indicating that the integration of biofertilizers with reduced chemical fertilizers and organic manure can be very effective for dry matter accumulation in chickpea.The lowest dry matter accumulation was observed with 75%RDF+5t FYM treatment, with 0.42 g at 30 DAS, 0.9 g at 60 DAS, 2.748 g at 90 DAS, and only 10.9 g at harvest, suggesting that excessive reduction in chemical fertilizers, even with organic amendments, might not be adequate for optimal growth.

Table 2. Effect of chickpea-based cropping system and nutrient management practices on plant height of chickpea

Treatment	Dry matter accumulation per plant (g)			
	30 DAS	60 DAS	90 DAS	At harvest
Cropping systems				
Pearl millet-chickpea	0.46	1.02	2.99	11.72
Clusterbean+seasamum - chickpea	0.50	1.08	3.31	13.16
LSD	NS	NS	NS	1.01
Nutrient management aspects				
100%RDF	0.52	1.14	3.17	13.50
75%RDF+5t FYM	0.42	0.90	2.75	10.90
75%RDF+5t FYM+BF	0.53	1.23	3.77	13.67
50%RDF+5t FYM+BF+crop residue	0.45	0.93	2.92	11.71
LSD	0.04	0.10	0.32	1.23

Higher values of growth parameters were observed with the application of 75% RDF + 5t FYM + BF (biofertilisers).This may be due to the combination of RDF with organic manure and biofertilizers, which may improve nutrient efficiency. FYM may improve soil structure and increase the cation exchange capacity, which enhances nutrient availability to plants (Youssefand Farag, 2021).Improved soil structure from organic matter can lead to better root development, allowing the plant to access more nutrients and water (The importance of soil organic matter Key to drought-resistant soil and sustained food production FAO SOILS BULLETIN 80, n.d.), leading to increased dry matter accumulation.The increase in growth attributes may be a result of the application of nitrogen and phosphorus through chemical fertilizer, which increased their availability and led to an increase in photosynthetic activity and the movement of photosynthates from sources to sinks, both of which contributed to higher growth.Similar outcomes were also reported by Mansuri (2016) and Sodavadiya*et al.*(2021) Patel and Thanki (2022) and Parmar et al. (2023) in chickpeas.

Comment [Mu6]: “biofertilizers” please

Yield attributes and yield

The data pertaining to yield attributes and yields are presented in Table 3.The results indicated that among the cropping systems, the cluster bean + sesame-chickpea cropping system had a significantly higher number of branches per plant (3.48).For the remaining parameters, the effect of cropping system was found to be non-significant. Within the nutrient management treatments, the application of 75% RDF combined with 5t FYM and biofertilizers (BF) yielded the highest number of branches (3.61) and pods per plant (33.10), this increase in yield attributing parameters were 23.63% and 13.51%, respectively, as compared to75%RDF+5t FYM,suggesting a synergistic effect of integrating organic and inorganic inputs. The 50% RDF with FYM, BF, and crop residue, while beneficial, was less effective than the 75% RDF with FYM+BF.

Table 3. Effect of chickpea-based cropping system and nutrient management practices on yield attributes and yield of chickpea

Treatments	No of branches per plant	No pods per plant	Test weight (g)	Grain yield (q ha^{-1})
Cropping System				
Pearl millet-chickpea	3.09b	30.67	135.29	10.77
Clusterbean+seasamum - chickpea	3.48a	31.74	138.00	11.47
LSD	0.31	NS	NS	NS
Nutrient management aspects				
100%RDF	3.50	32.45	139.94	12.3
75%RDF+5t FYM	2.92	29.16	129.97	10.4
75%RDF+5t FYM+BF	3.61	33.10	142.27	12.7
50%RDF+5t FYM+BF+crop residue	3.10	30.10	134.36	11.20
LSD	0.32	2.58	NS	1.11

The cropping sequence did not influence chickpea yield.However, a higher grain yield was noted in the cluster bean + sesame - chickpea cropping system.The judicious use of plant nutrient sources, that is, 75%RDF+5t FYM+BF, significantly improved grain yield (12.7 q ha^{-1}), which was on par with 100% RDF but significantly lower with 75%RDF+5t FYM (10.40 q ha^{-1}). The yield increment over 75%RDF+5t FYM was 22.11% with the application of 75%RDF+5t FYM+BF.

This improvement in yield attributes and yield of chickpea might be due to an increase in nutrient availability, leading to better synthesis of chlorophyll in leaves because bio-fertilizer contains appreciable quantities of magnesium apart from other nutrients, which might have helped in the production of more photosynthates and resulted in higher values of yield attributes.These findings corroborate those of Gawai and Pawar (2005) and Prasad et al.(2008) Biofertilizers contribute to the soil's microbial diversity, which can enhance nutrient cycling and availability, particularly nitrogen fixation in chickpeas, which are legumes (Kumar *et al.*, 2022).This may contribute to the higher values of yield-attributing traits and grain yields.This was largely attributed to the better plant growth in terms of plant height, number of branches, and dry matter accumulation per plant, which resulted in an adequate supply of photosynthates for sink development.The complementary role was played by the combined application of inorganic fertilizer and biofertilizers to produce chickpea seed yield.These results were in close agreement with those reported by Singh et al. (2017).

Conclusion

The experimental data revealed that the integration of 75% of the Recommended Dose of Fertilizers (RDF) with farmyard manure (FYM) and biofertilizers (BF) significantly enhanced chickpea growth and yield.This treatment improved plant height, dry matter accumulation, branch number, and pod count, reflecting the synergistic effect of combining organic and inorganic inputs.This approach not only boosted the seed yield by 22.11% compared to the 75% RDF + 5t FYM but also matched the performance of the 100% RDF, offering a more sustainable cultivation strategy.These findings underscore the benefits of integrated nutrient management in chickpea production in western Rajasthan.

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