

Effect of nitrogen and phosphorus on nutrient use efficiency of irrigated chickpea (*Cicer arietinum* L.) under Scarce Rainfall Zone of Andhra Pradesh

ABSTRACT

A field experiment was carried out on sandy loam soils at Agricultural College, Mahanandi during *rabi*, 2021-22 to study the yield, nutrient uptake and nutrient use efficiency of chickpea under varied levels of fertilizer application. The experimental field was arranged in a randomized block design, featuring ten treatments, each replicated three times. Nitrogen and phosphorus were applied to all plots using urea and single super phosphate, respectively. The results revealed that significantly higher values of seed yield (1346 kg ha^{-1}), harvest index (49.2), nutrient uptake (N, P and K uptake) and phosphorus use efficiency (22.4 %) were registered with treatment 20 kg N basal + 20 kg N split + 60 kg P_2O_5 basal (T_9), nitrogen use efficiency with 10 kg N basal + 10 kg N split + 70 kg P_2O_5 basal (T_4) and haulm yield (1352 kg ha^{-1}) with 20 kg N basal + 20 kg N split + 70 kg P_2O_5 basal (T_{10}). Harvest index and post-harvest soil nutrient status (available N, P_2O_5 and K_2O) were not significantly affected by levels of fertilizer application.

Keywords: Chickpea, nitrogen, phosphorus, nutrient uptake and yield.

1. INTRODUCTION

India is the world's largest producer, and consumer of pulses. Therefore, pulses are important for Indian economy. The nitrogen-fixing property of pulses improves soil fertility, increasing and extending the productivity of farmland and also reduces the need of synthetic nitrogen fertilizers. Pulses also produce a smaller carbon footprint, indirectly reducing greenhouse gas emissions. Pulses provide protein and fiber, as well as a significant source of vitamins and minerals such as iron, zinc, folate and magnesium. Chickpea (*Cicer arietinum* L.) is self-pollinated, *rabi* season legume crop that belongs to family Fabaceae, subfamily Faboideae. Chickpea normally referred as king of pulses. In India, chickpea is cultivated in 9.69 M ha with a production of 11.04 Mt, and with a productivity of 1142 kg ha^{-1} (www.indiastatagri.in 2020-21). In Andhra Pradesh, it is cultivated in 0.45 M ha with a production of 0.55 Mt and with a productivity of 1218 kg ha^{-1} (www.des.ap.gov.in 2020-21). Proper nutrient management is a key factor among many, that influence grain yield, significantly contributing to higher productivity. Though chickpea being a grain legume is capable of fixing atmospheric nitrogen, but a starter dose of nitrogen is required for proper

growth and development. Different measures have been suggested to increase crop nitrogen use efficiency, such as using the optimal rate, time and method of application to coordinate nitrogen supply with crop demand. Nitrogen fertilizer rates and application timing are decisive factors in obtaining more yields. Compared to single nitrogen application, split application of nitrogen fertilizer results in higher recovery efficiency, and higher grain yields (Malekian *et al.*, 2019). Commonly, legumes demand excessive amount of phosphorus as the process of symbiotic nitrogen fixation consumes a lot of energy (Schulze *et al.*, 2006).

Farmers are usually unaware of optimum dose of fertilizers when grown under irrigated conditions. The excessive, and imbalance application of fertilizers increase cost of production. This may in turn lead to the depletion of soil nutrient status or soil salinization. So proper nutrient management is mandatory for obtaining higher yield in chickpea. But such scientific work has not yet been conducted till now about the optimum level of fertilizers under irrigated conditions, but farmers are using more quantity of fertilizers in split doses where crop is cultivated with one irrigation at 30-35 DAS. By considering above points in view, the present field investigation entitled “**Effect of nitrogen and phosphorus on nutrient use efficiency of irrigated chickpea (*Cicer arietinum* L.) under Scarce Rainfall Zone of Andhra Pradesh**” was proposed to quantify the optimum dose of fertilizers under irrigated conditions.

2. MATERIALS AND METHODS

The study was carried out at the College Farm within the Mahanandi campus of Acharya N.G. Ranga Agricultural University during the *rabi* season of 2021-22. This location is positioned at 15.51° N latitude, 78.61° E longitude, and has an elevation of 233.48 meters above sea level. It falls within the Scarce Rainfall Zone of Andhra Pradesh and according to Troll's classification, is categorized as Semi-Arid Tropics (SAT).

The experimental field was arranged in a randomized block design, featuring ten treatments and was replicated three times that consists of 20 kg N basal + 50 kg P₂O₅ basal (RDF), 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal, 10 kg N basal + 10 kg N split + 60 kg P₂O₅ basal, 10 kg N basal + 10 kg N split + 70 kg P₂O₅ basal, 15 kg N basal + 15 kg N split + 50 kg P₂O₅ basal, 15 kg N basal + 15 kg N split + 60 kg P₂O₅ basal, 15 kg N basal + 15 kg N split + 70 kg P₂O₅ basal, 20 kg N basal + 20 kg N split + 50 kg P₂O₅ basal, 20 kg N

basal + 20 kg N split + 60 kg P₂O₅ basal and 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal.

The experimental field's soil was sandy loam texture, being neutral in pH (7.33). It had low levels of organic carbon (0.49 %), and available nitrogen (258 kg ha⁻¹), medium availability of phosphorus (49 kg ha⁻¹), and high levels of available potassium (584 kg ha⁻¹). The chickpea variety used was NBeG-3, with a growth duration of 90-100 days, sown at a spacing of 30 cm × 10 cm. Nitrogen, and phosphorus were applied to all plots using urea and single superphosphate, respectively. The nitrogen, allocated according to the treatments, was applied in two equal splits. Half of the nitrogen was used as a basal fertilizer at sowing, while the other half was side-dressed near the crop rows using furrows 30 days after sowing (DAS). The entire dose of single superphosphate was applied as a basal fertilizer at three levels (50, 60, and 70 kg P₂O₅ ha⁻¹).

Seed and haulm yields were measured from the net plot. The harvest index is defined by the ratio of grain yield to total biological yield, as reported by Donald in 1962. NPK uptake was calculated by multiplying the NPK content by the corresponding dry matter production, and expressed in kg ha⁻¹. Nutrient use efficiency is defined as seed yield produced per unit of total nutrients supply (Sowers *et al.*, 1994).

The critical difference was correlated at 5 per cent level of significance to compare different treatment means as suggested by Panse and Sukhatme (1985). The data were analysed statistically using the analysis of variance (ANOVA) technique with the MSTAT-C computer software. Duncan's Multiple Range Test (DMRT) was employed for mean comparison (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1 Yield attributes

3.1.1 Seed Yield (kg ha⁻¹)

The application of 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉) resulted in a significantly higher seed yield (1346 kg ha⁻¹) of chickpea and was at par with T₁₀(1309 kg ha⁻¹). Lower seed yield (783 kg ha⁻¹) was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) followed by T₃(841 kg ha⁻¹).

Higher fertilizer doses increased nutrient availability, boosting chickpea yield through improved growth, more pods and seeds per plant, and higher seed weight, ultimately enhancing overall grain yield significantly. Similar kind of results were obtained by Nawangeet *et al.* (2011), Devendra Singh and Harendra Singh (2012), and Das *et al.* (2016).

3.1.2 Haulm Yield(kg ha⁻¹)

Significantly higher haulm yield (1352kg ha⁻¹) of chickpea was recorded with 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀) and was at par with T₉(1351 kg ha⁻¹). Lower haulm yield (950 kg ha⁻¹) was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) followed by T₃(963 kg ha⁻¹), and T₁(971.0 kg ha⁻¹).

The application of higher fertilizer doses, which resulted in increased haulm yield, may be attributed to the sufficient supply of nitrogen and phosphorus, leading to enhanced vegetative growth with taller plants, and greater dry matter accumulation. Similar kind of results were obtained by Devendra Singh and Harendra Singh (2012), and Nawangeet *et al.* (2018)

3.1.3 Harvest Index

The harvest index in chickpea was not significantly affected by the different levels of fertilizer application. Higher harvest index (49.9 %) of chickpea was recorded in the treatment 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and lower harvest index (45.2 %) was recorded in 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂). Similar kinds of results were obtained by Neenu *et al.* (2014), and Singh (2017).

Table 1. Seed yield, haulm yield and harvest index as influenced by levels of fertilizers

Treatments	Seed yield (kg ha⁻¹)	Haulm yield (kg ha⁻¹)	Harvest index (%)
T ₁ : 20 kg N basal + 50 kg P ₂ O ₅ (RDF)	884	971	47.6
T ₂ : 10 kg N basal + 10 kg N split + 50 kg P ₂ O ₅ basal	783	950	45.2
T ₃ : 10 kg N basal + 10 kg N split + 60 kg P ₂ O ₅ basal	841	963	46.6
T ₄ : 10 kg N basal + 10 kg N split + 70 kg P ₂ O ₅ basal	1052	1092	49.0
T ₅ : 15 kg N basal + 15 kg N split + 50 kg P ₂ O ₅ basal	1059	1185	47.0
T ₆ : 15 kg N basal + 15 kg N split + 60 kg P ₂ O ₅ basal	1120	1218	47.8
T ₇ : 15 kg N basal + 15 kg N split + 70 kg P ₂ O ₅ basal	1119	1203	48.2
T ₈ : 20 kg N basal + 20 kg N split + 50 kg P ₂ O ₅ basal	1066	1201	47.0
T ₉ : 20 kg N basal + 20 kg N split + 60 kg P ₂ O ₅ basal	1346	1351	49.9
T ₁₀ : 20 kg N basal + 20 kg N split + 70 kg P ₂ O ₅ basal	1309	1352	49.2
S.Em_±	52.44	39.89	1.85
CD (P=0.05)	157.01	119.43	NS

3.2 NUTRIENT UPTAKE

3.2.1 N Uptake (kg ha⁻¹)

In seed, significantly higher uptake of nitrogen (43.91 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀) (42.66 kg ha⁻¹), and lowest nitrogen uptake was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) (23.24 kg ha⁻¹).

In haulm, significantly higher uptake of nitrogen (30.01 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀) (29.82 kg ha⁻¹), and lowest nitrogen uptake was recorded with 20 kg N basal + 50 kg P₂O₅ basal (T₁) (18.66 kg ha⁻¹).

3.3.2 P Uptake (kg ha⁻¹)

In seed, significantly higher uptake of phosphorus (16.59 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀), and was at par with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉) (16.44 kg ha⁻¹). The lowest phosphorus uptake was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) (9.13 kg ha⁻¹), and was on par with T₃ (10.05 kg ha⁻¹) and T₁ (10.38 kg ha⁻¹).

In haulm, significantly higher uptake of phosphorus (2.89 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with T₁₀ (2.74 kg ha⁻¹), T₈ (2.58 kg ha⁻¹), T₇ (2.56 kg ha⁻¹), and T₆ (2.40 kg ha⁻¹). The lowest phosphorus uptake was recorded with 10 kg N basal + 50 kg P₂O₅ basal (T₁) (1.97 kg ha⁻¹).

3.3.3 K Uptake (kg ha⁻¹)

In seed, significantly higher uptake of potassium (15.63 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀) (15.44 kg ha⁻¹), and lowest potassium uptake was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) (9.44 kg ha⁻¹).

In haulm, significantly higher uptake of potassium (6.06 kg ha⁻¹) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with T₇ (5.83 kg ha⁻¹),

T₆(5.36 kg ha⁻¹),and T₈(5.35 kg ha⁻¹). The lowest potassium uptake was recorded with 20 kg N basal + 50 kg P₂O₅ basal (T₁) (3.98 kg ha⁻¹).

Higher doses of fertilizers resulted in increased nutrient uptake in both the seed, and haulm of chickpea. This may be attributed to improved root proliferation and nodulation, which enhance the availability of nitrogen, phosphorus, and potassium. Similar kind of results were obtained by Rani and Krishna (2016), Yadav *et al.* (2017), and Singh *et al.* (2018).

3.3 NUTRIENT USE EFFICIENCY

Significantly higher nitrogen use efficiency (52.6 %) was recorded with 10 kg N basal + 10 kg N split + 70 kg P₂O₅ basal (T₄), and lower was recorded with T₆ (26.7). Significantly higher phosphorus use efficiency (22.4 %) was recorded with 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal (T₉), and was at par with T₈ (21.3 %), and T₅ (21.2 %) lower was recorded with T₆ (26.7), and significantly lower was recorded with T₃ (14.0 %) followed by T₄ (15.0 %). These results are similar with the findings of kumaret *al.*, (2011), who also observed reduction in efficiency of nutrients with increase in their application rate.

Table 2. Nutrient uptake (N, P and K uptake) as influenced by levels of fertilizers

Treatments	Nitrogen uptake (kg ha ⁻¹)		Phosphorus uptake (kg ha ⁻¹)		Potassium uptake (kg ha ⁻¹)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
T ₁ : 20 kg N basal + 50 kg P ₂ O ₅ (RDF)	26.83	18.66	10.38	1.97	10.30	3.98
T ₂ : 10 kg N basal + 10 kg N split + 50 kg P ₂ O ₅ basal	23.24	19.33	9.13	2.12	9.44	4.40
T ₃ : 10 kg N basal + 10 kg N split + 60 kg P ₂ O ₅ basal	25.77	20.34	10.05	2.12	10.38	4.01
T ₄ : 10 kg N basal + 10 kg N split + 70 kg P ₂ O ₅ basal	32.52	22.19	12.18	2.08	14.41	4.69
T ₅ : 15 kg N basal + 15 kg N split + 50 kg P ₂ O ₅ basal	32.81	24.56	12.65	2.11	13.80	4.99
T ₆ : 15 kg N basal + 15 kg N split + 60 kg P ₂ O ₅ basal	35.19	25.53	13.55	2.40	12.42	5.36
T ₇ : 15 kg N basal + 15 kg N split + 70 kg P ₂ O ₅ basal	35.65	25.10	13.76	2.56	13.93	5.83
T ₈ : 20 kg N basal + 20 kg N split + 50 kg P ₂ O ₅ basal	34.75	25.75	13.70	2.58	13.38	5.35
T ₉ : 20 kg N basal + 20 kg N split + 60 kg P ₂ O ₅ basal	43.91	30.01	16.44	2.89	15.63	6.06
T ₁₀ : 20 kg N basal + 20 kg N split + 70 kg P ₂ O ₅ basal	42.66	29.82	16.59	2.74	15.44	4.86
S.Em_±	1.87	1.31	0.86	0.18	1.08	0.34
CD (P=0.05)	5.61	3.90	2.56	0.55	3.22	1.03

Table 3. Nutrient use efficiency as influenced by levels of fertilizers

Treatments	NUE (kg/kg N)	PUE (kg/kg P)
T ₁ : 20 kg N basal + 50 kg P ₂ O ₅ basal (RDF)	44.2	17.7
T ₂ : 10 kg N basal + 10 kg N split + 50 kg P ₂ O ₅ basal	39.2	15.7
T ₃ : 10 kg N basal + 10 kg N split + 60 kg P ₂ O ₅ basal	42.1	14.0
T ₄ : 10 kg N basal + 10 kg N split + 70 kg P ₂ O ₅ basal	52.6	15.0
T ₅ : 15 kg N basal + 15 kg N split + 50 kg P ₂ O ₅ basal	35.3	21.2
T ₆ : 15 kg N basal + 15 kg N split + 60 kg P ₂ O ₅ basal	37.3	18.7
T ₇ : 15 kg N basal + 15 kg N split + 70 kg P ₂ O ₅ basal	37.3	16.0
T ₈ : 20 kg N basal + 20 kg N split + 50 kg P ₂ O ₅ basal	26.7	21.3
T ₉ : 20 kg N basal + 20 kg N split + 60 kg P ₂ O ₅ basal	33.7	22.4
T ₁₀ : 20 kg N basal + 20 kg N split + 70 kg P ₂ O ₅ basal	32.7	18.7
S.Em_±	1.9	1.0
CD (P=0.05)	5.6	2.8

3.4 Post-harvest soil nutrient status

3.4.1 Available N (kg ha⁻¹)

Soil available nitrogen after harvest of the crop was not significantly affected by the levels of fertilizer application. However slight increase (264.3 kg ha⁻¹) in available N was observed with application of 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀), and minimum soil available N was observed with 10 kg N basal + 10 kg N split + 70 kg P₂O₅ basal (T₄) (251.0 kg ha⁻¹). Similar kind of results were obtained by Rani and Krishna (2016).

3.4.2 Available P₂O₅(kg ha⁻¹)

Soil available P₂O₅ after harvest of the crop was not significantly affected by the levels of fertilizer application. However slight increase (54.3 kg ha⁻¹) in available P₂O₅ was recorded with application of 20 kg N basal + 20 kg N split + 70 kg P₂O₅ basal (T₁₀), and minimum soil available P₂O₅ was recorded with 10 kg N basal + 10 kg N split + 50 kg P₂O₅ basal (T₂) (47.7 kg ha⁻¹). Similar kind of results were obtained by Rani and Krishna (2016).

3.4.3 Available K₂O (kg ha⁻¹)

Soil available K₂O after harvest of the crop was not significantly affected by the various levels of fertilizer application. However, slight increase (578.0 kg ha⁻¹) in available K₂O was recorded with application of 20 kg N basal + 20 kg N split + 50 kg P₂O₅ basal (T₈), and minimum soil available K₂O was recorded with 20 kg N basal + 50 kg P₂O₅ basal (T₁) (566.7 kg ha⁻¹). Similar kind of results were obtained by Rani and Krishna (2016).

Table 4. Post-harvest soil nutrient status (available N, P₂O₅ and K₂O) as influenced by levels of fertilizers

Treatments	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)
T ₁ : 20 kg N basal + 50 kg P ₂ O ₅ basal (RDF)	254	48.9	567
T ₂ : 10 kg N basal + 10 kg N split + 50 kg P ₂ O ₅ basal	253	47.7	577
T ₃ : 10 kg N basal + 10 kg N split + 60 kg P ₂ O ₅ basal	252	48.2	578
T ₄ : 10 kg N basal + 10 kg N split + 70 kg P ₂ O ₅ basal	251	51.4	576
T ₅ : 15 kg N basal + 15 kg N split + 50 kg P ₂ O ₅ basal	255	50.2	569
T ₆ : 15 kg N basal + 15 kg N split + 60 kg P ₂ O ₅ basal	254	53.3	574
T ₇ : 15 kg N basal + 15 kg N split + 70 kg P ₂ O ₅ basal	259	53.3	573

T ₈ : 20 kg N basal + 20 kg N split + 50 kg P ₂ O ₅ basal	258	52.2	578
T ₉ : 20 kg N basal + 20 kg N split + 60 kg P ₂ O ₅ basal	263	53.0	576
T ₁₀ : 20 kg N basal + 20 kg N split + 70 kg P ₂ O ₅ basal	264	54.3	571
S.Em_±	4.85	2.01	5.08
CD (P=0.05)	NS	NS	NS

3. CONCLUSION

Based on the above investigation, it is concluded that application of 20 kg N basal + 20 kg N split + 60 kg P₂O₅ basal is the optimal fertilizer level to obtain higher yield, and higher nutrient uptake in scarce rainfall zone of Andhra Pradesh. The split application of nitrogen minimized losses, thereby enhancing chickpea growth, and yield. Additionally, this practice promoted long-term improvements in soil fertility and overall soil health.

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