



Sustainable Production of Cowpea Through Nutrient Use Efficient Technologies

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ABSTRACT

Background: Cowpea is one of the most versatile pulse crop that contributes significantly to the nutritional security of the country. However, cowpea yield is very low in various regions of country. Resource conservation technologies to increase productivity and nutrient use efficiency are lacking. Hence, the present research was focused on the sustainable cowpea production through nutrient use efficient technologies viz. fertilizer microdosing, nano NPK fertilization and designer seed technology.

Methods: During 2021, two pot culture experiments were conducted to standardize the fertilizer microdosing, nano NPK fertilization and designer seed technology. Based on the results, two best performing treatments from the above trials were identified; viz., recommended dose of fertilizer (RDF) (50% and 25%) applied through fertilizer microdosing with designer seeds, RDF (2/3 and 1/4) applied as nano fertilizer (NF) with designer seeds. These treatments were selected for field evaluation along with STCR (soil test crop response) equation based NPK with designer seeds, soil test based NPK with designer seeds, RDF (20: 30: 10 kg/ha) with designer seeds and control. Field evaluations were conducted thrice; during January to April 2022, October 2022 to January 2023 and February to May 2023.

Result: Results of the study indicated that for cowpea variety Anaswara, RDF (50%) applied through fertilizer microdosing with designer seeds was the best treatment in terms of growth, yield, Nutrient Use Efficiency (NUE) and profitability. In pot culture experiments, the treatment combination of RDF (50%, 25%) applied through microdosing with designer seeds and RDF (2/3, 1/4) applied as nano fertilizer (NF) with designer seeds performed the best in terms of yield parameters. Based on the field evaluation of nutrient use efficient technologies for the cowpea variety Anaswara, RDF (50%) applied through microdosing with designer seeds emerged as the best treatment in terms of growth, yield, nutrient use efficiency and profitability.

Key words: Cowpea, Designer seeds, Fertilizer microdosing, Nano fertilizer.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is a vital leguminous crop extensively cultivated across India's Semi-Arid Tropics (SAT) regions covering approximately 1.5 million hectares primarily in states such as Rajasthan, Maharashtra, Gujarat, Tamil Nadu, Karnataka and Kerala. Renowned for its high protein content, dietary fiber and essential nutrients cowpea significantly contributes to India's nutritional security by addressing protein deficiencies and mitigating malnutrition in both rural and urban populations. Despite its importance cowpea yields in India remains low, with an average yield of 567 kg/ha (Gireesha *et al.*, 2025) underscoring the need for improved productivity through efficient nutrient management strategies.

Conventional fertilizers have limited nutrient use efficiency with only 20-30 per cent being absorbed by plants and considerable nutrient losses to the environment (Fageria, 2014). Practices that can reduce the use of chemical inputs, optimize nutrient use efficiency and enable controlled release should be used to sustain productivity (Karthik and Maheswari, 2020). Nutrient use efficient practices such as fertilizer microdosing, nanofertilizer application and designer seed technology offer effective strategies for enhancing cowpea yield with limited resources. Applying fertilizers in microdoses permits more precise and timely fertilizer placement and

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appropriate management of fertilizers. Fertilizer microdosing technology consists of the application of a small quantity of mineral fertilizer together with seeds of the target crop in the planting hole at sowing or 3 to 4 weeks after planting (ICRISAT, 2009). Fertilizer microdosing involves precise, small scale fertilizer application alongside seeds during sowing, which enhances nutrient targeting and reduces input costs. Nano fertilizers are designed to release nutrients gradually and in a controlled manner, preventing environmental damage and boosting crop growth and productivity. This technology improves fertilizer use efficiency and minimizes nutrient accumulation in the

soil. Designer seed technology incorporates nutrients, plant protectants and bio-inoculants to promote seed quality, emergence and robust crop establishment. The present investigation is designed to enhance nutrient use efficiency and cowpea yield through these innovative approaches thereby contributing to nutrient security and sustainable productivity of cowpea.

MATERIALS AND METHODS

Two pot culture experiments were conducted separately during October to December 2021 at the Instructional Farm, College of Agriculture, Vellanikkara, Kerala Agricultural University (KAU), Thrissur, Kerala (10°54'N latitude and 76°26'E longitude). The objectives of the experiments were: (i) standardization of fertilizer microdosing and seed treatments and (ii) standardization of nano fertilizer doses and seed treatments. The first pot culture experiment (i) was laid out in a completely randomized design (CRD) with two factors, fertilizer microdosing at five levels and seed treatments at three levels resulting in 15 treatment combinations (Table 1) each replicated three times. The second pot culture experiment (ii) was also laid out in a completely randomized design (CRD) with two factors, nano fertilizer doses at six levels and seed treatments at three levels, comprising 18 treatment combinations (Table 2) each replicated three times. The cowpea variety Anaswara was used in both experiments.

Based on the grain yield data obtained from both pot culture experiments, the two best performing treatments from each trial were selected for field evaluation, along with additional comparative nutrient management treatments. The field experiment (iii) was conducted from January to April 2022 and repeated during October 2022 to January 2023, as well as in February to May 2023. The field experiment was laid out in a randomized block design (RBD) with eight treatments and three replications (Table 3). Cowpea variety Anaswara was used for the study. The treatments comprised of RDF 25% (5: 7.5: 2.5 kg/ha) applied through fertilizer microdosing with designer seeds (T1), RDF 50% (10: 15: 5 kg /ha) applied through fertilizer microdosing with designer seeds (T2), RDF (2/3) applied as NF with designer seeds (T3), RDF (1/4) applied as NF with designer seeds (T4), STCR equation based NPK with designer seeds (T5), Soil test based NPK with designer seeds (T6), RDF (20: 30: 10 kg/ha) with designer seeds (T7) and Control (T8).

Lime @ 250 kg/ha and FYM @ 20 t/ha as per package of practices (POP) of KAU were uniformly applied to all treatments. For microdosing treatments, fertilizers were applied along with the seeds at sowing and top dressing was applied as hill placement. In the case of nano fertilizer treatments, nano NPK (19:19:19) (Geolife) application was based on the potassium equivalent with the remaining nitrogen applied at 20 DAS and phosphorus applied as basal dressing. Fertilizer application based on STCR equation was carried out based on the STCR equation

specifically calibrated for cowpea. Additionally, treatments with soil test based fertilizer application followed by fertilizer application based on soil test values. The details of fertilizer applied in each treatments were given in Table 4. Designer seeds were prepared by soaking seeds in a micronutrient

Table 1: Details of treatment combinations of experiment I.

	Treatment details
T1	RDF (25%) applied through fertilizer microdosing with designer seeds
T2	RDF (25%) applied through fertilizer microdosing with rhizobium treated seeds
T3	RDF (25%) applied through fertilizer microdosing with untreated seeds
T4	RDF (50%) applied through fertilizer microdosing with designer seeds
T5	RDF (50%) applied through fertilizer microdosing with rhizobium treated seeds
T6	RDF (50%) applied through fertilizer microdosing with untreated seeds
T7	RDF (75%) applied through fertilizer microdosing with designer seeds
T8	RDF (75%) applied through fertilizer microdosing with rhizobium treated seeds
T9	RDF (75%) applied through fertilizer microdosing with untreated seeds
T10	RDF (20: 30: 10 kg/ha) with designer seeds
T11	RDF with rhizobium treated seeds
T12	RDF with untreated seeds
T13	Control with designer seeds
T14	Control with rhizobium treated seeds
T15	Control with untreated seeds

Table 2: Details of treatment combinations of experiment II.

	Treatment details
T1	2/3 NPK as per POP applied as NF with designer seeds
T2	2/3 NPK as per POP applied as NF with rhizobium treated seeds
T3	2/3 NPK as per POP applied as NF with untreated seeds
T4	1/2 NPK as per POP applied as NF with designer seeds
T5	1/2 NPK as per POP applied as NF with rhizobium treated seeds
T6	1/2 NPK as per POP applied as NF with untreated seeds
T7	1/3 NPK as per POP applied as NF with designer seeds
T8	1/3 NPK as per POP applied as NF with rhizobium treated seeds
T9	1/3 NPK as per POP applied as NF with untreated seeds
T10	1/4 NPK as per POP applied as NF with designer seeds
T11	1/4 NPK as per POP applied as NF with rhizobium treated seeds
T12	1/4 NPK as per POP applied as NF with untreated seeds
T13	NPK as per POP with designer seeds
T14	NPK as per POP with rhizobium treated seeds
T15	NPK as per POP with untreated seeds
T16	Absolute control with designer seeds
T17	Absolute control with rhizobium treated seeds
T18	Absolute control with untreated seeds

solution (KAU sampoorana micronutrient mix) of 100 ppm for 3 hours and drying back to original moisture content and then treating the seeds with polymer @ 3 ml/kg of seed, imidacloprid @ 2 ml/kg of seed, PGPR (plant growth promoting rhizobacteria) @ 4 g/kg of seed and *Rhizobium* @ 20 g/kg of seed. The growth and yield parameters viz., plant height (cm), Dry Matter Production (DMP) per plant (g), pod weight per plant (g) and grain yield (kg/ha) were recorded at harvest. The biochemical parameter total chlorophyll content (mg/g) was measured at flowering. Nutrient use efficiency of N, P and K in terms of partial factor productivity was assessed at harvest. Economic parameters including Cost of Cultivation (CC) (Rs/ha), Gross Returns (GR) (Rs/ha) and B:C ratio were also calculated. The experimental data on various parameters of cowpea were subjected to analysis of variance using statistical package 'GRAPES (General R based Analysis Platform Empowered by Statistics)' developed by Gopinath *et al.* (2020).

RESULTS AND DISCUSSION

Pot culture experiments

Yield parameters (Table 5, 6, 7 and 8)

The yield parameters from the experiment on the standardization of fertilizer microdosing and seed

Table 3: Details of treatments of experiment III.

Treatments	Treatment details
T1	RDF (25%) applied through fertilizer microdosing with designer seeds
T2	RDF (50%) applied through fertilizer microdosing with designer seeds
T3	RDF (2/3) applied as NF with designer seeds
T4	RDF (1/4) applied as NF with designer seeds
T5	STCR equation based NPK with designer seeds
T6	Soil test based NPK with designer seeds
T7	RDF (20: 30: 10 kg/ha) with designer seeds
T8	Control

Table 4: Details of fertilizer applied for experiment III.

Treatments	Urea (kg/ha)	SSP (kg/ha)	MOP (kg/ha)	Nano NPK (kg/ha)
T1 Microdosing (25%) of NPK as per POP + designer seeds	11	47	4	-
T2 Microdosing (50%) of NPK as per POP + designer seeds	22	94	8	-
T3 2/3 NPK as per POP applied as NF + designer seeds	17	43	-	29
T4 1/4 NPK as per POP applied as NF+ designer seeds	7	18	-	11
T5 STCR equation based NPK + designer seeds	33	312	143	-
T6 Soil test based NPK + designer seeds	35	112	10	-
T7 NPK as per POP + designer seeds	44	188	17	-
T8 Absolute control	-	-	-	-

➤ STCR equation for cowpea.

• $N = 3.88 T - 0.098 SN - 0.02 ON, P_2O_5 = 4.34 T - 0.619 SP - 0.01 OP.$

• $K_2O = 16.53 T - 0.489 SK - 0.08 OK.$

• Where, T- Target yield (15t/ha) SN, SP, SK- Soil N, P and K (kg/ha) ON, OP, OK - N, P, K applied through organic manure.

treatments (i) are presented in Tables 5 and 6. Concerning pod weight per plant, among fertilizer microdosing treatments, the highest value was observed in RDF (50%) applied through fertilizer microdosing (35.16 g), followed by RDF (25%) applied through fertilizer microdosing (33.59 g) (Table 5). Among the seed treatments, designer seeds exhibited the highest pod weight per plant (36.56 g). The treatment combination of RDF (50%) applied through fertilizer microdosing with designer seeds recorded the highest pod weight per plant (44.55 g). In terms of grain yield, the highest yield was recorded in RDF (50%) applied through fertilizer microdosing (640.24 kg/ha) and it was followed by RDF (25%) applied through fertilizer microdosing (579.16 kg/ha). The performance of lower fertilizer microdosing levels (50% and 25%) was superior compared to RDF in terms of yield parameters. Reducing fertilizer application by 50% led to a 19% increase in grain yield. Among seed treatments, designer seeds recorded the highest grain yield (683.43 kg/ha). Compared to rhizobium treated seeds, designer seeds recorded about 38% increase in grain yield and 114% increase in grain yield compared to untreated seeds. The treatment combination of RDF (50%) applied through fertilizer microdosing with designer seeds resulted in the highest grain yield of 969.87 kg/ha (Table 6). Applying fertilizer in microdoses permits more precise and timely fertilizer placement (Sanginga and Woomer, 2009), which enhanced the lateral root length density in the topsoil (Ibrahim *et al.*, 2015) and leads to higher growth parameters, yield attributes and nutrient uptake. The increased plant growth and vigour observed with designer seeds might be attributed to the early nutrient fortification of seeds (Sujatha and Ambika, 2016). The combination of these two techniques in RDF (50%) applied through fertilizer microdosing with designer seeds was found to be superior among treatment combinations.

The yield parameters of the experiment on standardization of nano fertilizer dose and seed treatments (ii) are shown in Table 7 and 8. A higher pod weight per plant was observed in plants treated with RDF (2/3) applied

as NF (33.80g), which was comparable to the treatment with RDF (1/4) applied as NF (32.29 g) (Table 7). Among seed treatments, designer seeds (37.95 g) recorded the highest pod weight per plant (37.95g). The interaction effect of nano fertilizer doses and seed treatments on pod weight per plant was highest in the treatment combination of RDF (2/3) applied as NF with designer seeds (48.62g), which was on par with RDF (1/4) applied as NF with designer seeds (45.98 kg/ha) (Table 8). The highest grain yield was recorded in the treatment with RDF (2/3) applied as NF (611.87 kg/ha), followed by RDF (1/4) applied as NF (594.32 kg/ha). This study revealed that RDF (2/3) applied as NF recorded a yield increase of 14% and 137% compared to RDF and Control. Among seed treatments,

designer seeds (714.04 kg/ha) recorded the highest grain yield (Table 7). Grain yield in designer seed treatment was 34% and 151% higher than that of the rhizobium seeds and untreated seeds respectively. A higher grain yield was recorded in the treatment combination RDF (2/3) applied as NF with designer seeds (838.47 kg/ha) which was comparable with RDF (25%) applied as NF with designer seeds (826.17 kg/ha) (Table 8). The smaller size and larger surface area of nanoparticles easily penetrated the plant and led to better uptake of nutrients. The higher uptake resulted in optimal growth and metabolic processes such as photosynthesis, which increased the accumulation and translocation of photosynthates to the economically productive parts of the plant. Similar results showing

Table 5: Effect of treatments on pod weight per plant (g) and grain yield per plant (kg/ha).

Treatments	Yield parameters	
	Pod weight per plant (g)	Grain yield (kg/ha)
Fertilizer microdosing		
RDF (25%) applied through fertilizer microdosing	33.59	579.16
RDF (50%) applied through fertilizer microdosing	35.16	640.24
RDF (75%) applied through fertilizer microdosing	28.53	482.73
RDF (20: 30: 10 kg/ha)	31.01	536.49
Control	21.53	258.25
CD (0.05)	1.41	15.28
SE(m)±	0.49	5.29
Seed treatments		
Designer seeds	36.56	683.43
Rhizobium seeds	28.75	494.88
Untreated seeds	24.59	319.82
CD (0.05)	1.09	11.83
SE(m)±	0.38	4.09

Table 6: Interaction effect of treatments on pod weight per plant (kg) and grain yield (kg/ha).

Treatments		Pod weight per plant (g)	Grain yield (kg/ha) at harvest
T1	RDF (25%) applied through fertilizer microdosing with designer seeds	41.06	842.67
T2	RDF (25%) applied through fertilizer microdosing with rhizobium seeds	29.62	559.10
T3	RDF (25%) applied through fertilizer microdosing with untreated seeds	25.63	313.77
T4	RDF (50%) applied through fertilizer microdosing with designer seeds	44.55	969.87
T5	RDF (50%) applied through fertilizer microdosing with rhizobium seeds	34.23	562.17
T6	RDF (50%) applied through fertilizer microdosing with untreated seeds	26.70	335.70
T7	RDF (75%) applied through fertilizer microdosing with designer seeds	34.15	596.26
T8	RDF (75%) applied through fertilizer microdosing with rhizobium seeds	26.92	513.70
T9	RDF (75%) applied through fertilizer microdosing with untreated seeds	24.53	372.33
T10	RDF with designer seeds	37.78	736.60
T11	RDF with rhizobium seeds	31.59	559.60
T12	RDF with untreated seeds	28.14	364.10
T13	Control with designer seeds	25.27	315.33
T14	Control with rhizobium seeds	21.37	246.23
T15	Control with untreated seeds	17.97	213.20
	CD (0.05)	2.45	26.47
	SE(m) ±	0.85	9.16

enhanced growth and yield of green pea were reported by Devi *et al.* (2025). The increase in the yield parameters through designer seeds was due to the enhanced assimilation of necessary nutrients and the improved movement of organic compounds from source to sink, resulting from seed pelleting with micronutrients, bio-inoculants and bio-fertilizers. Similar results with enhanced yield in rice were reported by Sowmiyabhanu *et al.* (2016). The combination of these two techniques in RDF (2/3)

Table 7: Effect of treatments on pod weight per plant (g) and grain yield (kg/ha).

Treatments	Yield parameters	
	Pod weight per plant (g)	Grain yield (kg/ha)
Fertilizer microdosing		
RDF (2/3) applied as NF	33.80	611.87
RDF (1/2) applied as NF	27.98	548.70
RDF (1/3) applied as NF	24.74	509.23
RDF (1/4) applied as NF	32.29	594.32
RDF	31.01	536.49
Control	20.34	258.25
CD (0.05)	1.52	14.09
SE(m)±	0.53	4.91
Seed treatments		
Designer seeds	37.95	714.04
Rhizobium seeds	26.47	535.05
Untreated seeds	21.22	284.00
CD (0.05)	1.07	9.67
SE(m)±	0.37	3.48

applied as NF with designer seeds was found to be superior among treatment combinations.

Field experiments

Growth and biochemical parameters (Table 9)

The tallest plants (105.52 cm) and highest dry matter production per plant (64.03 g) were recorded in RDF (50%) through fertilizer microdosing with designer seeds at harvest (Table 9). RDF (50%) through fertilizer microdosing with designer seeds showed a 26% increase in plant height compared to RDF with designer seeds at harvest. Furthermore, reducing the fertilizer dose to 50% led to an 18% increase in dry matter accumulation compared to RDF with designer seeds. The increase in dry matter production per plant could be attributed to hill placement of manure, as Ibrahim *et al.* (2015) reported that fertilizer microdosing enhanced total dry matter production in millets by an average of 23 per cent. Similarly, the designer seed treatment for black gram has been shown to improve plant growth and vigour leading to higher DMP (Sujatha and Ambika, 2016). These findings suggested that the combined application of RDF (50%) through fertilizer microdosing with designer seeds contributed significantly to the observed improvement in plant growth attributes. Regarding total chlorophyll content at flowering, the higher value was recorded in treatments where RDF (2/3) applied as NF with designer seeds (8.48 mg/g) which was statistically on par with RDF (1/4) applied as NF with designer seeds (8.42 mg/g) and RDF (50%) through fertilizer microdosing with designer seeds (8.16 mg/g). These results indicated the efficacy of nano fertilizers and designer seed technology

Table 8: Interaction effect of treatments on pod weight per plant (g) and grain yield (kg/ha).

Treatments		Pod weight per plant (g)	Grain yield (kg/ha)
T1	RDF (2/3) applied as NF + designer seeds	48.62	838.47
T2	RDF (2/3) applied as NF with rhizobium seeds	30.14	658.63
T3	RDF (2/3) applied as NF with untreated seeds	22.64	338.50
T4	RDF (1/2) applied as NF with designer seeds	35.63	772.43
T5	RDF (1/2) applied as NF with rhizobium seeds	26.29	544.30
T6	RDF (1/2) applied as NF untreated seeds	22.07	329.37
T7	RDF (1/3) applied as NF with designer seeds	31.59	736.60
T8	RDF (1/3) applied as NF with rhizobium seeds	22.12	335.70
T9	RDF (1/3) applied as NF with untreated seeds	18.47	241.07
T10	RDF (1/4) applied as NF with designer seeds	45.98	826.17
T11	RDF (1/4) applied as NF with rhizobium seeds	24.92	487.40
T12	RDF (1/4) applied as NF with untreated seeds	21.63	246.23
T13	RDF with designer seeds	41.06	795.23
T14	RDF with rhizobium seeds	31.23	714.63
T15	RDF with untrated seeds	28.14	559.10
T16	Control with designer seeds	25.27	315.33
T17	Control with rhizobium seeds	21.37	242.17
T18	Control with untreated seeds	14.37	213.20
	CD (0.05)	2.68	24.42
	SE(m) ±	0.92	8.51

in enhancing chlorophyll content, likely due to improved nutrient availability and utilization efficiency.

Yield parameters (Table 10)

From the pooled data on pod weight per plant, the higher pod weight per plant was recorded in RDF (50%) through fertilizer microdosing with designer seeds (48.62 g), which was comparable to RDF (1/4) applied as NF with designer seeds (47.27 g) and RDF (2/3) applied as NF with designer seeds (40.87 g) (Table 10). The highest grain yield was recorded in RDF (50%) through fertilizer microdosing with designer seeds (848.87 kg/ha) (Table 10).

The higher total chlorophyll content (Table 9) and enhanced photosynthetic ability during flowering and pod formation stages might have contributed to improved biomass partitioning. Along with the enhanced growth parameters associated with the RDF (50%) through fertilizer microdosing with designer seeds were reflected in increased grain yield (Table 3). Despite the reduction in the fertilizer dose to 50%, a yield increase of 16% was observed in the RDF (50%) through fertilizer microdosing with designer seeds compared to the RDF with designer seeds. This clearly indicates the effectiveness of microdosing combined with designer seeds in optimizing yield while reducing fertilizer input. The combined effect of hill placement of fertilizer

in microdosing and early nutrient availability through designer seeds resulted in higher growth attributes and this was reflected in enhanced yield. Tovihoudji *et al.* (2017) reported 99 % yield increase in maize through fertilizer microdosing compared to control. Sujatha and Ambika (2018) also reported that designer seeds increased the paddy yield by 25% compared with control.

Partial factor productivity (PFP) (Table 11)

The highest partial factor productivity of N, P and K were recorded in RDF (1/4) applied as NF with designer seeds (142.93 kg grain yield/kg of N applied, 95.29 kg grain yield/kg of P applied and 285.87 kg grain yield/kg of K applied) (Table 11). This was due to the comparatively higher yield achieved with a lower amount of nutrients applied. Slow and steady release of nutrients through nano fertilizers may resulted in lower nutrient fixation resulting in enhanced nutrient use efficiency (NUE). Similar results were reported by Subramanian and Rahale (2009), Nibin and Ushakumari (2019) and Swaroopa (2023). The lowest PFP for N observed in the RDF with designer seeds (36.56 kg grain yield/kg of N applied) was due to the higher amount of N applied. Similarly, lowest PFP values for P and K were found in the STCR equation based NPK with designer seeds treatment (12.22 kg grain yield /kg of P applied and 7.09 kg grain yield/kg

Table 9: Effect of treatments on plant height, dry matter production per plant and total chlorophyll content.

Treatments		Plant height (cm) at harvest	Dry matter production per plant (g) at harvest	Total chlorophyll content (mg/g) at flowering
T1	RDF (25%) fertilizer microdosing with designer seeds	94.31	57.26	5.75
T2	RDF (50%) fertilizer microdosing with designer seeds	105.52	64.03	8.16
T3	RDF (2/3) applied as NF with designer seeds	81.34	56.83	8.48
T4	RDF (1/4) applied as NF with designer seeds	96.22	60.19	8.42
T5	STCR equation based NPK with designer seeds	89.00	54.66	5.56
T6	Soil test based NPK with designer seeds	91.20	55.61	7.45
T7	RDF (20: 30: 10 kg/ha) with designer seeds	83.87	54.11	7.45
T8	Absolute control	53.01	41.36	4.46
	CD (0.05)	2.38	2.96	0.55
	SE(m) ±	0.79	0.98	0.18

Table 10: Effect of treatments on pod weight per plant and grain yield.

Treatments		Pod weight per plant (g) at harvest	Grain yield (kg/ha) at harvest
T1	RDF (25%) fertilizer microdosing with designer seeds	30.27	625.10
T2	RDF (50%) fertilizer microdosing with designer seeds	48.62	848.87
T3	RDF (2/3) applied as NF with designer seeds	40.87	726.97
T4	RDF (1/4) applied as NF with designer seeds	47.27	714.67
T5	STCR equation based NPK with designer seeds	28.27	608.10
T6	Soil test based NPK with designer seeds	29.83	715.17
T7	RDF (20: 30: 10 kg/ha) with designer seeds	35.76	731.17
T8	Absolute control	13.70	193.71
	CD (0.05)	8.25	14.38
	SE(m) ±	2.72	4.74

Table 11: Effect of treatments on partial factor productivity of N, P and K.

Treatments		Partial factor productivity (PFP)		
		PFP _N	PFP _P	PFP _K
T1	RDF (25%) fertilizer microdosing with designer seeds	125.02	83.35	250.04
T2	RDF (50%) fertilizer microdosing with designer seeds	84.89	56.59	169.77
T3	RDF (2/3) applied as NF with designer seeds	54.54	36.35	108.99
T4	RDF (1/4) applied as NF with designer seeds	142.93	95.29	285.87
T5	STCR equation based NPK with designer seeds	41.14	12.22	7.09
T6	Soil test based NPK with designer seeds	45.84	39.73	119.19
T7	RDF (20: 30: 10 kg/ha) with designer seeds	36.56	24.37	73.12
T8	Absolute control	-	-	-
CD (0.05)		1.92	1.29	3.89
SE(m) ±		0.62	0.42	1.26

Table 12: Effect of treatments on economics.

Treatments		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
T1	RDF (25%) fertilizer microdosing with designer seeds	75991	112518	1.48
T2	RDF (50%) fertilizer microdosing with designer seeds	78567	152796	1.94
T3	RDF (2/3) applied as NF with designer seeds	92467	130854	1.42
T4	RDF (1/4) applied as NF with designer seeds	76757	128640	1.68
T5	STCR equation based NPK with designer seeds	88533	109458	1.24
T6	Soil test based NPK with designer seeds	73225	128730	1.76
T7	RDF (20: 30: 10 kg/ha) with designer seeds	77359	131610	1.70
T8	Absolute control	55400	34867	0.63

of P applied respectively) attributed to the higher amount of nutrients added with a relatively lower yield.

Economics (Table 12)

Among the treatments, highest cost of cultivation was recorded in RDF (2/3) applied as NF with designer seeds (Rs. 92467). A higher gross return was recorded in RDF (50%) through fertilizer microdosing with designer seeds (Rs. 152796). Highest B:C ratio was also recorded in RDF (50%) through fertilizer microdosing with designer seeds (1.94). The economic analysis of the treatments revealed that RDF (50%) through fertilizer microdosing with designer seeds resulted in higher gross returns and B:C ratio for cowpea variety, Anaswara across all three seasons. This might be due to the higher yield obtained through this treatment because of the efficiency of placement of fertilizer through microdosing technique and the efficiency of designer seed treatments. Although the microdosing technique had a higher cost of cultivation compared to conventional fertilizer application, reducing the amount of fertilizer by 50% led to higher profit.

CONCLUSION

Based on the field evaluation study, it is evident that the application of RDF (50%) through fertilizer microdosing combined with designer seed treatment can enhance the grain yield of cowpea by 16 % despite a 50% reduction of fertilizer application. This approach can thus be considered

as a nutrient-use efficient technology and a sustainable practice for improving the growth, yield and profitability of cowpea variety Anaswara.

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Conflict of interest

All authors declared that there is no conflict of interest.

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