Original Research Article

Studies on nano DAP on growth, yield and quality of chickpeasunder rainfed conditions of northeastern dry zone of Karnataka

ABSTRACT

A field experiment was conducted at Zonal Agricultural Research Station, Kalaburagi, during *rabi* season of 2022-23 to study the growth and yield of chickpea as influenced by fertilizers and foliar application of nano DAP. The experiment includedfour levels of RDF in main plots *viz*., 0% RDF (M_1), 50% RDF (M_2), 75% RDF (M_3) and 100% RDF (M_3) and three levels of nano DAP sprays in subplots v*iz*., 2 ml litre^{-1} of water (S_1), 4 ml litre^{-1} of water (S_2), and Seed treatment with Nano DAP @ 5ml kg^{-1} seeds (S_3) laid out in split plot design. The results revealed that among all the treatment combinations,100% RDF + nano DAP @ 4 ml litre^{-1} of water recorded significantly higher growth, parameters*viz.,* plant height (37.56 cm), number of primary branches plant^{-1} (6.86), leaf area plant^{-1} (2.58 dm^2 plant^{-1}), LAI (0.86) and total dry matter accumulation in plant (20.24 g plant^{-1}) at harvest.; yield parameters *viz*., number of pods plant^{-1} (23.52), seed weight per plant (9.16 g), 100 seed weight (22.30 g), haulm yield (3550kg ha^{-1}), seed yield (1868 kg ha^{-1}), quality parameters viz., protein content (19.31%) and protein yield (361.15 kg ha^{-1}). This treatment was however found on par with 75 per cent RDF + foliar spray of nano DAP @ 4 ml litre^{-1} of water which recorded on par growth parameters *viz*., plant height (36.56 cm), number of primary branches plant^{-1} (6.59), leaf area plant^{-1} (2.51 dm^2 plant^{-1}), LAI (0.84), chlorophyll content (57.47) and total dry matter accumulation by plant (19.80 g plant^{-1}) at harvest.; yield parameters *viz*., number of pods plant^{-1} (23.25), seed weight per plant (9.04 g), 100 seed weight (21.16 g), haulm yield (3504kg ha^{-1}), seed yield (1796 kg ha^{-1}), protein content (19.04%) and protein yield (342.52 kg ha^{-1}).

Keywords: *chickpea, fertilizer, nano DAP, growth, yield, economics*

INTRODUCTION

Chickpea (*Cicerarietinum* L.) is one of the most prominent pulse crops not only in India but also in the world. It is called by different synonyms such as gram or bengalgram and is popularly referred to as chana in several places of the country. Chickpea is a cool season long-day legume crop belongs to the family fabaceae and subfamily faboideae. It is valued for its rich nutritive seed with enormous source of protein (23%), carbohydrate (63%), fat (5%), crude fiber (6%), ash (3%) and also rich in calcium, magnesium, iron and niacin [1]. Hence, it is increasingly consumed as a substitute for animal protein. It is predominantly consumed in the form of whole grain or dhal, sprouted grain, green or matured dry seeds and is used in the preparation of variety of snacks, sweets and condiments. Due to its high nutritional value, it has become an integral part of the daily dietary system for over millions of people. InIndia chickpea is grown on an area of 9.9 m ha, with a production of 11.9 m t and a productivity of 1192 kg ha^{-1}[2]. In Karnataka, Kalaburagi occupies the first position with respect to chickpea area (1.24 lakh ha), production (8.63 lakh tonnes) and productivity (733 kg ha^{-1}).Chickpea is grown during rabi under residual moisture conditions and marginal lands which are low in fertility status and facing various biotic and abiotic stresses. The overall productivity of chickpea in India is comparatively low as compared to other countries.Indian agriculture is facing a wide spectrum of challenges in crop production systems such as crop yield stagnation, declining organic matter, multi nutrient deficiencies, low use efficiency of fertilizers, shrinking arable land and water availability etc. Fertilizers play a pivotal role in agricultural production. Conventional chemical fertilizer application techniques are resulting in much nutrient loss such as fixation, immobilization, volatilization, leaching and runoff.

Foliar fertilization is the most economical way of supplying the plant nutrients. One main advantage of foliar nutrition is that it often brings about immediate improvement in plant growth and development. Foliar fertilization or foliar feeding encourages the supply of nutrients, plant hormones, stimulants and other beneficial substances in liquid form to plant through aerial parts of the plants to realize enhanced yield. Fertilizers which are applied to the soil at the time of sowing are not fully available to the plants as the crop approaches maturity. Due to moisture stress under rainfed condition where the availability of soil moisture becomes scarce, the application of nutrient fertilizers as foliar spray results in superior yield. Supplemental foliar application is one of the many techniques available which makes them readily available. Application of nutrients through foliar spray at appropriate stages of growth becomes very important for their utilization and helps in better performance of the crop [3]. Thus, an alternate technology such as nanotechnology is used to precisely deliver correct quantity of nutrients and other inputs required by crops in suitable proportion that promote productivity while ensuring environmental safety. Nano fertilizer is a useful tool in agriculture for improving crop growth, yield and quality metrics by increasing nutrient use efficiency, lowering fertilizer waste and cultivation costs. Nano fertilizers have a large surface area, high sorption capacity and controlled-release kinetics to specific locations, making them a clever delivery mechanism [4]. IFFCO has developed nanotechnology based liquid nano DAP fertilizers to address the imbalanced and excessive use of conventional urea and DAP fertilizers. This nano DAP contains about 8 per cent (80,000 ppm) of nitrogen and 16 per cent (1,60,000 ppm) of phosphorous. IFFCO nano DAP is prepared by nano technology that effectively fulfills crop nitrogen and phosphorous requirement when used as foliar spray and improves the productivity of crops. Thus, keeping theses points in view, an experiment to study the effect of nano technology on growth and yield of chickpea was planned and implemented.

MATERIAL AND METHODS

A field experiment was conducted during rabi season, 2022-23 at Zonal Agricultural Research Station, Kalaburagi (Karnataka) to assess the effect of nano DAP on growth and yield of chickpea (*Cicerarietinum* L.). The soil of the experimental site belonged to *Vertisols* having pH (8.12), medium in available nitrogen (237 kg ha^{-1}), phosphorous (31 kg ha^{-1}) and potassium (325 kg ha^{-1}). The experiment was laid out in split plot design with three replications. The experiment consisted of 12 treatment combinations involving four levels of RDF (0, 50, 75 and 100%) and three levels of nano DAP (2 and 4 ml per liter of water and seed treatment with nano DAP @ 5 ml per kg seed). Recommended quantity of farm yard manure at the rate of 5 t ha^{-1} was applied toeach plot three weeks prior to sowing as per the treatment**.** The nutrients *viz*., nitrogen and phosphorus were applied in the form of urea and SSP respectively at the time of sowing as per the treatments. Seed treatment of nano DAP @ 5 ml per kg seed was also done as per the treatment.Foliar spray of nano DAP was done after 30 days of sowing @ 2 and 4 ml $litre^{-1}$ of water. The certified seeds of chickpea variety JG-11 were used for sowing. The crop was sown by hand dibbling and maintaining spacing of 30 cm between rows and 10 cm between plants. Suitable plant protection measures were followed during the cropping season.Five plants were randomly selected in each net plot area for taking observations on growth and yield and quality attributing parameters as per the schedule. The crop in each net plot was harvested separately as per treatment and the values were converted into hectare basis and expressed in kilograms per hectare. The data recorded during the investigation were compiled and analyzed for statistical significance as per the analysis of variance for the split plot design. Fisher's method of analysis of variance (ANOVA) as described by Gomez and Gomez [5] was adopted for the purpose. Standard error of mean and coefficient of variability have been worked out for a set of observations under each character at P=0.05 to interpret the significance.

RESULTS AND DISCUSSION

Growth parameters

The results of the experiment revealed that the interaction effect between different levels of RDF and foliar sprays on growth parameters was found significant atp < 0.05(Table 1). Application of 100% RDF with foliar spray of nano @ DAP 4 ml litre^{-1} of water recorded significantly higher growth parameters *viz*., plant height (37.56 cm), number of branches plant^{-1} (6.86), leaf area plant^{-1} (2.58 dm^2 plant^{-1}), LAI (0.86) and total dry matter accumulation in plant (20.24 g plant^{-1}) at harvest. This treatmentwas on par with 100% RDF + foliar spray of nano DAP @ 2 ml litre^{-1} of water, 100% RDF + Seed treatment with nano DAP @ 5 ml per kg seed.However, 75% RDF + foliar spray of nano DAP @ 4 ml litre^{-1} of water recorded on par growth parameters viz., plant height (36.56 cm), number of branches plant^{-1} (6.59), leaf area plant^{-1} (2.51 dm^2 plant^{-1}), LAI (0.84) and total dry matter accumulation in plant (19.80 g plant^{-1}) with 100% RDF + foliar spray of nano DAP @ 2 and 4 ml litre^{-1} of water. The significantly higher growth parameters of chickpea in those treatments might be due to the high concentrations of nano DAP fertilizer with large permeability and high concentration of nanoparticles, that might have penetrated plant leaves and played an important role inpromoting plant growth parameters, where nitrogen has a positive role in increasing the activity of meristemtic tissues and cell division and its importance in building amino acids such as tryptophan, which is the basis for building Auxins that contribute to cell division and expansion which ultimately resulted in higher growth parameters [6] [7] [8].Significantly lower growth parameters were observed with 0% RDF + seed treatment @ 5 ml/kg of seeds. This might be due to unavailability of required quantity nutrients for growth processes of chickpea plant.

Table 1. Growth parameters of chickpea at harvest as influenced by different levels of RDF and nano DAP

Treatments	Plant height	Number of branches	leaf area plant^{-1}	Leaf Area Index (LAI)	Total dry matter accumulation in

	(cm)	plant^{-1}	(dm^2 plant^{-1})		plant (g plant^{-1})
Main plots : RDF levels					
M_1: 0%	29.84	4.68	2.16	0.72	15.75
M_2: 50%	30.83	5.48	2.24	0.75	17.38
M_3: 75%	34.12	6.23	2.35	0.78	18.98
M_4:100%	37.17	6.79	2.56	0.85	20.16
Mean SE ±	**0.44**	**0.06**	**0.04**	**0.01**	**0.17**
CD @ 5%	**1.52**	**0.21**	**0.14**	**0.05**	**0.58**
Sub plots: Nano DAP levels					
S_1: 2 ml/l of water	32.71	5.72	2.31	0.77	17.95
S_2: 4 ml ml/l of water	34.03	6.01	2.38	0.79	18.56
S_3: Seed treatment@ 5 ml/kg of seeds	32.22	5.65	2.29	0.76	17.69
Mean SE ±	**0.24**	**0.05**	**0.01**	**0.005**	**0.11**
CD @ 5%	**0.71**	**0.16**	**0.04**	**0.01**	**0.33**
Interaction					
$M_1 \times S_1$	29.52	4.55	2.17	0.72	15.55
$M_1 \times S_2$	30.67	5.08	2.18	0.73	16.25
$M_1 \times S_3$	29.32	4.41	2.15	0.72	15.43
$M_2 \times S_1$	30.87	5.50	2.25	0.75	17.25
$M_2 \times S_2$	31.34	5.50	2.26	0.75	17.94
$M_2 \times S_3$	30.28	5.44	2.21	0.74	16.95
$M_3 \times S_1$	33.45	6.04	2.28	0.76	18.77
$M_3 \times S_2$	36.56	6.59	2.51	0.84	19.80
$M_3 \times S_3$	32.35	6.05	2.27	0.76	18.36
$M_4 \times S_1$	37.02	6.80	2.56	0.85	20.21

M_4 x S_2	37.56	6.86	2.58	0.86	20.24
M_4 x S_3	36.92	6.71	2.53	0.84	20.03
Mean SE ±	**0.47**	**0.11**	**0.03**	**0.01**	**0.22**
CD @ 5%	**1.42**	**0.33**	**0.09**	**0.03**	**0.66**

Yield parameters

The results of the experiment clearly indicated that the interaction effect between different levels of RDF and foliar sprays on yield parameters was found significant atp < 0.05(Table 2). Application of 100% RDF with foliar spray of nano @ DAP 4 ml litre^{-1} of water registered significantly higher yield parameters *viz*., number of pods plant^{-1} (23.52), seed weight per plant (9.16 g), seed yield (1868 kg ha^{-1}) and haulm yield (3550kg ha^{-1}). It was found on par with 100% RDF + foliar spray of nano DAP @ 4 ml litre^{-1} of water, 100% RDF + seed treatment with nano DAP @ 5 ml/liter of water. However, application of 75% RDF + foliar spray of nano DAP @ 4 ml litre^{-1} of waterrecorded on par seed yield and yield parameters viz., number of pods plant^{-1} (23.25), seed weight per plant (9.04 g), 100 seed weight (21.16), seed yield (1796 kg ha^{-1}) and haulm yield (3504kg ha^{-1})with100 % RDF + foliar spray of nano DAP @ 2 and 4 ml litre^{-1} of water. This was mainly attributed to synergistic effect of conventional soil applied urea and SSP fertilizers and foliar applied nanoDAP which enhanced the uptake of nitrogen and phosphorus [7].The improved nitrogen and phosphorus availability at critical crop growth due to foliar spraying of nanoDAP (nitrogen and phosphorus) which helped to improve the uptake of nutrients. Nitrogen being a component of many amino acids helped in increased dry matter production and translocation of photosynthates from source to sink. The better source to sink relationship resulted in higher number of pods per plant, seed yield per plant, 100 seed weight resulted in higher seed yield in those treatments[9] [10] [11].Significantly lower yield and yield parameters were observed with 0% RDF + seed treatment @ 5 ml/kg of seeds. This might be due to unavailability of required quantity nutrients for growth processes of chickpea plant.

Table 2. Yield and yield parameters of chickpea as influenced by different levels of RDF and nano DAP

Treatments	Number of pods plant^{-1}	Seedweight per plant (g)	100 seed weight (g)	Seedyield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Main plots : RDF levels						
M_1: 0%	16.32	6.67	18.15	1451	3125	31.55

M_2: 50%	19.36	7.86	20.28	1609	3333	32.70
M_3: 75%	22.29	8.76	21.07	1718	3435	33.33
M_4:100%	23.42	9.13	21.75	1827	3523	34.14
Mean SE +	**0.23**	**0.08**	**0.19**	**15**	**23**	**0.18**
CD @ 5%	**0.78**	**0.28**	**0.65**	**50**	**82**	**0.63**
Sub plots: Nano DAP levels						
S_1: 2 ml/l of water	20.58	8.09	20.32	1624	3364	32.90
S_2: 4 ml ml/l of water	21.32	8.39	20.92	1722	3413	33.40
S_3: Seed treatment@ 5 ml/kg of seeds	19.15	7.85	19.70	1606	3285	32.49
Mean SE +	**0.15**	**0.07**	**0.13**	**12**	**8**	**0.19**
CD @ 5%	**0.44**	**0.22**	**0.38**	**37**	**26**	**NS**
Interaction						
M_1 x S_1	16.26	6.50	18.00	1389	3205	31.94
M_1 x S_2	18.30	7.34	19.56	1585	3238	32.87
M_1 x S_3	14.41	6.17	16.90	1375	2930	30.23
M_2 x S_1	20.11	8.01	20.43	1603	3338	32.45
M_2 x S_2	20.22	8.00	20.66	1637	3359	32.77
M_2 x S_3	17.76	7.58	19.76	1588	3303	32.48
M_3 x S_1	22.51	8.69	21.11	1691	3402	33.21
M_3 x S_2	23.25	9.04	21.16	1796	3504	33.87
M_3 x S_3	21.11	8.55	20.93	1666	3399	32.90
M_4 x S_1	23.44	9.15	21.73	1813	3512	34.04
M_4 x S_2	23.52	9.16	22.30	1868	3550	34.48
M_4 x S_3	23.31	9.09	21.21	1798	3507	33.90
Mean SE +	**0.30**	**0.15**	**0.25**	**25**	**17**	**0.37**
CD @ 5%	**0.89**	**0.44**	**NS**	**74**	**52**	**NS**

Quality parameters

It is clearly observed from the data that, the interaction effect between different levels of RDF and foliar sprays on yield parameters was found significantat $p < 0.05$ (Table 3). Significantly lower protein content and protein yield were observed with 0% RDF + seed treatment @ 5 ml/kg of seeds. Application of 100% RDF with foliar spray of nano @ DAP 4 ml $litre^{-1}$ of water registered significantly higher quality parameters *viz*., protein content (19.31 %) and protein yield (361.15 kg ha^{-1}). However, it was on par with 100% RDF + foliar spray of nano DAP @ 2 ml $litre^{-1}$ of water, 100% RDF + seed treatment with nano DAP @ 5 ml/liter of water and 75% RDF + foliar spray of nano DAP @ 4 ml $litre^{-1}$ of water at harvest. The higher protein content and protein yield recorded due to better uptake of nitrogen and converted into amino acids[12][13].

Table 3. Quality parameters of pigeonpea as influenced by different levels of RDF and nano DAP

Treatments	Protein content (%)	Protein yield (kg ha^{-1})
Main plot: RDF levels (M)		
M_1: 0%	14.62	212.25
M_2: 50%	15.89	255.94
M_3: 75%	17.70	304.79
M_4:100%	19.19	350.72
Mean SE ±	**0.12**	**5.28**
CD at 5 %	**0.43**	**18.27**
Sub plot: Nano DAP levels (S)		
S_1: 2 ml/l of water	16.81	275.60
S_2: 4 ml ml/l of water	17.43	302.25
S_3: Seed treatment@ 5 ml/kg of seeds	16.32	264.93
Mean SE ±	**0.11**	**3.16**
CD at 5 %	**0.34**	**9.48**
Interactions (M×S)		
$M_1 S_1$	14.72	204.75
$M_1 S_2$	14.94	236.85

$M_1 S_3$	14.19	195.16
$M_2 S_1$	15.73	252.24
$M_2 S_2$	16.40	268.46
$M_2 S_3$	15.55	247.10
$M_3 S_1$	17.57	297.27
$M_3 S_2$	19.04	342.52
$M_3 S_3$	16.48	274.58
$M_4 S_1$	19.20	348.14
$M_4 S_2$	19.31	361.15
$M_4 S_3$	19.06	342.87
Mean SE ±	**0.22**	**6.32**
CD at 5 %	**0.67**	**18.95**

CONCLUSION

The growth and yields obtained with application of 75% RDF + foliar spray of nano DAP @ 4 ml litre^{-1} of water indicated that,it was on par with 100% RDF with nano treatments and the use of nano DAP at right quantity helped plant to put better growth and yield parameters and finally yield. Thus 25% of RDF can be saved by using nano DAP @ 4 ml litre^{-1} of water. The nano DAP fertilizers are new genera of fertilizers which even in small quantity are equal to large volume of conventional fertilizers and are having high surface area by which they are absorbed by the plant system and thereby improving growth and yield of chickpea.

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