

## Original Research Article

# Studies on nano DAP on growth, yield and quality of chickpea under rainfed conditions of north eastern 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 included of four levels of RDF in main plots viz., 0% RDF (M<sub>1</sub>), 50% RDF (M<sub>2</sub>), 75% RDF (M<sub>3</sub>) and 100% RDF (M<sub>4</sub>) and three levels of nano DAP sprays in sub plots viz., 2 ml litre<sup>-1</sup> of water (S<sub>1</sub>), 4 ml litre<sup>-1</sup> of water (S<sub>2</sub>), and Seed treatment with Nano DAP @ 5ml kg<sup>-1</sup> seeds (S<sub>3</sub>) laid out in split plot design. The results revealed that among all the treatment combinations, 100% RDF + nano DAP @ 4 ml litre<sup>-1</sup> of water recorded significantly higher growth, parameters viz., plant height (37.56 cm), number of primary branches plant<sup>-1</sup> (6.86), leaf area plant<sup>-1</sup> (2.58 dm<sup>2</sup> plant<sup>-1</sup>), LAI (0.86) and total dry matter accumulation in plant (20.24 g plant<sup>-1</sup>) at harvest.; yield parameters viz., number of pods plant<sup>-1</sup> (23.52), seed weight per plant (9.16 g), 100 seed weight (22.30 g), haulm yield (3550 kg ha<sup>-1</sup>), seed yield (1868 kg ha<sup>-1</sup>), quality parameters viz., protein content (19.31%) and protein yield (361.15 kg ha<sup>-1</sup>). This treatment was however found on par with application of 75 per cent RDF + foliar spray of nano DAP @ 4 ml litre<sup>-1</sup> of water which recorded on par growth parameters viz., plant height (36.56 cm), number of primary branches plant<sup>-1</sup> (6.59), leaf area plant<sup>-1</sup> (2.51 dm<sup>2</sup> plant<sup>-1</sup>), LAI (0.84), chlorophyll content (57.47) and total dry matter accumulation by plant (19.80 g plant<sup>-1</sup>) at harvest.; yield parameters viz., number of pods plant<sup>-1</sup> (23.25), seed weight per plant (9.04 g), 100 seed weight (21.16 g), haulm yield (3504 kg ha<sup>-1</sup>), seed yield (1796 kg ha<sup>-1</sup>), protein content (19.04%) and protein yield (342.52 kg ha<sup>-1</sup>).

**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 bengal gram and popularly referred 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. In India 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<sup>-1</sup>[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<sup>-1</sup>). 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 these 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<sup>-1</sup>), phosphorous (31 kg ha<sup>-1</sup>) and potassium (325 kg ha<sup>-1</sup>). 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<sup>-1</sup> was applied to each 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<sup>-1</sup> 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 Fisher's method of analysis of variance technique was used for statistical analysis [5] and means of treatment were compared using t-test at 5% probability level using least significant difference.

## 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 (Table 1). Application of 100% RDF with foliar spray of nano @ DAP 4 ml litre<sup>-1</sup> of water recorded significantly higher growth parameters viz., plant height (37.56 cm), number of branches plant<sup>-1</sup> (6.86), leaf area plant<sup>-1</sup> (2.58 dm<sup>2</sup> plant<sup>-1</sup>), LAI (0.86) and total dry matter accumulation in plant (20.24 g plant<sup>-1</sup>) at harvest. This treatment it was on par with 100% RDF + foliar spray of nano DAP @ 2 ml litre<sup>-1</sup> 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<sup>-1</sup> of water recorded on par growth parameters viz., plant height (36.56 cm), number of branches plant<sup>-1</sup> (6.59), leaf area plant<sup>-1</sup> (2.51 dm<sup>2</sup> plant<sup>-1</sup>), LAI (0.84) and total dry matter accumulation in plant (19.80 g plant<sup>-1</sup>) with 100% RDF + foliar spray of nano DAP @ 2 and 4 ml litre<sup>-1</sup> 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 in promoting plant growth parameters, where nitrogen has a positive role in increasing the activity of meristematic 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 (cm)	Number of branches plant <sup>-1</sup>	leaf area plant <sup>-1</sup> (dm <sup>2</sup> plant <sup>-1</sup> )	LAI	Total dry matter accumulation in plant (g plant <sup>-1</sup> )
<b>Main plots : RDF levels</b>					
M <sub>1</sub> : 0%	29.84	4.68	2.16	0.72	15.75
M <sub>2</sub> : 50%	30.83	5.48	2.24	0.75	17.38
M <sub>3</sub> : 75%	34.12	6.23	2.35	0.78	18.98

M <sub>4</sub> :100%	37.17	6.79	2.56	0.85	20.16
<b>S.Em±</b>	<b>0.44</b>	<b>0.06</b>	<b>0.04</b>	<b>0.01</b>	<b>0.17</b>
<b>CD @ 5%</b>	<b>1.52</b>	<b>0.21</b>	<b>0.14</b>	<b>0.05</b>	<b>0.58</b>
<b>Sub plots: Nano DAP levels</b>					
S <sub>1</sub> : 2 ml/l of water	32.71	5.72	2.31	0.77	17.95
S <sub>2</sub> : 4 ml ml/l of water	34.03	6.01	2.38	0.79	18.56
S <sub>3</sub> : Seed treatment@ 5 ml/kg of seeds	32.22	5.65	2.29	0.76	17.69
<b>S.Em±</b>	<b>0.24</b>	<b>0.05</b>	<b>0.01</b>	<b>0.005</b>	<b>0.11</b>
<b>CD @ 5%</b>	<b>0.71</b>	<b>0.16</b>	<b>0.04</b>	<b>0.01</b>	<b>0.33</b>
<b>Interaction</b>					
M <sub>1</sub> x S <sub>1</sub>	29.52	4.55	2.17	0.72	15.55
M <sub>1</sub> x S <sub>2</sub>	30.67	5.08	2.18	0.73	16.25
M <sub>1</sub> x S <sub>3</sub>	29.32	4.41	2.15	0.72	15.43
M <sub>2</sub> x S <sub>1</sub>	30.87	5.50	2.25	0.75	17.25
M <sub>2</sub> x S <sub>2</sub>	31.34	5.50	2.26	0.75	17.94
M <sub>2</sub> x S <sub>3</sub>	30.28	5.44	2.21	0.74	16.95
M <sub>3</sub> x S <sub>1</sub>	33.45	6.04	2.28	0.76	18.77
M <sub>3</sub> x S <sub>2</sub>	36.56	6.59	2.51	0.84	19.80
M <sub>3</sub> x S <sub>3</sub>	32.35	6.05	2.27	0.76	18.36
M <sub>4</sub> x S <sub>1</sub>	37.02	6.80	2.56	0.85	20.21
M <sub>4</sub> x S <sub>2</sub>	37.56	6.86	2.58	0.86	20.24
M <sub>4</sub> x S <sub>3</sub>	36.92	6.71	2.53	0.84	20.03
<b>S.Em±</b>	<b>0.47</b>	<b>0.11</b>	<b>0.03</b>	<b>0.01</b>	<b>0.22</b>
<b>CD @ 5%</b>	<b>1.42</b>	<b>0.33</b>	<b>0.09</b>	<b>0.03</b>	<b>0.66</b>

## 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 (Table 2). Application of 100% RDF with foliar spray of nano @ DAP 4 ml litre<sup>-1</sup> of water registered significantly higher yield parameters viz., number of pods plant<sup>-1</sup> (23.52), seed weight per plant (9.16 g), seed yield (1868 kg ha<sup>-1</sup>) and haulm yield (3550kg ha<sup>-1</sup>). It was found on par with 100% RDF + foliar spray of nano DAP @ 4 ml litre<sup>-1</sup> 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<sup>-1</sup> of water recorded on par seed yield and yield parameters viz., number of pods plant<sup>-1</sup> (23.25), seed weight per plant (9.04 g), 100 seed weight (21.16), seed yield (1796 kg ha<sup>-1</sup>) and haulm yield (3504kg ha<sup>-1</sup>) with 100 % RDF + foliar spray of nano DAP @ 2 and 4 ml litre<sup>-1</sup> 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 <sup>-1</sup>	Seedweight per plant (g)	100 seed weight (g)	Seedyield (kg ha <sup>-1</sup> )	Haulm yield (kg ha <sup>-1</sup> )	Harvest index (%)
<b>Main plots : RDF levels</b>						
M <sub>1</sub> : 0%	16.32	6.67	18.15	1451	3125	31.55
M <sub>2</sub> : 50%	19.36	7.86	20.28	1609	3333	32.70
M <sub>3</sub> : 75%	22.29	8.76	21.07	1718	3435	33.33
M <sub>4</sub> : 100%	23.42	9.13	21.75	1827	3523	34.14
<b>S.Em±</b>	<b>0.23</b>	<b>0.08</b>	<b>0.19</b>	<b>15</b>	<b>23</b>	<b>0.18</b>
<b>CD @ 5%</b>	<b>0.78</b>	<b>0.28</b>	<b>0.65</b>	<b>50</b>	<b>82</b>	<b>0.63</b>

<b>Sub plots: Nano DAP levels</b>						
S <sub>1</sub> : 2 ml/l of water	20.58	8.09	20.32	1624	3364	32.90
S <sub>2</sub> : 4 ml ml/l of water	21.32	8.39	20.92	1722	3413	33.40
S <sub>3</sub> : Seed treatment@ 5 ml/kg of seeds	19.15	7.85	19.70	1606	3285	32.49
S.Em±	<b>0.15</b>	<b>0.07</b>	<b>0.13</b>	<b>12</b>	<b>8</b>	<b>0.19</b>
CD @ 5%	<b>0.44</b>	<b>0.22</b>	<b>0.38</b>	<b>37</b>	<b>26</b>	<b>NS</b>
<b>Interaction</b>						
M <sub>1</sub> x S <sub>1</sub>	16.26	6.50	18.00	1389	3205	31.94
M <sub>1</sub> x S <sub>2</sub>	18.30	7.34	19.56	1585	3238	32.87
M <sub>1</sub> x S <sub>3</sub>	14.41	6.17	16.90	1375	2930	30.23
M <sub>2</sub> x S <sub>1</sub>	20.11	8.01	20.43	1603	3338	32.45
M <sub>2</sub> x S <sub>2</sub>	20.22	8.00	20.66	1637	3359	32.77
M <sub>2</sub> x S <sub>3</sub>	17.76	7.58	19.76	1588	3303	32.48
M <sub>3</sub> x S <sub>1</sub>	22.51	8.69	21.11	1691	3402	33.21
M <sub>3</sub> x S <sub>2</sub>	23.25	9.04	21.16	1796	3504	33.87
M <sub>3</sub> x S <sub>3</sub>	21.11	8.55	20.93	1666	3399	32.90
M <sub>4</sub> x S <sub>1</sub>	23.44	9.15	21.73	1813	3512	34.04
M <sub>4</sub> x S <sub>2</sub>	23.52	9.16	22.30	1868	3550	34.48
M <sub>4</sub> x S <sub>3</sub>	23.31	9.09	21.21	1798	3507	33.90
S.Em±	<b>0.30</b>	<b>0.15</b>	<b>0.25</b>	<b>25</b>	<b>17</b>	<b>0.37</b>
CD @ 5%	<b>0.89</b>	<b>0.44</b>	<b>NS</b>	<b>74</b>	<b>52</b>	<b>NS</b>

**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 significant (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<sup>-1</sup> of water registered significantly higher quality parameters viz., protein content (19.31 %) and protein yield (361.15 kg ha<sup>-1</sup>). However, it was on par with 100% RDF + foliar spray of nano DAP @ 2 ml litre<sup>-1</sup> 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<sup>-1</sup> 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 <sup>-1</sup> )
<b>Main plot: RDF levels (M)</b>		
M <sub>1</sub> : 0%	14.62	212.25
M <sub>2</sub> : 50%	15.89	255.94
M <sub>3</sub> : 75%	17.70	304.79
M <sub>4</sub> :100%	19.19	350.72
<b>S.Em ±</b>	<b>0.12</b>	<b>5.28</b>
<b>CD at 5 %</b>	<b>0.43</b>	<b>18.27</b>
<b>Sub plot: Nano DAP levels (S)</b>		
S <sub>1</sub> : 2 ml/l of water	16.81	275.60
S <sub>2</sub> : 4 ml ml/l of water	17.43	302.25
S <sub>3</sub> : Seed treatment @ 5 ml/kg of seeds	16.32	264.93
<b>S.Em ±</b>	<b>0.11</b>	<b>3.16</b>
<b>CD at 5 %</b>	<b>0.34</b>	<b>9.48</b>
<b>Interactions (M×S)</b>		
M <sub>1</sub> S <sub>1</sub>	14.72	204.75
M <sub>1</sub> S <sub>2</sub>	14.94	236.85
M <sub>1</sub> S <sub>3</sub>	14.19	195.16

M <sub>2</sub> S <sub>1</sub>	15.73	252.24
M <sub>2</sub> S <sub>2</sub>	16.40	268.46
M <sub>2</sub> S <sub>3</sub>	15.55	247.10
M <sub>3</sub> S <sub>1</sub>	17.57	297.27
M <sub>3</sub> S <sub>2</sub>	19.04	342.52
M <sub>3</sub> S <sub>3</sub>	16.48	274.58
M <sub>4</sub> S <sub>1</sub>	19.20	348.14
M <sub>4</sub> S <sub>2</sub>	19.31	361.15
M <sub>4</sub> S <sub>3</sub>	19.06	342.87
<b>S.Em ±</b>	<b>0.22</b>	<b>6.32</b>
<b>CD at 5 %</b>	<b>0.67</b>	<b>18.95</b>

## CONCLUSION

Application of 100 per cent RDF with foliar spray of nano DAP @ 4 ml litre<sup>-1</sup> of water recorded significantly higher growth, yield and quality of chickpea. The growth and yields obtained with application of 75% RDF + foliar spray of nano DAP @ 4 ml litre<sup>-1</sup> 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<sup>-1</sup> 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.

## REFERENCES

1. Mula, M. G., Gonzales, F. R., Mula, R. P., Gaur, P. M., Gonzales, I. C., Dar, W. D., Eusebio, J. E. and Ilao, S. S. L., Chickpea (Garbanoz): An emerging crop for the rainfed and dryland areas of the Philippines. Information Bulletin No. 88 Patancheru, Andhra Pradesh, India. ICRISAT., 2011, pp. 88.

2. Annual Report, All India Coordinated Research Project on chickpea, Area, Yield and Production for the year 2021-22.
3. Anandhakrishnaveni, S., Palchamy, A. and Mahendran, S., Effect of foliar spray of nutrients on growth and yield of green gram. *Legume Res.*, 2004, 27: 149-50.
4. Solanki, P., Bhargava, A., Chhipa, H., Jain, N. and Panwar, J., Nano-fertilizers and their smart delivery system. *Nanotechnologies in food and agriculture*, 2015, pp. 81-101.
5. Panse, V. G. and Sukhatme, P. V., Statistical Methods for Agricultural Workers, *Indian Council Agric. Res.* 1967; New Delhi.
6. AlqaderSaleh, Al-jobourilaythmazin, Eshoaa H., Effect of nitrogenous and urea nano-hydroxyapatite fertilizer on growth and yield of two cultivars of broad bean (*ViciaFaba L.*). *Euphrates J. Agri. Sci.*, 2020, 12 (2): 598-618.
7. Kumar, N., Manuja, S., Sankhyan, N. K., Kumar, P., Kumar, A. and Sharma, T., Effect of application of nano dap and conventional fertilizers on rice yield. In: *Proc. of Sustainable Agricultural Innovations for Resilient Agri-Food Systems*, 2022, pp. 373
8. Aziz, B. R. and Zrar, D. B., Effect of foliar application of nano-NPK fertilizer on growth and yield of bean (*ViciafabaL.*). *J.PureAppl.Sci.*, 2021, 33(4):90-99.
9. Choudhary, P., Singh, D., Kaushik, M. K., Sharma, S. S., Jain, H. K., Saharan, V., Singh, D. P., Sharma, R. K. and Chouhan, D., Production, productivity and quality of maize (*Zea mays L.*) as affected by foliar application of zinc based nano fertilizer and different fertility levels. *Pharm. Innov. J.*, 2022, 11(2): 1878-1882.
10. Kumar Y, Tiwari K N, Singh T, and Raliya Nanofertilizers and their role in sustainable agriculture. *Annals of Plant and Soil Research*, R, 2021, 23(3): 238-255.
11. Aziz, B. R. and Zrar, D. B., Effect of foliar application of nano-NPK fertilizer on growth and yield of bean (*ViciafabaL.*). *J.PureAppl.Sci.*, 2021, 33(4):90-99.
12. Pruthvi R N, Response of cotton (*GossypiumhirsutumL.*) to seed treatment and foliar application of nano zinc. *M.Sc. Thesis*. University of Agricultural Sciences, Dharwad (India). 2018.
13. Manjunath, G., Effect of nano nutrients on growth, seed yield and quality in cowpea (*Vigna unguiculata L.*). *M.Sc Thesis*, Univ. Agric. Sci., GKVK, Bengaluru, 2018.