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EFFECT OF NANO FORMULATED NITROGEN AND PHOSPHORUS FERTILIZERS ON GROWTH AND YIELD IN CUCUMBER

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ABSTRACT

The experiment entitled "Effect of nano formulated nitrogen and phosphorus fertilizers on growth, yield and economics of cucumber (*Cucumis sativus* L.) was conducted at New orchard, MARS, UAS, Raichur during the *Rabi* of 2022-23. The experiment was laid out in Randomized Complete Block Design (RCBD) with eight treatments replicated thrice. The results revealed that the application of 50% RDN soil application at basal followed by seedling dip in nano-DAP @ 4 ml l-1 and foliar spray of nano-DAP @ 4 ml l-1 at 30 and 45 DAT reported significantly higher performance interms of leaf area per plant (21058 cm^2), leaf area index (1.87), Normalized Difference Vegetation Index (NDVI) (0.77), average fruit weight (95.95 g), fruit yield per plant (2.11 kg), fruit yield per plot (48.77 kg), fruit yield per hectare (18.07 t), gross returns (2,71,050 ha1) and B:C (2.36) compared to nitrogen free control.

***Key words*:** Cucumber, Nano formulated Nitrogen, Nano formulated Phosphorus, Growth, Yield.

Introduction

Vegetables are important nutritive component of the daily diet because of their nutritive value as a vital source of micronutrients, vitamins, minerals. Thus, vegetables are getting increasingly higher importance in India as well as in the world due to their relevance in achieving nutritional security from emerging nutritional problems in human beings. India is the world's second largest producer of vegetables next to China. In India, total area under vegetable production 10.83 million ha with the total production of 196.26 million tons and productivity 17.01 t ha^{-1} (Anon., 2021).

Among the vegetable crops, cucumber (*Cucumis sativus* L.; 2n=2x=14) is considered as one of the major vegetable crops in India as well as in the world. Cucumber is the second most widely cultivated cucurbit in the world after watermelon. In India, it occupies an area of 118 thousand ha with production of 1665 thousand MT (Anon., 2021). Cucumber is grown primarily for processing (pickling) or for fresh market (slicing). The cucumber fruit is said to have cooling effect, prevents constipation and checks jaundice and indigestion. The fruits are eaten with salt and pepper or as ingredient of salad and pickles. Immature fruits are also used with curd for the preparation of "Rayata". Mature fruits are also used as vegetable in India.

The fruits are used as an astringent and antipyretic, while pulp of fruits is used for making cakes. The seed oil is also used as antipyretic. Cucumber contain 96.30 per cent of water and 100 g of fruit contains 0.70 mg protein, 24 mg calcium, 20 universal units of vitamin A, 0.07 mg riboflavin (Vitamin B2) and 0.30 mg of niacin. It has antioxidants which help to discard substances from the body known free radicals. Some free radicals come from natural bodily processes and some come from outside pressures, such as pollution. If more accumulation of free radicals in the body, they can lead to cell damage and various types of diseases.

Currently, nano fertilizers are now being used in specific concentrations in accordance with the nutritional requirements of the crops, ensuring minimal differential losses to improve the nutrient use efficiency. So, these are considered as alternative to conventional fertilizers for better crop yield and productivity.

Material and Methods

The present investigation on "Effect of nano formulated nitrogen and phosphorus fertilizers on growth, yield and quality of cucumber" was carried out at New orchard MARS, UAS, Raichur during 2022-23. The details of the material used and experimental techniques. Cucumber hybrid- Sravani was selected for the present study. Plants were 180-190cm tall, vigorous, uniform with dark green foliage, yellow-coloured flowers and were most suitable for salad purpose.

The data collected from field observations were subjected to statistical analysis by standard analysis of variance (ANOVA) technique as described in "Statistical Procedure for Agricultural Research" by Gomez and Gomez (1984). For significant treatment effects, standard error of means (S.Em.) and critical differences were calculated at 5 per cent level of significance. Data pertaining to different characters were tabulated and subjected to statistical analysis as per the factorial randomized block design. Analysis was done with OPSTAT software. Comparison of treatments was also performed statistically.

Treatment Details

T1: Seedling dip in nano-DAP @ 4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT

T2: 50% RDN soil application at basal + nano-DAP seedling dip @ 4ml/l at transplanting

T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT

T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT

T5: 50% RDN soil application at basal + seedling dip in nano-DAP @4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT

T6: Conventional urea spray @1% at 30 and 45 DAT

T7: RDF soil application (solid fertilizers)

T8: Nitrogen free control

RDF: Recommended Dose of Fertilizer (60:50:80 kg ha-1)

RDN: Recommended Dose of Nitrogen (60 kg ha-1)

DAT: Days After Transplanting

Recommended P and K is common for all the treatments

The experimental field was thoroughly ploughed to bring the soil to fine tilth. Stone, pebbles and residues of the previous crop were removed manually. Preparation of the twelve beds, each measuring 40m length and 1m width was done. The gap between two beds was 0.50m. Cultural operations were done manually, on each bed one driplateral was inserted and finally the beds were covered with black polythene mulch.

Table 1: Plant height (cm) of cucumber at different stages of growth as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	40 DAT	60 DAT
T1: Seedling dip in nano-DAP @4 ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	150.60	190.10
T2: 50% RDN soil application at basal + nano-DAP seedling dip @ 4ml/l at transplanting	164.50	192.50
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	143.30	189.00
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	142.10	217.00
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	158.90	208.40
T6: Conventional urea spray @1% at 30 and 45 DAT	128.20	185.20
T7: RDF soil application (solid fertilizers)	135.40	185.50
T8: Nitrogen free control	129.60	177.10
S.Em. ±	2.00	3.70
C.D @ 5 %	6.00	11.30

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

Results and Discussion

A field experiment on "Effect of nano formulated nitrogen and phosphorus fertilizers on growth, yield of cucumber" was conducted at New orchard MARS, UAS, Raichur during *Rabi* 2022-23. The results are as follows

Plant Height

The data on plant height (Table 1) at different growth stages of cucumber was significantly influenced by the application of nano formulated nitrogen and phosphorus fertilizers. At 40 DAT, significantly taller plants were recorded by soil application of 50% RDN at basal followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} at transplanting (164.50 cm) (T2) which was on par with the application of 50 % RDN at basal followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP fertilizer

Table 2: Leaf area per plant (cm^2) of cucumber at different stages of growth as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	40 DAT	60 DAT
T1: Seedling dip in nano-DAP @4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	13069	18913
T2: 50% RDN soil application at basal +nano-DAP seedling dip @ 4ml/l at transplanting	14410	16513
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	11758	18498
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	11787	20906
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	14362	21058
T6: Conventional urea spray @1% at 30 and 45 DAT	9120	14592
T7: RDF soil application (solid fertilizers)	10416	14349
T8: Nitrogen free control	9010	12512
S.Em. ±	422	417
C.D @ 5 %	1279	1264

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

@ 4.0 ml l^{-1} at 30 and 45 DAT (158.90 cm) (T5). The dwarf plants were observed in conventional urea spray @ 1% at 30 and 45 DAT (128.20 cm) (T6).

At 60 DAT, significantly higher plant height was recorded by application of 50% RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (217.00 cm) (T4) which was on par with the basal application of 50 % RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4 ml l^{-1} at 30 and 45 DAT (208.40 cm) (T5). The lowest plant height was observed in nitrogen free control (177.10 cm) (T8). Present findings are in line with the reports of Lekshmi *et al.,* (2023) which showed that application nano-NPK recorded significantly higher plant height in okra.

Leaf Area

Leaf area per plant of cucumber (Table 2) differed significantly at different growth stages (Table 2). Significantly larger leaves were recorded at 40 DAT by application of 50 % RDN followed by seedling dip in

Table 3: Days to first flowering and days to 50% flowering of cucumber as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	Days to first flowering	Days to 50 % flowering
T1: Seedling dip in nano-DAP @4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	14.33	17.33
T2: 50% RDN soil application at basal +nano-DAP seedling dip @ 4ml/l at transplanting	13.67	16.67
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	14.00	17.67
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	14.33	17.33
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	14.00	17.00
T6: Conventional urea spray @1% at 30 and 45 DAT	16.00	21.00
T7: RDF soil application (solid fertilizers)	15.00	18.67
T8: Nitrogen free control	16.00	21.33
S.Em. ±	0.29	0.44
C.D @ 5 %	0.87	1.34

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

nano-DAP @ 4.0 ml l^{-1} at transplanting (14410 cm^2) (T2) which was on par with the basal application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (14362 cm^2) (T5). The smaller leaf area per plant was recorded in N free control (9010 cm^2) (T8).

Significantly larger leaves per plant were recorded at 60 DAT by application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (21058 cm^2) (T5). It was on par with the application of 50% RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (20906 cm^2) (T4). The lowest leaf area per plant was recorded in nitrogen free control (12512cm^2) (T8). Similar outcomes on application of 50% nano N increased the leaf area per plant of lettuce reported by Nofal *et al.,* (2021).

Table 4: Average fruit weight and Fruits per plant of cucumber as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	Average fruit weight (g)	Fruits per plant
T1: Seedling dip in nano-DAP @4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	91.83	18.67
T2: 50% RDN soil application at basal +nano-DAP seedling dip @ 4ml/l at transplanting	89.33	17.67
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	90.50	18.67
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	94.85	19.33
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	95.95	19.67
T6: Conventional urea spray @1% at 30 and 45 DAT	85.67	16.33
T7: RDF soil application (solid fertilizers)	86.00	16.00
T8: Nitrogen free control	86.67	15.00
S.Em. ±	1.14	0.30
C.D @ 5 %	3.46	0.90

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

Table 5: Fruit girth and fruit length of cucumber as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	Fruit girth (cm)	Fruit length (cm)
T1: Seedling dip in nano-DAP @4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	3.27	17.27
T2: 50% RDN soil application at basal +nano-DAP seedling dip @ 4ml/l at transplanting	3.14	17.96
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	3.19	17.33
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	3.32	18.17
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	3.37	18.12
T6: Conventional urea spray @1% at 30 and 45 DAT	3.03	17.17
T7: RDF soil application (solid fertilizers)	2.93	17.21
T8: Nitrogen free control	2.79	17.33
S.Em. ±	0.03	NS
C.D @ 5 %	0.09	NS

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

Days to 50 percent flowering

Data on days to 50 per cent flowering of different treatments was recorded (Table 3). Minimum number of days for 50 per cent flowering (16.67) was recorded by application of 50 % RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} at transplanting (T2) which is on par with the basal application of 50% RDN followed by seedling dip of nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (17) (T5). Whereas, nitrogen free control (21.33) (T8) recorded maximum number of days for flowering. Similar results were obtained by Ali *et al.,* (2021) imn tulip.

Average fruit weight

The data on average fruit weight was recorded (Table 4) and significantly influenced by the application of nano formulated nitrogen and phosphorus fertilizers. Application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) recorded significantly higher average fruit weight (95.95 g) which is on par with basal application of 50 % RDN followed by foliar spray of nano-DAP @ 4 ml l^{-1} at 30 and 45 DAT (94.85 g) (T4) and it produced 11.50 per cent higher average fruit weight as compared to recommended dose of fertilizers soil application. Whereas, lowest average fruit weight was recorded in conventional urea spray @ 1% at 30 and 45 DAT (T6) *i.e.,* 85.67 g which is on par with nitrogen free control (86.67 g) (T8).

The increased average fruit weight of cucumber by application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP Maximum fruits per plant obtained by application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4 ml l^{-1} at 30 and 45 DAT (T5) due to application of foliar nano fertilizers which plays vital role for extended vegetative growth, metabolism

Table 6: Fruit yield per plant, fruit yield per plot and fruit yield per hectare of cucumber as influenced by the application of nano formulated nitrogen and diammonium phosphate.

Treatments	Fruit yield per plant (kg)	Fruit yield per plot (kg)	Fruit yield (t)
T1: Seedling dip in nano-DAP @4ml/l + nano urea spray @ 4ml/l at 30 and 45 DAT	1.94	45.50	16.87
T2: 50% RDN soil application at basal + nano-DAP seedling dip @ 4ml/l at transplanting	1.86	42.90	15.90
T3: 50% RDN soil application at basal + nano urea spray @ 4ml/l at 30 and 45 DAT	1.95	45.23	16.77
T4: 50% RDN soil application at basal + nano-DAP spray @ 4ml/l at 30 and 45 DAT	2.03	47.03	17.43
T5: 50% RDN soil application at basal + Seedling dip in nano-DAP @ 4ml/l + foliar spray of nano-DAP @ 4ml/l at 30 and 45 DAT	2.11	48.77	18.07
T6: Conventional urea spray @1% at 30 and 45 DAT	1.73	39.93	14.80
T7: RDF soil application (solid fertilizers)	1.69	38.83	14.40
T8: Nitrogen free control	1.60	36.77	13.60
S.Em. ±	0.02	0.62	0.23
CD @5%	0.07	1.89	0.69

RDF: Recommended Dose of Fertilizer (60: 50: 80 kg/ha)
RDN: Recommended Dose of Nitrogen (60 kg/ha)
DAT: Days After Transplanting

of RNA, proteins and DNA formation. The increased vegetative growth and balance C/N ratio lead to increased synthesis of carbohydrate which ultimately promoted greater number of fruits. Present findings are in agreement with the results of Lekshmi *et al.,* (2023) in okra.

Fruit girth

The data on fruit girth of different treatments was recorded (Table 5). It was recorded significantly higher (3.37 cm) by application of 50% RDN followed by seedling dip of nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l-1 at 30 and 45 DAT (T5) which is on par with basal application of 50 % RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (3.32 cm) (T4) and it produced 15.01 per cent higher fruit girth has compared to recommended dose of fertilizers soil application. The lowest fruit girth was recorded in nitrogen free control (2.79 cm) (T8).

Higher fruit girth was noticed by application of 50% RDN followed by seedling dip of nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT might be due to greater leaf area per plant, LAI, dry matter production and its accumulation. Sufficient supply of nitrogen and phosphorus through different sources also responsible for production of larger fruits. These research findings were in line with work of Lekshmi *et al.,* (2023).

Fruit yield per plant

It was significantly influenced (Table 6) by the application of nano formulated nitrogen and phosphorus fertilizers. Application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) recorded significantly higher fruit yield per plant (2.11 kg) which is on par with basal application of 50 % RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (2.03 kg) (T4) and it produced 24.85 per cent higher fruit yield per plant as compared to recommended dose of fertilizers soil application. Whereas, lowest fruit yield per plant was recorded in nitrogen free control *i.e.*, 1.60 kg (T8) compared to all other treatments.

Significantly higher fruit yield per plant was obtained by application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) was due to foliar feeding of fertilizers which enhances plant height, leaf area, LAI, dry matter production, chlorophyll production, rate of the photosynthesis resulting in more production and translocation of photosynthates to different parts of the plant which leads to increase number of fruits per plant and fruit yield per plant (Akhlesh *et al*., 2020). Lower yield in nitrogen free control was mainly due to competition for nitrogen among the crop plants has resulted improper growth and poor yield. These results were in accordance with the findings of Merghany *et al*., (2019) in cucumber.

Fruit yield per plot

Data on fruit yield per plot of different treatments was recorded (Table 6). Fruit yield per plot was recorded significantly higher (48.77 kg) by application of 50% RDN followed by seedling dip of nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) which is on par with basal application of 50 % RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30

and 45 DAT (47.03 kg) (T4) and it produced 25.59 per cent higher fruit yield per plot as compared to recommended dose of fertilizers soil application. The lowest fruit yield per plot was recorded in nitrogen free control (36.77 kg) (T8).

Fruit yield per hectare

Fruit yield per hectare (Table 6) was significantly influenced by the application of nano formulated nitrogen and phosphorus fertilizers. Application of 50% RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) recorded significantly higher fruit yield per hectare (18.07 t) which is on par with basal application of 50% RDN followed by foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (17.43 t) (T4) and it produced 25.40 per cent higher fruit yield per hectare as compared to recommended dose of fertilizers soil application. Whereas, lowest fruit yield per hectare was recorded in nitrogen free control *i.e.*, 13.60 t (T8) compared to all other treatments.

Fruit yield of cucumber was mainly dependent on yield attributes such average fruit weight, fruit girth and fruit yield per plant. These yield attributes were recorded higher by application of 50 % RDN followed by seedling dip in nano-DAP @ 4.0 ml l^{-1} and foliar spray of nano-DAP @ 4.0 ml l^{-1} at 30 and 45 DAT (T5) due to the interaction between nano particle and fertilization achieved increased concentrations of nitrogen and phosphorus elements in the fruits, therefore, this reflected positively on the increase ingrowth and yield (Al-Jabri *et al.*, 2020). These results are in close conformity with the earlier findings of Lekshmi *et al.*, (2023).

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