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Evaluation of Effect of Nano DAP Fertilizer on Growth, Yield Performance and on Cost of Cultivation in Potato (*Solanum Tuberosum* L.)

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Abstract

A study was conducted for the evaluation of effect of nano DAP fertilizer on production and economic feasibility of potato crop during rabi season in 2021 and 2022 in village Chattanpura in district Firozabad, Uttar Pradesh. The fertilizer treatment was done at various stages before and after sowing. Before sowing, potato tubers were dipped in Nano DAP solution at a concentration of 0.5% (5 ml per litre of water). The Nano DAP was sprayed at two times during crop cultivation; first after 35 days of sowing and second after 54days of sowing. After 60 days of growth, the weight of potato tubers per plant was found increased with an average weight of 159 g which was high as compared to the T1 and T2 plants.The cost benefit ratio was evaluated from cultivation to harvesting of potato crop. It was noted that the cost: benefit ratio was highest in the T3 plot (1:2.02) as compared to the T1 plot (1:1.79). The net income was found highest in the T2 plants because the total yield was maximum in T2 plot (408 q) as compared to the T1 (396 q) and T3 (402 q) plots.

Key words: Solanumtuberosum, Nano DAP, FCO, cost benefit ratio, FFP

Introduction

Potato (*Solanumtuberosum* L.) is a nutritional warehouse, offering both affordability and flexibility as India's favourite vegetable. Potato has been regarded as the most valuable food crop of the developing as well as developed countries of the world. Potato is a temperate crop and is grown under subtropical climate in India. The potato is a staple crop which has always been the 'poor man's friend'. In India, potato is being cultivated for the last more than 300 years. It has become one of the most consumed vegetable crops of the country. Potatoes are low priced food; they provide a source of human dietary energy. Potatoes are a rich source of starch, vitamins, especially C and B1 and many minerals. They contain 20.6 % carbohydrates, 2.1 % protein, 0.3 % fat, 1.1 % crude fibre and 0.9 % ash. Potatoes also contain good quantity of essential amino acids like leucine, tryptophan and isoleucine etc.

Potatoes are also used for obtaining several industrial products, such as starch and alcohol. Potato starch (farina) is used in laundries for sizing yarn in textile mills. Potatoes are also used for the production of dextrin and glucose. A large number of food items and dishes are prepared using potato as a main ingredient. Apart from food use, potato products are being used for non-food applications such as biodegradable packaging, fermentation, vaccines and pharmaceuticals[8].

The contribution of Uttar Pradesh alone in the area, production, and productivity is 0.65 mha, 15.58 mt, and 22.7 t/ha respectively. As far as potato production statistics in Uttar Pradesh in the

current and last year; it was reported 25,963.000 kg/ha, which had been an all-time high production as compared to the 2021 cultivation of 25,484.000 kg/ha (CEIC data**,** 2024). In the year 2021-22, the potato crop contributed more than Rs. 67000 crore as gross production value[10]. Within seventy five years of independence, India has achieved the total potato production of more than 60 million tonnes with an average of 25t/ha[10].

Potato is a massive feeder crop, requiring proper nutrient supplement and management (Mishra, 2018). A fertilizer dose combination of 180-240 kg N, 60-90 kg P_2O_5 and 85-125 kg K_2O is recommended for alluvial soils of Indo-Gangetic plains. Whole of phosphorous and potash are applied as basal dressing. Half of nitrogen is applied at planting and the remaining nitrogen at the time of earthing-up. In order to overcome the limitations of conventional chemical fertilizers, some nano-fertilizers are available, that can reduce the doses of fertilizers and multi-nutrient deficiency in soil by increasing nutrient use efficiency[9,11]. The nano particles are characterized by their small size and large specific surface area, making them be ideal materials in the manufacture of fertilizers called smart fertilizers after encapsulation with polymers or chelated to be slow release to suit the stages of plant[7].

Nano-DAP fertilizer is a very potential source of available nitrogen (N) and phosphorus (P_2O_5) for the major crops. It helps in satisfying the Nitrogen & Phosphorus deficiencies in standing crops like potato. One of the most important advantages of nano-technology based nano-fertilizer is the application of nutrients in proportion to the growth of the crop to meet the nutritional needs and high accuracy and then achieve a high yield of the crop[2]. The formulation of nano-DAP contains Nitrogen (8.0% N w/v) and Phosphorus (16.0 % P_2O_5 w/v). Liquid nano-DAP has an advantage in terms of surface area to volume, as its particle size is less than 100 nanometre (nm). The nano particles enter easily inside the seed surface or through stomata and other plant openings. Nano clusters of Nitrogen and Phosphorus in nano-DAP are activated with bio-polymers and other excipients. Enhanced dissemination capability and assimilation of nano-DAP within the plant system results in higher seed vigour, more chlorophyll production, photosynthetic efficiency, and qualitative and quantitative improvement in crop yields. Besides, Nano DAP through precision and targeted application satisfies the nutritional requirement of potato crop without harming the environment. Nano-fertilizers are one of the most promising engineered materials that are being tested, either for soil or foliar applications[4]. Instead of chemical fertilizers, effective utilization of nano fertilizers is vital in preventing the over dosage of fertilizers and also play an important role in reducing pollution and leaching, while being cost effective.

Nano DAP (Liquid) is the first new nano-fertilizer notified under Fertilizer Control Order (FCO, 1985). It is made in India fertiliser with more than 90% nutrient efficiency under optimum filed conditions. The nutritional quality of field crops production and availability, their sufficiently effective legislation, and associated risk management is the prime limiting factors in their general adoption as plant nutrient sources. IFFCO has successfully innovated and achieved the goal of the development and manufacturing of Nano Urea[3].

Nano-fertilizers of less than 100 nm size, has emerged as an innovative

science to develop concentrated sources of plant nutrients having higher absorption rates, utilization efficacy, and minimum losses. Chemical fertilizer contributes to over 40% of our agriculture's food grain production. Due to ultra-small particle size, such nutrients can rapidly be uptake by the plants so minimizing nutrient losses. Inside the plant cell, these nutrients slowly release the active nutrient component which involves in the plant's cellular metabolism for their growth and development[1]. The field application of Nano DAP reduces excessive application of bulk fertilizers like DAP and reduction in associated volatilization, leaching and run off losses. Precision and targeted application of Nano DAP to crops therefore leads to agriculture sustainability and safety of the environment by reducing soil, air and water pollution.

IFFCO Nano DAP increases farmer's income due to reduction in input cost, higher crop yield and better quality of crop produce.

The present investigation outcomes in terms of both yield of potato crop production and the cultivation cost.

Material and Methods

A field performance study to evaluate the effect of nano-urea on growth, yield in potato crop was carried out during the Rabi season- from November 2021 to February 2022. A potato cultivation cost evaluation was also carried out to compare the economic viability of the use of nano-urea and the granular urea. The experiments were conducted at the farmland of the village Chattanpura in district Firozabad, Uttar Pradesh. Firozabad is located in north central India, in western Uttar Pradesh state, 40 km away from Agra and around 240 km away from Delhi, at the northern edge of the Deccan Plateau, at 27°09′N 78°24′E / 27.15°N 78.4°E / 27.15; 78.4. The height above sea level is 164 meters (540 ft). The agricultural field is situated in North-Central India in the western part of Uttar Pradesh. It is located at 27.054465 degree latitude and 78.580337 degree longitude. The entire district of Firozabad, is a vast level plain. The climate of Firozabad is extremely dry.In winter the temperature can go down to as low as 2° C. The winter months are almost dry, with virtually no rainfall.

The experiments were conducted in plots for three treatments with or without Farmer's Fertilizer Practice (FFP). These are- T1(FFP 100% DAP), T2 (FFP 50% + Nano DAPat the rate of 0.25%) and and T3 (FFP 0%+ Nano DAP at the rate of 0.25%). The variety……..of potato was used for study. Potato tubers were sown in the 2nd fortnight of November 2021. Before sowing, potato tubers were dipped in Nano DAP solution at a concentration of 0.5% (5 ml per litre of water) and sown in experimental plots T2 and T3. The experimental plot T1 was kept untreated with NanoDAP as control. The Nano DAP was sprayed at two times during crop cultivation; first after 35 days of sowing and second after 54days of sowing. The data for various agronomic parameters and yield performance were recorded at 60 days, 75 days of crop cultivation. Crop harvesting was done after 126 days of crop, in the month of March 2022. The post-harvest evaluation for cost of cultivation and cost benefit ratio of IFFCO Nano DAP was carried out for all the three treatments. The average values were calculated for various growth parameters.

Results and Discussion

Many researchers worldwide have reported that nitrogen management through nano- fertilizers is one of the important approaches in achieving high productivity of potato[5,6].

Plant height: The data of plant height, after 60 day of sowing, showed that no significant effect was observed when IFFCO DAP Nano-fertilizer was sprayed on the crop. However, maximum mean plant height (93 cm) was recorded in the plot T1 plants where DAP Nano-fertilizer was not used and the plants were grown by using FFP and 100% DAP in granular form. In T2 and T2 plants, the average plant height was recorded to be 91 and 92 cm, respectively (Table 1).

After 75 days of growth, no increase in plant height was recorded in the plants of all the three categories. The T1 plants, cultivated only on the FFP and without addition of IFFCO DAP Nano fertilizer gave maximum plant height (93 cm) (Table.2).

Shoot length: After 60 days of sowing, the data of shoot length, showed that no significant effect was recorded on the shoot length when IFFCO DAP Nano-fertilizer was sprayed on the crop. The maximum mean shoot length (73 cm) was observed in the plot T1 plants where IFFCO DAP Nano-fertilizer was not used and the plants were grown by using FFP and 100% DAP in granular form. In both T2 and T2 plants, the average plant height was recorded to be 70 cm (Table 1). No any further increase in shoot length was recorded after 75 days of growth.

Root length: The data of root length, after 60 day of sowing, showed that no significant effect was observed when IFFCO DAP Nano-fertilizer was sprayed on the crop. However, maximum mean root length (22 cm) was recorded in the plot T3 plants where DAP Nano-fertilizer was used (FFP 0%+ 0.25% Nano DAP). In T1 and T2 plants, the average plant height was recorded to be 20 and 21 cm, respectively (Table 1).

A remarkable promotive effect of use of DAP Nano fertilizer on the root length was observed after 75 days of growth. The mean root length increased in the plants of both T2 (28 cm) and T3 (29) plots when DAP Nano fertilizer was applied in a concentration of FFP+ Nano DAP (0.25%) and only Nano DAP (0.25%) without FFP, respectively (Table.2).

Plant weight: Weight of plant shows its growth and health. A healthy plant may have more weight (biomass). In this reference, the use of IFFCO DAP Nano-fertilizer was found to be useful. After 60 days of sowing, in the plants of T3 plot, a significant enhance in weight was recorded. The average weight of plant (775 g) was observed in the T3 plants where DAP Nano-fertilizer was used (FFP 0%+ 0.25% Nano DAP). The plants of T1 were showing minimum average biomass (751 g). Effect of IFFCO DAP Nano-fertilizer was slightly promotive when it was used in FFP+ 50% DAP + 0.25% Nano DAP combination on the T2 plants (Table.1).

Among various growth parameters, the plant weight was found to be highly responsive when IFFCO DAP Nano fertilizer was applied. After 75 days of growth, the average plant weight was recorded maximum in the T3 plants (1020 g). In the T2 plants also the plant weight enhanced remarkably (1008 g). The average weight of plant was recorded minimum in the T1 plants (957 g) (Table.3).

Shoot weight: Effect of IFFCO DAP Nano fertilizer on the weight of shoot

was recorded to be slightly negative. After 60 days, the growth of the plant was satisfactory but the average weight of shoot in the T3 plants was recorded minimum of all the treatments (530 g). However, in the plants of treatment T2, the shoot weight increased significantly (564 g) as compared to the T1 plants shoot weight (549 g) grown without supplementation of IFFCO DAP Nano fertilizer (Table.1).

After 75 days of growth, a decrease in shoot weight was recorded in all the three treatments. It showed that role of IFFCO DAP Nano fertilizer was not significant in reduction of the mean shoot weight. However, weight reduction was less in the T3 plants as compared to the T1 and T2 plants (Table.2).

Root weight: After 60 days of growth, the mean root weight was recorded for all three treatments. The effect of IFFCO DAP Nano fertilizer was found to be promotive. However the effect was not remarkably variable. In the plants of T1 treatment, the mean root weight was recorded to be 84 g. On addition of IFFCO DAP Nano fertilizer (0.25% Nano DAP), the root weight slightly enhanced (86 g), but it was non- significant. A combination of FFP (50%) and DAP Nano fertilizer (0.25%) expressed negative effect as the mean root weight decreased (78 g) (Table.1).

Similar results were obtained with reference to the root weight. A reduction in mean root weight was recorded in all the three treatment plots after 75 days of the growth.

No. of tubers/plant: The most economically viable parameter is the number of tubers per plant; as the potato crop is used for its tubers. The number of tubers directly shows the yield of the plant. After 60 days of growth, the number of potato tubers per plant was found highest in the T3 plant (22), which is significantly high as compared to the T1 and T2 plants (Table.1).

After 75 days of growth, a significant and highly positive effect on number of tubers per plants was observed. After 75 days of growth, number of potato tubers was recorded. It was observed that number of tubers per plant remained unchanged in the plants of T1 and T3 plots (Table.2). In the T2 plants, mean root weight increased by 4 g (Table.2).

Weight of tubers: The weight of potato tubers directly correlates with the yield of the crop. After 60 days of growth, the weight of potato tubers per plant enhanced significantly in the plants of T3 treatment. An average weight of tubers was recorded to be 159 g which is high as compared to the T1 and T2 plants. In the T3 plants, only IFFCO DAP Nano fertilizer was applied (0.25 %). A combination of FFP (50%) and IFFCO DAP (0.25%) showed a negative effect on the tuber weight (115 g) (Table.1).

Growth of potato tubers during 60-75 days is critical. It has been observed that during this period, weight of tubers increased 3-4 times. The maximum mean tuber weight was recorded in the plants grown in T3 plot (470 g), in which DAP Nano fertilizer was sprayed at a rate of 0.25% without FFP (Table.2). However, effect of DAP Nano fertilizer on the increase of potato tuber weight was found optimum in the plants grown on FFP 50% and DAP Nano fertilizer (0.25%) during 61 to 75 days of growth (463 g) (Table.2).

Table 1 Evaluation of field performance of potato crop treated with IFFCO DAP Nano-fertilizer after 60 days of sowing for various growth parameters and yield attributes

S. No.	Parameters	T_1 FFP 100% DAP (M±SD)	T_2 FFP 50% DAP + 0.25% Nano DAP (M±SD)	T_3 FFP 0% DAP + 0.25% Nano DAP (M±SD)
1	Plant height (cm)	93±3.00	91±1.22	92±2.54
2	Shoot length (cm)	73±4.30	70±3.67	70±3.49
3	Root length (cm)	20±1.87	21±2.73	22±2.73
4	Plant weight (g)	751±3.67	757±5.43	775±3.39
5	Shoot weight (g)	549±5.24	564±3.74	530±3.80
6	Root weight (g)	84±4.06	78±2.23	89±2.23
7	No. of tubers/plant	17±2.12	18±2.73	22±5.84
8	Weight of tubers (g)	118±2.23	115±3.08	159±2.91

Table 2 Evaluation of field performance of potato crop treated with IFFCO DAP Nano-fertilizer after 75 days of sowing for various growth parameters and yield attributes

S. No.	Parameters	T_1 FFP 100% DAP (M±SD)	T_2 FFP 50% DAP + 0.25% Nano DAP (M±SD)	T_3 FFP 0% DAP + 0.25% Nano DAP (M±SD)
1	Plant height (cm)	93±1.22	92±2.54	92±2.77
2	Shoot length (cm)	73±2.91	70±1.87	70±1.87
3	Root length (cm)	23±2.54	28±1.87	29±2.73
4	Plant weight (g)	957±6.28	1008±3.08	1020±7.90
5	Shoot weight (g)	456±4.30	475±4.74	480±8.36
6	Root weight (g)	66±1.58	70±2.91	70±2.54
7	No. of tubers/plant	17±3.08	22±1.22	22±1.58
8	Weight of tubers (g)	435±9.92	463±5.38	470±2.73

Cost of cultivation: Potato is a cash crop. It has high market value for its various processed products and it is mostly consumed with other vegetables as potato enhances the taste of various dishes along with providing a massive volume to the recipe. It is a low cost food, affordable by a large population worldwide. The cost of cultivation and cost-benefit ratio of the produce of all the three plots were evaluated and compared with the potato crop grown traditionally by using FFP practices.

The cost of cultivation evaluated was found to be highest for the plot T1. In the traditional FFP method, the potato crop was fed with DAP that was a major factor of high cultivation cost. In the T2 plot, the cost of DAP reduced to half and in T3 it was nil, as no DAP was used in cultivation of these plants (Table.3). Similarly, the cost of IFFCO DAP Nano fertilizer is nominal (INR 900.00/L) as compared to the granular DAPbag (INR 1200.00/50 kg).Total cost of granular DAP (18 bags) and total cost of Nano DAP (2 Litre) reduced the cost of cultivation of potato

crop in T3 plot. The total cost of cultivation was INR 170182.00 per hectare when FFP DAP was applied and it was only INR 159982.00 per hectare when IFFCO DAP Nano fertilizer was applied (Table.3).

Cost-benefit ratio: The cost benefit ratio was evaluated from cultivation to harvesting of potato crop. It was found that the cost: benefit ratio was highest in the T3 plot (1:2.02) as compared to the T1 plot (1:1.79) (Table. 4). The net income was found highest in the T2 plants because the total yield was maximum in T2 plot (408 q) as compared to the T1 (396 q) and T3 (402 q) plots (Table. 4).

Table 3 Comparative evaluation of cost of cultivation of potato crop per hectare after using IFFCO DAP Nano-fertilizer (crop harvested after 126 days)

S. no.	Head of expenditures on crop cultivation	Quantity	Rate (in INR)	Total cost (in INR)		
				T_1	T_2	T_3
1	Ploughing & sowing	4 1	1000+ 4800	16800	16800	16800
2	Irrigation before sowing	1	2500	2500	2500	2500
3	Seed	50 (q)	1500	75000	75000	75000
4	Fertilizers and allied – (i) DAP (ii) Urea (2 dose) (iii) Potash (iv) Sulphur/Zinc/others (v) Nano DAP cost	 18 bags 24 bags 18 bags ----- -----	 1200 266.50 850 2850	 14400 2132 5100 2850 00	 7200 2132 5100 2850 900	 00 2132 5100 2850 1350
5	Plant protection & allied- *(i) Seed treatment* *(ii) Fungicide spray* *(iii) Weed eradication*	 1 time 2 times 1 time	 1500 2500 2000	 1500 5000 2000	 1500 5000 2000	 1500 5000 2000
6	Irrigation	3 times	2500	7500	7500	7500
7	Inter culture operation etc	----	2000	2000	2000	2000
8	Labour charges *(sowing, Fertilizer application, Sprays & other activities)*	-------	12500	12500	12500	12500
9	Harvesting/grading	-----	22000	22000	22000	22000
10	Bardana	-----	1750	1750	1750	1750
11	Total cost of Cultivation	-----	-------	170182	166732	159982

Table 4 Comparison of cost of cultivation and Cost-benefit ratio in potato after using IFFCO DAP Nano-fertilizer (crop harvested after 126 days) per hectare

S. no.	Evaluation parameters	T_1 FFP+100% DAP	T_2 FFP+ 50% DAP + 0.25% Nano DAP	T_3 FFP 0%+ 0.25% Nano DAP
1	Cost of cultivation (in INR)	170182	166732	159982
2	Yield (q)	396	408	402
3	Gross income (in INR)	475200	489600	482400
4	Net income (in INR)	305018	322868	322418
5	Additional profit (in INR)*	00	17850	17400
6	Cost: benefit ratio for Net cost	1:1.79	1:1.94	1:2.02

* Estimation of additional profit is made by comparing net income of T2 and T3 with T1

Conclusion

The agriculture is backbone of the economy of India. The farmers are solely dependent upon the agricultural production and economic outcomes. The potato crop production and profit are directly related to the yield. On the basis of the results of the present investigation, it can be concluded that the use of FFP and granular DAP, as traditionally, low yield could be obtained. The yield could be increased by applying the IFFCO Nano DAP. It not only reduces the cost of cultivation but also enhances the crop yield. Nano DAP reduces the cost of cultivation upto 6%. Net profit is also gained upto 6%. It can be concluded that use of Nano DAP is economically beneficial and convenient to apply on crops.

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