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Effect of phosphorus and nano urea on yield and economics of maize (*Zea mays L.*)

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Abstract
A field experiment was conducted during *Kharif* season 2023 at Crop Research Farm, Department of Agronomy. Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh. The treatments consisted of three levels of Phosphorus (40, 60 and 80 kg/ha) and three levels of Nano Urea (01, 03 and 04 ml/l) along with control (120-80-40 NPK kg/ha). The experiment was laid out in a Randomized Block Design with ten treatments which have replicated thrice. The results of the experiment revealed that the Application of Phosphorus at 60 kg/ha along with Nano Urea 03 ml/l (Treatment 8) recorded significantly higher Seed yield (05.54 t/ha), higher Stover yield (08.29 t/ha) and harvest index (35.86%). The same treatment also recorded maximum gross return (INR.110019.80 /ha), net return (INR. 66939.84 /ha) and benefit cost ratio (1.55).

Keywords: Maize, phosphorus, nano urea, yield and economics

Introduction
After rice and wheat, maize (*Zea mays L.*) is one of the most significant cereal crops and is widely used in agriculture worldwide. In India, it is ranked third, behind wheat and rice. It is grown in India for industrial purposes, as well as for use as a component in feed mixtures for cattle and poultry, and as grain and fodder. One of the world's most important and strategically placed crops is maize, often known as corn. Mexico is the country of origin (Central America). Because of its high production potential and greater seasonal adaptability, this C_4 plant is referred to as the "Queen of Cereals."

It is known as the "Miracle Crop" due to its efficient use of solar energy and tremendous potential for increasing output. Maize is crucial for food and nutritional security due to its high protein content. Protein contributes to the nutritional profile of 100 g of maize: Four grams. 30 grams of carbohydrates, 3.5 grams of fiber, 1.5 grams of fat, 3.6 grams of sugar, 4 milligrams of calcium, 0.72 milligrams of zinc, and so on (Dragana *et al*., 2015) [4]. The maize plant's grain, leaves, stalk, tassel, and cob are all economically valuable and used to make a variety of food and non-food goods.

Over 170 countries farm 188 million hectares of maize, yielding 1423 million tonnes of grain. Since 2005, India has placed sixth in terms of annual production at 31.65 million MT and fourth in terms of area, with 9.89 million hectares under corn. Madhya Pradesh and Karnataka, India, have the highest percentage of maize-planted land (15%). These states are followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%), Bihar (7%), and Telangana (6%). Currently, 47% of maize farmed in India is used to feed poultry, 13% to feed cattle, 13% for food, 14% for the starch industry, and the remaining 7% and 6% for export and other purposes. (2020, IIMR).

Phosphate molecules store energy from photosynthesis and the metabolism of carbohydrates for use in subsequent processes like as development and reproduction (Ayub *et al.* (2002) [2]. According to Ali *et al.* (2002) [1], it is easily transferred across plants, going from older to younger tissues as the plant divides into cells and grows roots, stems, and leaves.

Faster growth, early maturity, and higher-quality vegetative development are all encouraged by enough P. Lack of phosphorus makes maize kernels twist and form small ears, or nubbies, which leads to uneven and absent rows.

Higher vegetative growth quality, early maturity, and faster growth all need on adequate phosphorus levels. Phosphorus is required for a number of essential functions in plants, but its function in the transport and storage of energy is by far the most important. Seeds contain a large amount of phosphorus, which is assumed to be essential for seed formation. According to Ibrahim *et al.* (2007), phosphorus is required for the inflorescence, grain growth, ripening, and reproductive components of maize plants.

Development, nucleus formation, photosynthesis, utilization of carbohydrates and sugar, cell division, and the production of fat and albumen all depend on it. Within plants, it is easily translocated from older to younger tissues (Ali *et al*. 2002) [1].

After the Industrial Revolution in the middle of the eighteenth century, the nuclear energy revolution in the 1940s, the green revolution in the 1960s, the information technology revolution in the 1980s, and the biotechnology revolution in the 1990s, nanotechnology is emerging as the sixth revolutionary technology of the modern era. These days, a wide range of academic disciplines, including physics, chemistry, biology, material science, electronics, medicine, energy, the environment, and the health sector, are using this rapidly developing and expanding field of study.

Nano fertilizers (NFs) are a type of modern fertilizer or alternative technology that is more efficient, non-toxic, and ecologically benign. Because of its function in increasing nutrient usage efficiency, it has a significant potential to increase plant production and quality.

Nano fertilizers (NFs) are a type of modern fertilizer or alternative technology that is more efficient, non-toxic, and ecologically benign. Because of its function in increasing nutrient usage efficiency, it has a significant potential to increase plant production and quality. Nano fertilizers are very active because of their large surface area (Lee *et al.* 2010) [9]. It had a major effect on germination rates, growth, enhancing nutrient availability, chlorophyll generation, and dry matter production in agriculture. Plant growth is enhanced by their ability to swiftly permeate the soil and plant roots (Dhoke *et al.* 2013) [3].

Plants only consume about 30–40% of the nitrogen in urea; the remainder is lost to rapid chemical transformation from leaching, volatilization, denitrification, and runoff, resulting in low usage efficiency. However, nano urea has a high nitrogen use efficiency and is safe for the environment. This fertilizer is known as "smart fertilizer" in popular culture because it reduces the production of nitrous oxide, which is primarily responsible for contaminating soil, air, and water bodies in addition to contributing to global warming. Liquid nano fertilizer is currently the best alternative to urea fertilizer. 45 kg of urea fertilizer may be obtained from a single 500 ml bottle of nano urea, which is 10% less than a bag of normal urea.

In sustainable agriculture, nano-fertilizers are becoming more important because they can boost crop yield, improve nutrient utilization efficiency, and lower cultivation costs and chemical fertilizer waste. In order to address the current issues with nutrient availability and uptake, crop yield, and environmental protection, new developments on the application of nano-fertilizer in agriculture, plant mineral nutrition, soil health, and interactions with soil microorganisms are directed toward a sustainable way by substituting conventional fertilizers with their nano-particulate counterparts possessing superior properties.

With the ability to match crop growth stage to nutrient availability and perhaps supply nutrient throughout the crop growth period, nano-fertilizers are an incredibly useful tool for accurate nutrient management in precision agriculture.

Because they are more reactive and able to pass through cuticles, nano fertilizers ensure focused delivery and regulated release. In terms of nitrogen fertilizers, the use of nanotechnology can produce fertilizers that release nitrogen when crops require it. This will eventually increase the efficiency of nitrogen by reducing emissions and leaching of nitrogen and allowing soil microorganisms to incorporate nitrogen over an extended period of time (Naderi and Danesh-Shahraki, 2013; Suman *et al*. 2010) [10, 11].

The nitrogen-containing nano-fertilizer formulations' pattern of nutrient release. In cereal crops, the nitrogen can be released for a longer duration (> 1000 hours) by the nano-clay based fertilizer formulations (zeolite and montmorillonite, with dimensions of 30–40 nm) than by traditional fertilizers (< 500 hours).

Materials and Methods

A field trial was conducted During *Kharif* season 2023, at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). which is located at 25.43’58’’ N latitude, 81.84’ 63” E longitude and 98 m altitude above the mean sea level (SL). The soil of experimental plot was sandy loam, having a nearly neutral soil reaction (pH 7.1), electrical conductivity 0.48 ds/m, medium in available nitrogen (270.81 kg/ha) and potassium (215.9 kg/ha), and low in available phosphorous (11.5 kg/ha). The experiment was conducted in a Randomized Block Design consisting of ten treatment combinations and three replications. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, single super phosphate (SSP) and murate of potash (MOP), applied as per the recommended dose of 120:80:40 NPK kg/ha. The plot size of each treatment was 3m x 3m. Factors are Phosphorus (40, 60 and 80 kg/ha) and three levels of Foliar spray Nano Urea (01, 03 and 04 ml/l). The Maize crop was sown on 06 August 2023. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The treatment details are as follows T_1: Phosphorus 40 kg/ha + Nano Urea 1 ml/l, T_2: Phosphorus 60 kg/ha + Nano Urea 1 ml/l T_3: Phosphorus 80 kg/ha + Nano Urea 1 ml/l, T_4: Phosphorus 40 kg/ha + Nano Urea 3 ml/l, T_5: Phosphorus 60 kg/ha + Nano Urea 3 ml/l, T_6: Phosphorus 80 kg/ha + Nano Urea 3 ml/l, T_7: Phosphorus 40 kg/ha + Nano Urea 4 ml/l, T_8: Phosphorus 60 kg/ha + Nano Urea 4 ml/l, T_9: Phosphorus 80 kg/ha + Nano Urea 4 ml/l and Control Plot. The observations were recorded for number of cobs/plant, number of seeds/row, number of row/cob, seed index (g), seed yield (t/ha) and stover yield (t/ha), Harvest Index (%). The observed data was statistically analyed using analysis of variance (ANOVA) as applicable to randomized block design (Gomez and Gomez, 1984).

Results and Discussions

Seed yield (t/ha): The data showed that significantly highest grain yield (5.54 t/ha) was found with application of Phosphorus 60 kg/ha along with Nano Urea 4 ml/l whereas treatments 3, 4, 5, 6, 7 and 9 (4.71, 4.85, 5.12, 5.05, 4.90 and 5.35 t/ha respectively) which was found to be statistically at par with all treatments. Significant and higher seed yield was recorded with Phosphorus (60 kg/ha) might be due to phosphorus application, enhanced the yield potential and reproductive parts and the fraction of the total duration devoted to grain filling which leads increase in total grain yield. Similar result was reported.

Nano urea boost their solubility and improve nutritional availability. This increased nutrient uptake nitrogen, can lead to improved plant growth, development. and finally, greater maize yields (Kumar *et al*. 2019) [7]. Improved photosynthetic efficiency can lead to higher biomass accumulation and yield in maize, and nano urea has been shown to specifically improve plant growth parameters like plant height, leaf area, and chlorophyll content.

3.2 Harvest index (%): At harvest, highest harvest index (35.86 %) was recorded in treatment-8 with the application of Phosphorus 60 kg/ha along with Nano Urea 4 ml/l, though there was significant difference among the treatments.

Economics

The data on the economics of different treatments presented in Table 2 showed that the maximum gross return (INR.110019.80 /ha), net return (INR.66939.84 /ha) and benefit-cost ratio (1.55) was recorded treatment-8 with the application of Phosphorus 60 kg/ha along with Nano Urea 04 ml/l and the minimum gross return (INR.64018.80 /ha), net return (INR.21578.80 /ha) and benefit-cost ratio (0.55) was observed in the treatment-10 with the application of N 120 Kg/ha, P 80 kg/ha, K 40 Kg/ha.

Table 1: Influence of phosphorus and nano urea on yield of maize

S. No.	Treatments	Grain yield (t/ha)	Yield Harvest index (%)
1.	Phosphorus 40 kg/ha + Nano urea 1 ml/l	4.37	34.07
2.	Phosphorus 60 kg/ha + Nano urea 1 ml/l	4.34	34.40
3.	Phosphorus 80 kg/ha + Nano urea 1 ml/l	4.71	34.90
4.	Phosphorus 40 kg/ha + Nano urea 3 ml/l	4.85	34.42
5.	Phosphorus 60 kg/ha + Nano urea 3 ml/l	5.12	35.42
6.	Phosphorus 80 kg/ha + Nano urea 3 ml/l	5.05	35.80
7.	Phosphorus 40 kg/ha + Nano urea 4 ml/l	4.90	34.33
8.	Phosphorus 60 kg/ha + Nano urea 4 ml/l	5.54	35.86
9.	Phosphorus 80 kg/ha + Nano urea 4 ml/l	5.35	35.11
10.	N P K 120 80 40 Kg/ha	3.16	25.19
	Ftest	S	S
	SEm(+)	0.45	2.72
	CD (P= 0.05)	0.94	5.72

Table 2: Effect of phosphorus and nano urea on economics of maize

S. No.	Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit Cost Ratio (B:C)
1.	Phosphorus 40 kg/ha + Nano urea 1 ml/l	42145.00	88016.96	45871.96	1.08
2.	Phosphorus 60 kg/ha + Nano urea 1 ml/l	42405.00	86016.34	43611.34	1.02
3.	Phosphorus 80 kg/ha + Nano urea 1 ml/l	42665.00	94017.58	51352.58	1.20
4.	Phosphorus 40 kg/ha + Nano urea 3 ml/l	42595.00	96018.46	53423.46	1.25
5.	Phosphorus 60 kg/ha + Nano urea 3 ml/l	42855.00	102018.60	59163.64	1.38
6.	Phosphorus 80 kg/ha + Nano urea 3 ml/l	43115.00	102018.00	58903.04	1.36
7.	Phosphorus 40 kg/ha + Nano urea 4 ml/l	42820.00	98018.72	55198.72	1.28
8.	Phosphorus 60 kg/ha + Nano urea 4 ml/l	43080.00	110019.80	66939.84	1.55
9.	Phosphorus 80 kg/ha + Nano urea 4 ml/l	43340.00	106019.80	62679.76	1.44
10.	N P K 120 80 40 kg/ha	42440.00	64018.80	21578.80	0.50

Note- Price of grain yield - `20000/t (MSP) and price of stover yield - `2000/t

Conclusion

From the results, it is concluded that application of Phosphorus 60 kg/ha along with nano urea 04 ml/l (Treatment 8) in Maize has recorded highest Grain yield, gross return, net return and benefit cost ratio.

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