The Pharma Innovation Journal 2023; 12(8): 2123-2126

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 2123-2126

www.thepharmajournal.com
Received: 20-05-2023
Accepted: 24-06-2023

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Effect of nano fertilizers on growth and yield of maize (*Zea mays* L.) in Southern Rajasthan

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Abstract
At the Dryland Farming Research Station, Arjia, Bhilwara, MPUAT, Udaipur a field investigation was carried out during *Kharif*, 2022. The investigation was laid out in Randomized Block Design (RBD) made up of eight treatments which were replicated four times. The results revealed that the application of T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS) make out significantly higher growth attributes of plant height, dry matter accumulation and leaf area index, and yield attributes of number of cob/plant (1.63), number of grain/cob (519.0), grain weight/cob (201.8 g), cob length (19.2 cm) and teat weight (237.0 g) as well as grain (52.5 q/ha), stover (84.7 q/ha) and biological yield (137.2 q/ha) over control. Even so, it remained statistically on par with treatment T_8 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS). The finding of this experiment shows that one-half recommended dose of chemical nitrogen fertilizer can be turn down by application of nano nitrogen which may reduce detrimental effect of chemical fertilizers.

Keywords: Nano nitrogen, nano zinc, DAS, RDF, RD-PK, maize, *Kharif*

1. Introduction
Maize (*Zea mays* L.) crop has higher genetic yielding potential compared to rice, wheat and barley. Therefore, it is called as 'miracle crop' and also 'queen of cereals'. It is very efficient in converting solar energy into chemical energy hence, consequently increased dry matter. As heavy feeder of nutrients (Kannan *et al*., 2013) [4]. Maize is the worldwide dominant crop and is widely cultivated as cereal grain. It is a multi-purpose crop used as a food tool for human beings and feed and fodder for animals, and also an outstanding source of biofuel in present context also remained in the past (Kaul *et al*., 2019) [7]. Maize is the sole edible cereal crop that could be grown throughout a number of seasons, making it one of its most adaptable new crops. One of the most adaptable developing crops is this one. In India, maize is grown in 10.04 million hectares area with production and productivity of 33.62 million tonnes and 3348 kg/ha, respectively (Anonymous, 2022) [2]. Further, in Rajasthan, It is grown on 0.95 million hectares, producing 2.04 million tonnes, with a mean productivity of 2147 kg/ha. (Anonymous, 2022) [2].

The majority of Indian soils lack adequate nitrogen levels. In lighter textured soils, it is significantly more prevalent. One of the essential elements for plants, nitrogen is necessary for the manufacture of protein, nucleic acids, growth hormones, and vitamins. It also makes up a major part of chlorophyll. Large-scale materials or extracts from plants, microorganisms or animals are known as nano fertilizers. They originate by chemical, physical, mechanical and biological processes utilising top-down or bottom-up procedures. Nano urea is an important supplier of nitrogen needed for more crop growth and development, ultimately leading to increased productivity. When used at crucial growing phases, IFFCO nano urea efficiently provides crop nitrogen requirements. It can be a substitute for conventional urea for better environment, farmer's profitability and soil health. Nano urea contains 4 per cent by weight in its nano form. The word "nano" is a translation of the Greek word for "dwarf". The word "nano" is defined as one billionth of a metre and 10^{-9}. "Nanoparticles" are defined as particles with more than one dimension smaller than 100 nm. Due to their unique features, high surface area to volume ratio and nanoscale regime, nanoparticles are widely used. (Kumar *et al*., 2021) [9].

Micro nutrient deficiency has been a major problem in recent years due to intensive cultivation. Zinc is the fourth most yield limiting nutrient over globe after nitrogen, phosphorus and potassium.

Zinc deficiency is expected in 36.5 per cent of Indian soils (Khardia *et al*., 2022) [8]. Zinc as a micro nutrient plays many important roles in various physiological and metabolic processes in plant and also have vital function in structural molecules such as DNA and different metabolic and regulatory enzymes. Zinc can be shown to have a vital role in events such as photosynthesis, protein synthesis, cell division, preserving the integrity of membrane structures, resistance to pathogen infection and sexual reproduction through its effects on pollen production, shape and stigma. (Mosanna *et al*., 2015) [11].

2. Materials and Methods

During *kharif*, 2022 a field experiment at Dryland Farming Research Station (DFRS), Arjia, Bhilwara, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India was carried out. The investigation was done to assess the effect of nano fertilizer on growth and yield of maize. Using randomized block design, experiment was laid out with eight treatments *viz*., T_1 (Control), T_2 (100% RDF), T_3 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 DAS), T_4 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 60 DAS), T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS), T_6 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 DAS), T_7 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 60 DAS) and T_8 (50% RDN + RD-PK + nano nitrogen @ 4
ml/l and 0.3 g/l at 30 and 60 DAS) and was replicated four times.

The RDF was 90 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha. As per treatment requirement whole of phosphorus and potassium was applied at the time of sowing. Nitrogen was applied in three split doses, half at the time of sowing and remaining at 30 and 60 DAS in two equal splits. Foliar spray of nano nitrogen and nano zinc was applied as per treatments. The maize crop variety DHM-121 was sown on 21th july, 2022 and using 20 kg seed/ha with a spacing of 60 × 25 cm. (RDF:- Recommended dose of fertilizer), (RD-PK:- Recommended dose of phosphorus and potassium), (DAS:- Day after sowing).

3. Results and Discussion

The data about various crop growth parameters studied of plant height and dry matter accumulation at 35, 70 and at harvest and leaf area index at 35 and 70 DAS were recorded as affected by application of nano fertilizers was given in table 1.

The maximum plant height, dry matter accumulation at 35, 70 DAS and at harvest, leaf area index at 35 and 70 DAS was highest in T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) which was statistically at par with T_8 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS), T_3 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 DAS) and T_4 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 60 DAS). Further, application of T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) recorded significantly higher rest of the treatments. A high concentration of nanofertilizer, which increased auxin synthesis, is responsible for the growth improve. Across all emerging plant sections, auxin could stimulate cell division and cell elongation.

Hence, the improved plant height and growth parameters resulting in increase dry matter with crop growth in progression. Further, this rise may be related to the fact that nano fertilisers, which are quickly absorbed by plants, may lead to increased rates of photosynthesis and a buildup of dry matter (Navya *et al*., 2022) [12]. Similar results were also observed by Samui *et al*. (2022) [17], Sannathimmappa *et al*. (2022) [18], Singh *et al*. (2022) [20], Kashyap *et al*. (2022) [6], Ajitkumar *et al*. (2021) [1] and Reddy *et al*. (2022) [14].

Significantly higher grain (52.5 q/ha), stover (84.7 q/ha) and biological yield (137.5 q/ha) observed in the treatment T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) it was on at par with T_8 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS), T_3 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 DAS) and T_4 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 60 DAS). Further, T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) significantly higher rest of the treatments but no significant variation was observed on harvest index due to nano fertilizers. To achieve balanced nutrient management the 5R's concept *i.e.* right time. right technique, right quantity, right place and right source (Sannathimmappa *et al*., 2022) [18] is quite effective. Similar is the case with nano nitrogen. Use of nano nitrogen through nano urea enhanced the cell division which increases cell elongation that strengthens the sink ability which favours to get high photosynthesis. Nano fertilizers in conjunction with traditional fertilizers improve nutrient translocation, increasing productivity and grain yield. Nano particles less than 5 nm in the cuticles of leaves can enter through stomotal pores and move through vascular systems, affecting the effecting the efficacy of nanoparticles by affecting chemical composition and shape, which can lead to biological yield (Reddy *et al*., 2022) [14]. Nano nitrogen is increased in growth and yield attributes and yield of maize. Hence, improved nutritional environment in the plant metabolic system leading to higher plant metabolism and photosynthesis (Pandav *et al*., 2022) [13]. Increased dry matter production was caused by more number of leaves plant^{-1} at harvest T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) improved the total quantity of dry matter recorded in the stem at harvest and enhanced the percentage of photosynthesis for the sink, both of which increased the amounts of stover produced. Zinc is a catalytic nutrient and act as an activator of enzymes in plant and is directly involved in the biosynthesis of auxins, which produce more cells and dry matter that in turn will be stored in seeds. Thus, there was increase in yield. Similar results were also observed by Ajitkumar *et al*. (2021) [1], Middle *et al*. (2022) [10] in rice, Sahu *et al*. (2022) in rice, Sannathimmappa *et al*. (2022) [18] and Samui *et al*. (2022) [17].

Significantly higher number of cob/plant (1.63), number of grain/cob (455.3), grain weight/cob (455). cob length (19.15 cm) and test weight (644) recorded in the treatment T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) it was on at par with T_8 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 and 60 DAS), T_3 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 30 DAS) and T_4 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and 0.3 g/l at 60 DAS). Further, T_5 (75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS) significantly higher over rest of the

treatments this is mainly caused by small magnitude and large effective surface area of nano fertilizers could easily penetrated into the plant lead to better uptake of nitrogen and zinc. Also indicated that application of nano fertilizer significantly increased the nutrient use efficiency of applied fertilizers and thus increased the yield attributes of the crop (Saitheja *et al*., 2022) [16]. Almost identical results were found by Sannathimmappa *et al.* (2022) [18], Reddy *et al*. (2022) [14], Sarwar *et al*. (2021) [19], Jadhav *et al*. (2022) [3], Kashyap *et al.* (2022) [6].

Table 1: Effect of nano fertilizers on growth parameters of maize

Treatment	Plant height (cm)			Dry matter accumulation (g/plant)			LAI	
	35 DAS	70 DAS	At harvest	35 DAS	70 DAS	At harvest	35 DAS	70 DAS
T_1	46.5	181.3	188.3	12.1	190.3	279.3	2.46	3.01
T_2	58.0	212.0	223.8	15.1	246.8	314.5	2.65	3.23
T_3	63.0	229.5	251.5	16.8	262.3	345.0	2.88	3.46
T_4	55.3	227.0	248.0	14.1	260.3	343.0	2.63	3.41
T_5	65.3	235.0	261.5	17.9	273.0	349.8	2.90	3.61
T_6	60.0	213.5	230.0	16.6	248.3	318.5	2.76	3.26
T_7	54.0	212.5	225.8	14.0	247.0	315.8	2.61	3.26
T_8	60.8	231.5	259.5	16.8	270.5	347.0	2.77	3.60
SEm ±	2.05	6.55	7.41	0.52	7.55	10.09	0.077	0.093
CD at 5%	6.04	19.25	21.79	1.54	22.21	29.69	0.227	0.273

Table 2: Effect of nano fertilizers on yield and yield attributes at harvest of maize

Treatment	Number of cob/plant	Number of grain/cob	Grain weight/cob	Cob length (cm)	Test weight (g)	Shelling (%)
T_1	1.00	398.5	155.5	15.6	190.8	77.0
T_2	1.34	460.0	179.0	17.3	213.2	78.2
T_3	1.56	496.5	187.3	18.8	232.1	77.3
T_4	1.50	491.8	186.0	18.2	231.7	77.3
T_5	1.63	519.0	201.8	19.2	237.0	77.0
T_6	1.39	461.3	180.8	17.4	215.3	77.6
T_7	1.36	461.0	179.8	17.4	213.8	77.4
T_8	1.60	517.3	199.3	19.1	235.3	76.7
SEm ±	0.049	16.72	5.95	0.54	6.71	2.81
CD at 5%	0.144	49.18	17.50	1.57	19.74	NS

Table 3: Effect of nano fertilizer on yield of maize

Treatment	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T_1	30.3	56.7	86.9	35.06
T_2	40.1	67.6	107.8	37.44
T_3	49.3	79.1	128.5	38.42
T_4	48.5	77.8	126.3	38.38
T_5	52.5	84.7	137.2	38.43
T_6	43.9	71.9	115.8	37.97
T_7	42.9	71.5	114.5	37.76
T_8	51.4	81.8	133.2	38.77
SEm ±	1.71	2.67	4.53	1.825
CD at 5%	5.02	7.86	13.31	NS

4. Conclusion

Based on the results of this investigation, it was found that application of 75% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS (T_5) achieved maximum consequentially impact on growth, yield and yield parameters of maize. However, it was statistically on par with T_8 (50% RDN + RD-PK + nano nitrogen @ 4 ml/l and nano zinc @ 0.3 g/l at 30 and 60 DAS). Keeping in view of the reduction in fertilizer dose without significant decline in yield and growth of maize T_8 can recommended to achieve higher productivity of maize in Southern Rajasthan.

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