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Influence of Nano-Fertilizers on Crop Growth, Seed Yield and Quality in Groundnut (*Arachis hypogaea* L.)

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Abstract

The field experiment was conducted during *kharif* 2020 at Seed Technology Research Centre, GKVK, Bengaluru to study the influence of nano-fertilizers on crop growth, seed yield and quality in groundnut. The experiment was laid under RCBD design with three replications and ten different doses of nano-fertilizer seed treatments (Nano P and Nano Zn + Fe). Among the treatments studied, the treatment [75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] (T_6) recorded highest growth and yield parameters *viz*., field emergence (94.66%), plant height at 30 DAS (8.2 cm) and harvest (32.01 cm), number of pods per plant (26.9), pod yield (14.85 q ha^{-1}), shelling (75.00%) and SMK (88.40%) compared to control (83.63%, 6.27 cm, 25.90 cm, 14.7, 10.87 qha^{-1}, 70.00% and 82.00%, respectively). Additionally, highest net returns (Rs.53568 ha^{-1}) and B:C ratio (2.25:1) was noticed in the same treatment. The application of Zn + Fe in nano form enhanced the efficiency of nutrients and contributed to higher growth and yield. Hence, there is a possibility of enhancing the yield and net monetary returns of groundnut by treating the seeds with nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating).

Keywords : Nano-Zn, Nano-P, Seed-coating, Yield parameters, Sound mature kernels

Arachis hypogaea (L.) is the botanical name of the groundnut popularly known as pea nut. It is a legume crop farmed primarily for the oil it produces and widely grown throughout the tropics and subtropics with small marginal and major commercial growers relying on it. Because of its high protein and oil content, it is categorized as both a grain legume and an oil seed crop. It provides high-quality edible oil (48-50%), protein (26-28%), carbs (10-25%), vitamins (E, K and B complex), minerals (Ca, P, Mg, Zn and Fe) and fiber. The shell is used for fuel and also animal feed; and the haulm is used as animal fodder or manure. It contributes nitrogen (100-152 kg ha^{-1}) and organic matter to the soil because it is a legume crop (Nigam *et al.,* 2014). Globally, groundnut is cultivated in 26.4m ha with total production of 37.10 m.t. and a productivity of 14 q ha^{-1}. In India, it is cultivated in 4.73m ha with a total yield of 6.72 m.t. and productivity of 12.22 q ha^{-1} and accounts for nearly 50 per cent of total oil seed production. In Karnataka, it is grown on an area of 0.52 m. ha with a yield of 0.34 m.t. and a productivity of 7.59 q ha^{-1} (Anonymous, 2019). Agriculture sector development can only be achieved by improving resource utilization efficiency while causing the minimum amount of environmental damage which is feasible through the efficient application of novel technology. Nano technology is a vast and multidisciplinary field of research and development focused on the most effective use of nano particles that has exploded in adoration over the last few years. Nano technology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to produce new or drastically different materials and technologies (Roco *et al.,* 1999).

The nanoparticle has a dimension measured in nm (1nm=10^{-9} m). Nano fertilizers are known to improve solubility and dispersion of insoluble nutrients in soil. They also increase fertilizer use efficiency (three times), uptake ratio of the soil nutrients in crop production and save fertilizer resource. They extend effective duration of nutrient supply of fertilizers to crops and reduce loss of fertilizers into soil by leaching. They help in improving the crop yield by 17-24 per cent, owing to their small size and higher surface area there will be more nutrient mobilization in the plants (Cui *et al.,* 2010).

Zinc is the most important transition metal in organisms following iron and it is the only metal found in all six enzyme types (oxidoreductases, transferases, hydrolases, isomerases and ligases), according to the National Institute of Health (Auld, 2001). During seed development, zinc plays an important role in chlorophyll synthesis, pollen function, fertilization, germination and biomass production (Cakmak, 2008). Although iron (Fe) is the fourth most prevalent metal in soil, plant in sufficiency is most common. Because iron is required for metabolic activities such as DNA synthesis, respiration and photosynthesis, it is an important micronutrient for nearly all living species. Iron is required for the production of chlorophyll and the preservation of chloroplast structure and function in plants (Gyana and Sunita, 2015).

Phosphorus (P) is the second most major nutrient for plants following nitrogen, it is present in every living plant cell, plays an important role in energy transfer, photosynthesis, sugar and starch transformation, nutrient transport throughout the plant and the transmission of genetic information from one generation to the next. Furthermore, the function of phosphorus in cellular and whole-plant developmental processes, such as seed germination, seedling establishment, root, shoot, flower and seed development, respiration and nitrogen fixing is very important (Malhotra *et al.,* 2018).

The goal of this study was to explore the effect of different nanoparticle concentrations on crop development, seed production and quality in groundnut. There have been very scanty studies on the concentration of nanoparticles to increase groundnut seed production and quality. There fore, a comprehensive study was initiated to generate firsthand information on influence of nano-fertilizers on crop growth, seed yield and quality in groundnut.

MATERIAL AND METHODS

The field experiment was conducted during *kharif,* 2020 at Seed Technology Research Unit, AICRP on Seed (Crops), UAS, GKVK, Bangalore (12° 15' N Latitude and 77° 35' E longitude 930 m above Mean sea level). The annual rainfall ranges from 528 mm to 1374.4 mm with the mean of 915.8 mm. During *kharif* 2020 the average rainfall received at Bangalore was 1155.8 mm as against 91 rainy days. The experimental soil was sandy (46.3%) with pH (7.5%), EC (0.40 dsm^{-1}), available nitrogen (194.4kg ha-1), available P_2O_5 (15.2 kg ha^{-1}) and K_2O (242.1 kg ha^{-1}). Groundnut variety RG 578 was used in this experiment. The field trial was laid out in randomized complete block design (RCBD) in three replications with ten different dozes of nano-fertilizer treatments (Nano P and Nano Zn + Fe). The treatment details of the experiment are given below.

T_1 : No fertilizer (control)

T_2 : According to RDF (20 : 60 : 30 kg NPK kg ha^{-1}) incl. Zn + Fe (Soil application)

T_3 : 100 % RDF incl. Zn + Fe (Soil application) + Seed coating of nano P (Phosphorus) @ 125 ml ha^{-1} (100 kg / ha seed) (100 % seed coating)

T_4 : 100 % RDF incl. Zn + Fe (Soil application) + Seed coating of nano Zn + Fe (Zinc+Iron) @ 125 ml ha^{-1} (100 kg / ha seed) (100% seed coating)

T_5 : 100% N, K, Zn + Fe with 75% P (Soil application) + Seed coating of nano (Phosphorus) @ 125 ml ha^{-1} (100 kg / ha seed) (100% seed coating)

T_6 : 100% NPK and 75% Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100 kg / ha seed) (100 % seed coating)

T_7 : 100% RDF incl. Zn + Fe (Soil application) + Seed coating of nano P @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50% seed coating + 50% foliar spray)

T_8 : 100% RDF incl. Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of nano Zn + Fe @ 250 ml ha^{-1} (50% seed coating + 50% foliar spray)

T_9 : 100 % RDF of N, K, Zn + Fe and 75% P (Phosphorus) (Soil application) + Seed coating of nano P (Phosphorus) @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50% seed coating + 50% foliar spray)

T_{10}: 100% RDF and 75% Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of Zn + Fe @ 250 ml ha^{-1} (50% seed coating + 50% foliar spray).

Recommended package of practice were adopted to raise a healthy crop. The seeds were treated with nano particles as per the treatment details (Plate 1). Seeds were sown with the spacing of 40 cm between rows and 15 cm between seeds at proper depth of 5-6 cm. The calculated quantity of nitrogen (N), phosphorus (P) and potassium (K) were applied through urea, di-ammonium phosphate and muriate of potash, respectively as per the treatments. Foliar application of nano P @ 1 ml / litre and nano Zn + Fe @ 1 ml / litrewas carried out by taking calculated quantity of nano P and nano Zn + Fe by taking required concentrations and sprayed on crops as per the treatments.

Five plants from each treatment in three replications were tagged to collect the growth and yield attributes of groundnut. Observations including field emergence (%), plant height, number of pods per plant, pod yield per plant (g), pod yield per plot (kg), pod yield per hectare (q), shelling (%), sound mature kernels (%), net returns (Rs.) and benefit cost ratio (B:C) were recorded. The data was statistically analyzed by using RCBD method and differences between the treatments were worked out at five per cent significance (Snedecor and Cochran, 1967). Statistical significance was accepted when the probability of the result assuming the null hypothesis (p) is less than 0.05 level of probability. Critical difference values were calculated whenever F test was significant.

Plate 1 : Nano-fertilizer treated seeds used for sowing

TABLE 1

Influence of nano nutrient seed coating and foliar spray on plant growth parameters of groundnut

Treatments		Filed emergence (%)	Plant height @ 30 DAS (cm)	Plant height @ harvest (cm)
T_1-	No fertilizer (control)	83.63	6.27	25.90
T_2-	According to RDF (20 : 60 : 30 kg NPK ha^{-1}) incl. Zn + Fe (Soil application)	91.31	6.33	29.77
T_3-	100 % RDF + Seed coating of nano P (Phosphorus) @ 125 ml ha^{-1}	92.52	8.07	30.11
T_4-	100 % RDF + Seed coating of nano Zn + Fe (Zinc+Iron) @ 125 ml ha^{-1}	92.52	7.93	30.34
T_5-	100 % N, K, Zn + Fe with 75 % P (Soil application) + Seed coating of nano (Phosphorus) @ 125 ml ha^{-1}	93.13	8.00	31.20
T_6-	100 % NPK and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 125 ml ha^{-1}	94.74	8.20	32.01
T_7-	100 % RDF + Seed coating of nano P @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	93.33	7.93	27.93
T_8-	100 % RDF + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of nano Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	92.72	7.17	27.61
T_9-	100 % RDF of N, K, Zn + Fe and 75 % P (Phosphorus) (Soil application) + Seed coating of nano P (Phosphorus) @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	93.72	8.03	28.41
T_{10}-	100 % RDF and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray	92.32	7.97	29.06
	Mean	91.99	7.49	29.23
	S.Em±	0.97	0.387	0.749
	CD (p=0.05)	3.09	1.151	2.224
	CV(%)	1.80	8.96	5.44

RESULTS AND DISCUSSION

The data on growth parameters of groundnut presented in Tables 1 & 2, the results indicated that field emergence significantly enhanced in all the Nano seed treatments (T_3 to T_{10}) ranging from 92.32 per cent to 94.74 per cent compared to control (T_1-83.63%) and RDF (T_2-91.31%) treatment. The beneficial effects of ZnO and Fe_2O_3 NPs *viz.,* higher precursor activity of nanoscale Zn and Fe in the production of essential biomolecules, increased cofactor activity in essential enzymatic systems and

TABLE 2

Influence of nano nutrient seed coating and foliar spray on plant growth parameters of groundnut

Treatments		Days to first flowering	Days to 50 % flowering	Chlorophyll content (SPAD values)
T_1-	No fertilizer (control)	45.00	51.00	41.44
T_2-	According to RDF (20 : 60 : 30 kg NPK ha^{-1}) incl. Zn + Fe (Soil application)	44.00	50.00	41.91
T_3-	100 % RDF + Seed coating of nano P (Phosphorus) @ 125 ml ha^{-1}	44.33	50.33	43.17
T_4-	100 % RDF + Seed coating of nano Zn + Fe (Zinc+Iron) @ 125 ml ha^{-1}	44.00	50.00	42.93
T_5-	100 % N, K, Zn + Fe with 75 % P (Soil application) + Seed coating of nano (Phosphorus) @ 125 ml ha^{-1}	43.67	49.67	44.26
T_6-	100 % NPK and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 125 ml ha^{-1}	43.00	49.00	44.38
T_7-	100 % RDF + Seed coating of nano P @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	43.33	49.33	41.82
T_8-	100 % RDF + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of nano Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	43.67	49.67	41.64
T_9-	100 % RDF of N, K, Zn + Fe and 75 % P (Phosphorus) (Soil application) + Seed coating of nano P (Phosphorus) @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	42.67	49.00	42.54
T_{10}-	100 % RDF and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray	43.67	49.67	43.71
Mean		43.73	49.77	42.78
S.Em±		0.45	0.45	2.06
CD (p=0.05)		1.45	1.46	NS
CV(%)		1.80	1.60	8.40

also positive effect on reactivity of the phytohormones during the field emergence (Krishna Shyla and Natarajan, 2014). The highest plant heightat 30 DAS (8.20 cm) and at harvest (32.01 cm) was recorded in T_6 [100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] and on par results were recorded in all nano treatments. While, lowest was recorded in control (6.27 cm and 25.90 cm, respectively) and T_2 (6.33 cm and 27.61cm, respectively) (Plate 2; Table 1). The increase in plant height was due to increased internodal length. Such increase may be ascribed to higher precursor activity of nanoscale ZnO in the production of auxin (Kobayashi and Mizutani, 1970). The Fe_2O_3 NPs also increased plant height by regulating phytohormone contents and antioxidant enzymes (Rui *et al.,* 2016).These results were in correlation with the results obtained by Prasad *et al.,* (2012), Subbaiah *et al.* (2016), Harish and Gowda (2017) and EI-Metwally *et al.* (2018).

Early days to first flowering (42.67) and 50 per cent flowering (49.00) was also induced in nano treatment (T_9) as compared to control-T_1 (45 & 51 days, respectively). With respect to chlorophyll content, no significant differences in SPAD meter readings were detected. However the higher SPAD meter value (44.38) was recorded in T_6 (100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^1 (100% seed coating), whereas lower SPAD meter value was recorded in control (41.44). Prasad *et al.* (2012) studied the effect of zinc oxide nano particles on growth of groundnut and reported that higher leaf chlorophyll content might be due to compatible effect of other inherent nutrients like Mn, Fe and S. The Fe_2O_3 NPs also increased chlorophyll content (Rui *et al.,* 2016).

The data pertaining to yield parameters *viz.,* No. of pods plant^{-1}, pod yield plant^{-1}, pod yield plot^{-1}, pod yield ha^{-1} as influenced by application of nano fertilizers is presented in Table 3. The experimental data indicated that, significantly highest number of pods plant^{-1} (26.9) (Plate 2) was recorded in T_6 [100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] and on par results were recorded in T_7 (24.0) and T_9 (25.3) and lowest was noted in T_1 (14.7) *viz.,* complete control and T_2 (14.8) *viz.,* RDF treatment. Lowest pod yield plant^{-1} was recorded in control T_1 (15.67g) and RDF treatment T_2 (15.87g) which was significantly enhanced to 19.73 g in T_6

Plate 2 : Effect of nano-fertilizers on number of pods per plant of groundnut variety RG 578

TABLE 3

Influence of nano nutrient seed coating and foliar spray on yield and attributing parameters of groundnut

	Treatments	No. of pods plant^{-1}	Pod yield plant^{-1} (g)	Pod yield plot^{-1} (kg)	Pod yield ha^{-1} (q)
T_1-	No fertilizer (control)	14.7	15.67	1.09	10.87
T_2-	According to RDF (20:60:30 kg NPK ha^{-1}) incl. Zn + Fe (Soil application)	14.8	15.87	1.32	13.16
T_3-	100 % RDF + Seed coating of nano P (Phosphorus) @ 125 ml ha^{-1}	15.9	16.93	1.39	13.85
T_4-	100 % RDF + Seed coating of nano Zn + Fe (Zinc+Iron) @ 125 ml ha^{-1}	19.0	16.07	1.39	13.92
T_5-	100 % N, K, Zn + Fe with 75 % P (Soil application) + Seed coating of nano (Phosphorus) @ 125 ml ha^{-1}	20.1	16.53	1.37	13.66
T_6-	100 % NPK and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 125 ml ha^{-1}	26.9	19.73	1.49	14.85
T_7-	100 % RDF + Seed coating of nano P @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	24.0	18.07	1.40	13.97

Table 3 Conti....

Treatments	No. of pods $plant^{-1}$	Pod yield $plant^{-1}$ (g)	Pod yield $plot^{-1}$ (kg)	Pod yield ha^{-1} (q)
T_8- 100 % RDF + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of nano Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	22.0	17.27	1.35	13.53
T_9- 100 % RDF of N, K, Zn + Fe and 75 % P (Phosphorus) (Soil application) + Seed coating of nano P (Phosphorus) @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	25.3	17.93	1.38	13.79
T_{10}- 100 % RDF and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray	23.3	17.60	1.35	13.53
Mean	20.6	17.17	1.35	13.51
S.Em±	1.176	0.592	0.038	0.383
CD (p=0.05)	3.493	1.757	0.114	1.138
CV(%)	9.89	5.97	5.91	5.91

[100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] and 18.07 g in T_7 (Seed coating of nano P @ 62.5 ml ha^{-1} + Foliar spray of nano P @ 250 ml ha^{-1}). Similarly, highest pod yield $plot^{-1}$ (1.49 kg) and pod yield ha^{-1} (14.85 q) was recorded in T_6 [100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] and lowest was recorded in control (1.09 kg and 10.87q, respectively). The beneficial effect of nano nutrient application resulted in increased leaf area, which resulted in increased photosynthesis and production of more photo synthates, resulting in enhanced source sink relationship with well-organized photosynthate translocation to the grains resulting in an increased number of filled grains per panicle. ElMetwally *et al.* (2018) also observed increase in number of pods per plant due to the application of Fe_2O_3 NPs. Application of nano iron at flowering stage of cowpea increased pod number per plant through increase in the shelf life of flowers and turn it into the pods (Marschner, 1995). These results were in relation with the results obtained by Prasad *et al.* (2012) and Harish *et al.* (2019).

Additionally, with respect to yield attributing parameters (Table 4) the highest shelling per cent age (75.00) and sound mature kernels (88.40%) was recorded in T_6 [100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] which was on par with T_7 (73.0% and 86.33, respectively). Where as, lowest shelling percentage (70.00%) and sound mature kernels (82.00%) were recorded in control. Rashmi and Prakash (2023) reported that application of 75 per cent RDP through SSP + 5 per cent RDP through soil application of Nano phosphorus (NP1) + 1 per cent RDP through foliar spray of NP1 recorded significantly highest cob length, number of rows cob^{-1}, number of kernels row^{-1} in maize over absolute control and better when compared to 100 per cent RPP. Nano particles are known to have a high mobility confirming to improved phloem transport and ensuring that nutrients reach all regions of the plant. All of these variables might have contributed to the greater yields achieved by using nanoparticles rather than bulk (Harish *et al.,* 2019). The application of iron oxide NPs increased chlorophy ll content thereby increased photosynthesis which in turn led to improved biomass and yield attributing parameters (Rui *et al.,* 2016).

Additionally, the highest net returns (Rs.53568 ha^{-1}) and B:C ratio (2.25) (Table 4) were noticed in T_6

TABLE 4

Influence of nano nutrient seed coating and foliar spray on yield attributes and economic indicators of groundnut

	Treatments	Shelling (%)	Sound mature kernels	Net Monetary returns (Rs.)	B:C ratio
T_1-	No fertilizer (control)	70.00	82.00	35924	2.03 : 1
T_2-	According to RDF (20:60:30 kg NPK ha^{-1}) incl. Zn + Fe (Soil application)	72.00	83.67	44009	2.06 : 1
T_3-	100 % RDF + Seed coating of nano P (Phosphorus) @ 125 ml ha^{-1}	70.33	85.50	48406	2.16 : 1
T_4-	100 % RDF + Seed coating of nano Zn + Fe (Zinc+Iron) @ 125 ml ha^{-1}	72.67	83.77	47385	2.10 : 1
T_5-	100 % N, K, Zn + Fe with 75 % P (Soil application) + Seed coating of nano (Phosphorus) @ 125 ml ha^{-1}	71.33	85.50	47774	2.16 : 1
T_6-	100 % NPK and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 125 ml ha^{-1}	75.00	88.40	53568	2.25 : 1
T_7-	100 % RDF + Seed coating of nano P @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	73.00	86.33	49205	2.18 : 1
T_8-	100 % RDF + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of nano Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	72.33	84.17	44950	2.05 : 1
T_9-	100 % RDF of N, K, Zn + Fe and 75 % P (Phosphorus) (Soil application) + Seed coating of nano P (Phosphorus) @ 62.5 ml ha^{-1} (100 kg / ha seed) + Foliar spray of nano P @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray)	70.33	84.00	48737	2.19 : 1
T_{10}-	100 % RDF and 75 % Zn + Fe (Soil application) + Seed coating of nano Zn + Fe @ 62.5 ml ha^{-1} (100 kg / ha seed)+ Foliar spray of Zn + Fe @ 250 ml ha^{-1} (50 % seed coating + 50 % foliar spray	72.67	83.77	44986	2.05 : 1
	Mean	71.97	84.71		
	S.Em±	0.922	1.133		
	CD (p=0.05)	2.740	3.365		
	CV(%)	2.22	2.32		

[100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] whereas, lowest net returns (Rs.35924 ha^{-1}) and B:C ratio (2.03:1) was recorded in control. Improved yield characteristics of groundnut as influenced by the application of nano-fertilizers resulted in increased net returns and B:C ratio. Similar findings were observed by Aruna *et al.* (2001), Rashid and Akhtar (2006) and Gnanesh *et al.* (2018).

Nano particles having a large surface area and a tiny size are predicted to be good candidates for use as plant fertilizers. The results from the present study revealed that groundnut seed treatment with nano-fertilizers *viz.,* T_6 [100% NPK and 75% Zn + Fe (soil application) + seed coating of nano Zn + Fe @ 125 ml ha^{-1} (100% seed coating)] increased growth and yield parameters *viz.,* plant height (30 DAS, 60 DAS and at harvest), number of pods per plant, pod yield per plant, pod yield per plot, pod yield per hectare, shelling (%) and sound mature kernels (%). The same treatment also gave highest net returns (Rs.53568 ha^{-1}) and B:C ratio (2.25). The treatment (T_6) showed positive influence on crop growth, yield and quality of groundnut with minimum input cost and hence this could be used as seed treatment to enhance seed yield and quality in groundnut.

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