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Effect of Nano Nitrogen on Productivity of Sweet Corn (*Zea mays S*accharata) and Soil Fertility in Sub-montane Zone of Maharashtra, India

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ABSTRACT: Enhancing Nitrogen use efficiency is key task since, it meagrely ranges between 30-35% indicating loss of more than 50 per cent applied N through various means. Use of innovative techniques, such as Nano fertilizers could be the plausible answer to this worry. Nano elements due to its size dependent qualities, high surface-volume ratio and unique optical properties are having competency to modify the existing synthetic framework practiced in modern agriculture by increasing the efficiency of supplied plant nutrients. With this aim a field experiment was conducted on black Vertisols of Agronomy farm, RCSM College of Agriculture, Kolhapur (M.S.), India during *kharif*, 2020.The experiment was statistically tested using split plot design with 4 replications, the main plot factors consisted of time of application of nano nitrogen (NN) *viz* T_1:15 (DAS), T_2: 30 DAS and T_3: 45 DAS and sub plot factors consist of levels of NN fertilizers *viz* N_1: 1.00, N_2: 1.25 and N_3:1.50 L per ha. The foliar application of NN at 15 DAS produced significantly higher length of cob (20.56 cm), diameter of cob (19.71 cm), weight of cob (222.29 g plant^{-1}), number of grains (402.07cob^{-1}), green cob yield (138.32q ha^{-1}) and stover yield (359.75q ha^{-1}). Significantly higher total N, P, K and protein in grain (1.58, 0.59, 0.92 and 9.74%), stover (0.85, 0.40, 1.75 and 5.18%) and total uptake (288, 114 and 262 kg ha^{-1}) was observed with foliar application of NN at 15 DAS. The soil available N, P and K (201, 35.7 and 312 kg ha^{-1}) respectively, at harvest were found to be significantly lower with NN foliar spray at 15 DAS (T_1). The maximum number of colonies of *Azotobacter* (CFU 14 × 10^6), *phosphate solubilizing bacteria* (PSB) (CFU 12 × 10^6) and *Azospirillum* (CFU 6 × 10^6) were observed at T_1. Besides, time of NN foliar application, varied concentration of NN foliar application as another factor also exhibited substantial influence on soil properties, uptake of nutrients and yield of maize crop. The treatments receiving NN foliar spray @ 1.5 L ha^{-1} (N_3) revealed significantly higher cob length (18.55 cm), cob diameter (16.83 cm), cob weight (208.65 g plant^{-1}), number of grains (371.25 cob^{-1}), green cob yield (125.96 q ha^{-1}) and green fodder yield (344.39 q ha^{-1}) over NN foliar spray @ 1.0 L ha^{-1} (N_1) however, it was at par with NN foliar spray @ 1.25 L ha^{-1} (N_2). Similarly, the total N, P, K and protein content in grain (1.49, 0.89, 0.58 and 9.29%) and straw (0.83, 1.66, 0.38 and 5.10%) respectively, moreover, total N, P and K uptake (264, 98 and 230 kg ha^{-1}) respectively, were found to significantly highest in N_3 over N_1 however, it was at par with N_2. The soil available N, P and K status (212, 41.9 and 323 kg ha^{-1}) respectively, after harvest of maize was significantly lowest with N_3. The combination treatment T_1N_3 i.e. NN foliar application at 15 DAS @ 1.5 L ha^{-1} recorded significantly highest green cob (147.98 q ha^{-1}) and green fodder (389.81 q ha^{-1}) yields.

Keywords: Sweet corn, Nano nitrogen (NN), grain yield, stover yield, quality, soil properties.

INTRODUCTION

Maize (*Zea mays* L) is one of the most versatile emerging wonder crops having wider adaptability under diverse agro-climatic condition. Globally, maize is well known as queen of cereals because it has the highest genetic yield potential among the other cereals (Anonymous, 2017). Among all the types of maize, sweet corn (*Zea mays saccharata*) is distinguished from other maize varieties by its delicious taste and high sugar content (14 – 20 per cent) at milk or immature stage. Sweet corn is a good source of energy and about 20 per cent of the dry matter is sugar, compared with only 3 per cent in dent maize at ear stage (Kipps, 1959).Sweet corn is different from other types due to presence of gene or genes that affect starch synthesis in endosperm, for increasing sugar content in the maize grain. The eight genes affect endosperms carbohydrates synthesis, which are being used either singly or in combination in sweet corn variety (Singh, 1998).

Nitrogen, which is a key nutrient source for food, biomass and fibre production in agriculture, is most important element in fertilizers when judged in terms of energy required for its synthesis, tonnage used and monetary value. However, compared with the amounts of nitrogen applied to the soil, the nitrogen use efficiency (NUE) of crops is very low. It is well documented only 30-50 per cent of theapplied nitrogen using conventional fertilizers-plant nutrient formulations with dimensions greater than 100nmis utilizable by plant, while rest of nitrogen is subjected to leaching in the form of water-soluble nitrates, emission of gaseous ammonia and nitrogen oxides and long-term incorporation of mineral nitrogen into soil organic matter by soil microorganisms. Numerous attempts to increase the NUE have so far met with little success, and the time have come to apply nanotechnology to solve some of these problems (Maria, 2010).

The nano fertilizers have unique advantages due to their small size and larger surface area leading to increase the absorption, the high process of photosynthesis and increased production of active substances in the plant (Al-Sharay and Al-Rubaee, 2019). The basis of work of the nano fertilizer is the rapid supply of the nutrients and increased the duration of the fertilizer effect.

Nanotechnology has a significant impact on improving the solubility of other soil elements, displacing and replacing insoluble elements, reducing nutrient mineralization, increasing bioavailability and easily absorbed by the plants, (Naderi and Danesh-Shahraki, 2013). Nano fertilizers are so effective that they reduce the fertilizer application rate or annual demand or when the traditional negative environmental impact fertilizers need to be resolved by regulations. There are some signs of economic possibilities of nano fertilizers proposed by nanotechnology experts dedicated to improving fertilizers (Anonymous[2], 2017).

Keeping these aspects as maize or sweet corn being an important crop, demerits of mineral fertilizer and efficiency of nano fertilizer, a field experiment entitled "Effect of nano nitrogen on sweet corn productivity (sugar-75) and soil health in sub montane zone of Maharashtra, India" was conducted at Agronomy Farm, RCSM College of Agriculture, Kolhapur-416004, MH, India.

MATERIALS AND METHODS

The Kolhapur comesunder the Sub-montane Zone of Maharashtra and is situated at an elevation of 548 m above the mean sea level on 16°42'.548 North latitude and 74°14'.329 East longitudinal. The experimental plot was medium black Vertisol having 90 cm depth, low in available Nitrogen (197 kg ha^{-1}), high in available phosphorus (40.19 kg ha^{-1}) and available potassium (297 kg ha^{-1}). The status of organic carbon content (0.59%) was high. The electrical conductivity and pH values were 0.28 dSm^{-1} and 7.90, respectively. The experiment was carried out under split plot design with four replications and two factors, where main plot factors consist of time of application *viz* T_1:15 days after sowing (DAS), T_2: 30 DAS and T_3: 45 DAS and sub plot factors consist of levels of nano nitrogen (NN) fertilizers *viz* N_1: 1.00 L per ha, N_2: 1.25 L per ha and N_3:1.50 L per ha making total nine treatment combinations.The variety sugar 75 was used for the experiment @ 15 kg ha^{-1}. The recommended dose of inorganic mineral fertilizers @ 120:60:40 NPK kg ha^{-1} was also given.The inorganic mineral fertilizers were applied as per the recommended dose, where in half dose of nitrogenous fertilizer and full dose of phosphatic and potassic fertilizers were applied at the time of sowing as basal dose.Gross and net plot size were 6.00 m × 4.00 m and 4.5 m × 3.2 m respectively. The periodical observations of crop growth attributes and yield were recorded after seed emergence w. e. f. 30 DAS on 15 days interval up to harvest and at harvest *viz*., plant population, plant height (cm), number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$ (dm^2), dry matter accumulation $plant^{-1}$(g), grain yield (q ha^{-1}) and stover yield (q ha^{-1}). The protein content in grain and stover were also calculated. The experimental data was statistically analysed by using a standard method of "analysis of variance" as reported by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

A. Yield.

The data in Table 1 showed that yield contributing characters of main plot like length of cob (20.56 cm), diameter of cob(19.71 cm), weight of cob per plant (222.29 g), number of grains per cob (402.07), green cob yield per ha (138.32 q) and green fodder yield per ha (359.75 q) were significantly maximum when spraying was done at 15 DAS (T_1) over later spraying at 30 DAS (T_2) and 45 DAS (T_3). The yield contributing character of sub plot *viz*. length of cob (18.55 cm), diameter of cob (16.83 cm), weight of cob per plant (208.65 g), number of grains per cob (371.25), green cob yield per ha (125.96 q) and green fodder yield per ha (344.39 q) obtained from treatment N_3 (1.5 litre ha^{-1}) were maximum, which was on par with treatment N_2 (1.25 litre ha^{-1}) and significantly superior over N_1 (1 litre ha^{-1}). The reason may be high dose of nano nitrogen fertilizer gave more area for various metabolic process in the plant thereby increasing the rate of photosynthesis and its role in stimulating the enzyme involved in influencing these traits by increasing the activity of chemical reactions and reducing the impact of free radicles that negatively affect the efficiency of work of some organelles in the plant thus increasing the overall yield of crop was observed by (Sorooshzadah *et al.* 2012). It had also been found that early application of nano nitrogen fertilizer helps for extended release of the nutrients thereby sustaining the nutrient supply of the plant which has a positive effect on improving plant growth (source) and finally the yield (sink) as proposed by (Subramanian and Sharmila, 2009). Further, it reduces the proportion of ovarian absorption and thus increased pollination and fertilization which leads to increased length of the cobs and number of rows in ears results are in line with those reported by (*Al*-Saray and *Al*-Rubaee, 2019). The other probable reason could be due to higher level of NN foliar application might have resulted in increased size and efficiency of source, which in turn have resulted in higher yield attributes thus grain and stover yield (Sharifi and Namvar, 2016). Jian *et al.,* (2008), Fan *et al.,* (2012), Morteza *et al.,* (2013), Kole *et al.*,(2013), Anupama *et al.* (2020) and Al-Juthery *et al.* (2019) reported similar findings.

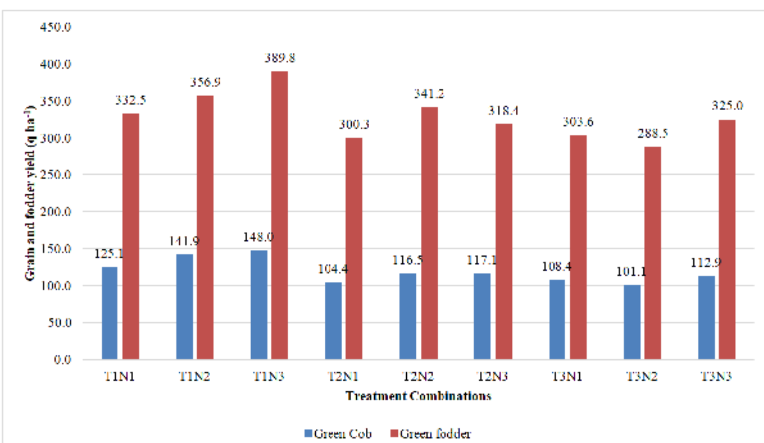

Fig. 1. Effect of different treatment combinations on grain and fodder yield.

B. Nutrient concentration and protein content

The data presented in Table 2 indicated that in main plot,the per cent content of N, P, K and protein in grain (1.58, 0.59, 0.92 and 9.74) and stover (0.85, 0.40, 1.75 and 5.18) respectively,were significantly maximum when foliar application was done at 15 DAS (T_1) over later application at 30 DAS (T_2) and 45 DAS (T_3).While in sub plot, the per cent content of total N, K and protein in grain (1.49, 0.89 and 9.29), stover (0.83, 1.66 and 5.10) were maximum with treatment N_3 (1.5 litre ha^{-1}) which was on par with treatment N_2 (1.25 litre ha^{-1}) and significantly superior over N_1 (1 litre ha^{-1}). The treatment N_2 (1.25 litre ha^{-1}) noted maximum content for phosphorous in grain and stover and was at par with treatment N_3 (1.5 litre ha^{-1}). The reason may be highdose of nano nitrogen fertilizer provided more surface area and more availability of nutrients to the crop plant which help to increase the protein content of grain and stover by enhancing the rate of reaction or synthesis process in the plant system (Singh and Kumar, 2017). The protein content varied significantly with higher levels of NN application which could be due to increased N content in grain. The NN and inorganic fertilizer might have provided substantial amount of nutrients for protein synthesis (Sharifi and Taghizaden, 2016). Similar results were reported by Prasad *et al.*, (2012), Suriyaprabha *et al.*, (2012), *El*-Metwally *et al.*,(2018), Kha *et al.*, (2019) and Melika *et al.*, (2015).

Table 2: Effect of time of application and levels of nano nitrogen fertilizeron nutrient concentration and protein content in grain and stover of sweet corn.

Treatments	Nitrogen		Phosphorus		Potassium		Protein Content	
	---(%)---------------------------------------							
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Time of Application (T)								
15 DAS (T_1)	1.58	0.85	0.59	0.40	0.92	1.75	9.74	5.18
30 DAS (T_2)	1.42	0.79	0.53	0.34	0.85	1.53	8.86	4.92
45 DAS (T_3)	1.34	0.75	0.52	0.33	0.84	1.39	8.52	4.82
S.Em±	0.03	0.01	0.01	0.01	0.02	0.04	0.13	0.07
CD at 5%	0.10	0.04	0.04	0.04	0.06	0.15	0.47	0.23
Levels of Nano nitrogen fertilizer (N)								
NN @ 1.00 L ha^{-1} (N_1)	1.39	0.75	0.52	0.32	0.83	1.44	8.74	4.83
NN @ 1.25 L ha^{-1} (N_2)	1.46	0.80	0.56	0.37	0.88	1.56	9.08	4.99
NN @ 1.5 L ha^{-1} (N_3)	1.49	0.83	0.57	0.38	0.89	1.66	9.29	5.10
S.E. ±	0.02	0.01	0.01	0.01	0.01	0.03	0.09	0.05
CD at 5%	0.05	0.03	0.03	0.03	0.04	0.10	0.27	0.14
Interactions (T × N)								
S.Em ±	0.03	0.02	0.02	0.02	0.02	0.06	0.16	0.08
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of time of application and dose of nano nitrogen fertilizer on total uptake of nitrogen, phosphorus and potassium.

Treatments	Nutrient uptake(kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
Time of application (T)			
15 DAS (T_1)	288	114	262
30 DAS (T_2)	231	82	194
45 DAS (T_3)	215	75	178
S.Em ±	6.89	2.84	5.57
CD at 5%	23.84	9.81	19.29
Levels of nano nitrogen fertilizer (N)			
NN @ 1.00 L ha^{-1} (N_1)	221	78	184
NN @ 1.25 L ha^{-1} (N_2)	249	95	220
NN @ 1.5 L ha^{-1} (N_3)	264	98	230
S.Em ±	5.51	2.04	3.39
CD at 5%	16.36	6.07	10.06
Interactions (T × N)			
S.Em ±	9.54	3.54	5.86
CD at 5%	NS	NS	NS

C. Effect on uptake and biological properties: The reprisal of data in Table 3 and 4 indicated that main plot factor *i.e.*application of NN at 15 DAS (T_1) had contributed significantly maximum amount of total nutrients uptake (288, 114 and 262 kg ha^{-1}) over application time at 30 DAS (T_2) and 45 DAS (T_3) for all the three nutrients, namely N, P and K respectively. It also showed that maximum number of colonies of *azotobacter* (CFU 14 × 10^6), *Phosphate solubilizing bacteria* (P.S.B.) (CFU 12 × 10^6) and *Azospirillum* (CFU 6 × 10^6) were obtained from foliar application at 15 DAS (T_1). While in sub plot, the treatment N_3 (1.5 L ha^{-1}) recorded higher total uptake (264, 98 and 230 Kg ha^{-1}) which is on par with treatment N_2 (1.25 litre ha^{-1}) and superior over treatment N_1 (1.00 litre ha^{-1}) for all the three nutrients, namely N, P and K respectively. The biological properties of soil also showed that treatment T_1 (15 DAS) have higher number of colonies of all the three microbes (CFU 14 × 10^6, 12 × 10^6, 6 × 10^6 of *Azotobacter*, P.S.B. and *Azospirillum* respectively) which may be due to more beneficial effect of nano fertilizer under greater period of exposure under T_1 (15 DAS) causing greater available organic carbon content in soil. Similar results were reported by Chavan *et al.* (2019), Anupama *et al.* (2020), Mir *et al.* (2015), Dhansil *et al.* (2018), Prihastani *et al.* (2018), Shebl *et al.* (2018), Singh (2015), Suriyaprabha *et al.* (2012), Nibin *et al.* (2019) and Prasad *et al.* (2012).

Table 4: Effect of time of application (T) and levels of nano nitrogen on biological properties of soil.

Treatment	*Azotobacter* (number of colonies)	*Phosphate solubilizing bacteria* (number of colonies)	*Azospirillum* (number of colonies)
	(CFU)		
Time of Application (T)			
15 DAS (T_1)	14×10^6	12×10^6	6×10^6
30 DAS (T_2)	11×10^6	11×10^6	4×10^6
45 DAS (T_3)	10×10^6	9×10^6	4×10^6
Levels of Nano nitrogen fertilizer (N)			
Nano-nitrogen @ 1.00 l ha^{-1} (N_1)	9×10^6	9×10^6	3×10^6
Nano-nitrogen @ 1.25 l ha^{-1} (N_2)	10×10^6	10×10^6	4×10^6
Nano-nitrogen @ 1.5 l ha^{-1} (N_3)	12×10^6	11×10^6	5×10^6

D. Soil properties and soil available nutrients

The data presented in Table 5. indicated that the soil available N, P_2O_5 and K_2O content was highly influenced by the time of application and levels of nano nitrogen fertilizer, but there was no significant effect of time of application on PH, EC and organic carbon content. The available nutrients namely N, P_2O_5 and K_2O were noted significantly highest at 45 DAS (T_3) over T_2(30 DAS) and T_1 (15 DAS) with significant difference between the latter two spraying time. The application time at 15 DAS (T_1) had significantly minimum amount of available nutrients namely N, P_2O_5 and K_2O (201, 35.7 and 312 kg ha^{-1}) respectively. Whereas in the sub plot, treatment N_1 (1.00 litre ha^{-1}) has higher amount of available nutrients in soil namely, N, P_2O_5 and K_2O content which was at par with treatment N_2 (1.25 litre ha^{-1}) and significantly superior over treatment N_3 (1.5 litre ha^{-1}). However, for available Nitrogen content in soil, treatment N_2 (1.25 litre ha^{-1}) was at par with N_3 (1.5 litre ha^{-1}). The marginal diminution in the available phosphorous in main plot and organic carbon content over the initial value may be due to the fibrous root system which may have led to exhaustive nature of sweet corn. The reason may be increased microbial population have enhanced the soil available nutrients like nitrogen (Wu *et. al.*, 2005). Similar results were reported by Benzon *et al.* (2015), Abdel-Aziz *et al.* (2018), Davarpanath *et al.* (2016), Prasad *et al.* (2012 and Prihastani *et al.* (2018).

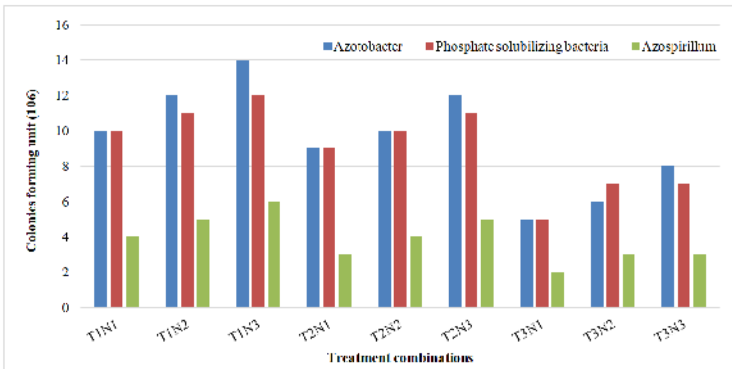

Fig. 2. Colonies of different soil microbes in different treatment of time of application and NN.

Table 5: Effect of time of application and levels of nano nitrogen fertilizeron available nutrient content of soil.

Treatments	Soil available nutrients					
	PH	EC	Org. Carbon	N	P	K
	(1:2.5)		(%)	(Kg ha^{-1})		
Time of Application (T)						
15 DAS (T_1)	7.24	0.21	0.56	201	35.7	312
30 DAS (T_2)	7.63	0.23	0.49	220	43.9	337
45 DAS (T_3)	7.81	0.24	0.48	240	54.9	353
S.Em ±	0.11	0.01	0.02	3.93	1.44	4.26
CD at 5%	NS	NS	NS	13.59	4.97	14.74
Levels of Nano nitrogen fertilizer (N)						
NN @ 1.00 L ha^{-1} (N_1)	7.43	0.19	0.49	229	46.7	342
NN @ 1.25 L ha^{-1} (N_2)	7.63	0.22	0.51	220	45.9	337
NN @ 1.5 L ha^{-1} (N_3)	7.91	0.23	0.54	212	41.9	323
S.Em ±	0.09	0.01	0.02	3.00	1.06	3.82
CD at 5%	NS	NS	NS	8.92	3.15	11.34
Interaction (T × N)						
S.Em ±	0.10	0.02	0.03	5.20	1.84	6.61
CD at 5%	NS	NS	NS	NS	NS	NS
Initial values	**7.90**	**0.28**	**0.59**	**197.16**	**40.19**	**297.04**

CONCLUSION

It is suggested to apply foliar spray of nano nitrogen fertilizer at 15 days after sowing with 1.25 litre per ha or 1.5 litre per ha for getting optimum yield and returns thereby maintaining the soil health.

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REFERENCES

Abdel-Aziz, H. M. M., M. N. A. and Arya, M. O. (2018). Foliar application of nano chitosan NPK fertilizer improves the yield of wheat plants grown on two different soils. *The Egyptian Journal of Experimental Biology (Botany), 14*(1): 63-72.

Al-Juthery, H.W.A, Hardan, H. M., Al-Swedi, F.G.A., Obaid, M.H. and *Al*-Shami, Q.M.N. (2019). Effect of foliar nutrition of nano-fertilizers and amino acids on growth and yield of wheat. *IOP Conf. Series: Earth and Environmental Science*388.

Al-Sharay, M.K.S. and Al-Rubaee, F.W.H. (2019). Effect of nano-nitrogen and manufacture organic fertilizer as supplementary fertilizer in the yield and its component for three synthetics of maize (*Zea mays* L.). *Plant Archives*, *19* (2): 1473-1479.

Anonymous[1], (2017). Agricultural Statistics at a Glance, Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics, New Delhi.

Anonymous[2], (2017). The Economist, How to stop fertilizer being washed away by rain?

Anupama, R., Rajeew K., Vijay, P.L. S. and Bandana, B. (2020). Effect of plant-based nano-sized gypsum on growth parameters and yield of wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies*, *8* (4): 2991-2993.

Benzon, H.R.L., Rubenecia, M.R.U.R., Venecio, U.U.J. and Sang, C.L. (2015). Nano-fertilizer affects the growth, development and chemical properties of rice. *Int. J. Agri. & Agri. R.*, *7* (1): 105-117.

Chavan, Y. S. and Yashpal, S.(2019). Effect of age of seedling, crop geometry and nano-fertilizers on performance of *kharif* rice in Konkan region of Maharashtra. Krishikosh. *Trends in Biosciences*, *12*(18): 1202-1207.

Davarpanah, S., Tehranifara, A., Davaynejad, G., Abadia, J. and Khorasani, R. (2016). Effect of foliar applications of zinc and boron nano-fertilizers on pomegranate fruit yield and quality. *Scientia Horticulture, 210*: 1-8.

Dhansil, A., Zalawadia, N.M., Bhawani, S. P. and Kamlesh, Y. (2018). Effect of nano-phosphatic fertilizer on nutrient content and uptake by pearl millet (*Pennisetum glaucum* L.) crop. *Int. J. Curr. Microbiol. App. Sci. 7* (12): 2327-2337.

El-Metwally, I. M., Doaa, M. R., Abo-Basha and *El*-Aziz, M. E. (2018). Response of peanut plants to different foliar applications of nano-iron, manganese and zinc under sandy soil conditions. *Middle East Journal of Applied Science*, *8*(2): 474-482.

Fan, L., Wang, Y., Shaho, X. and Geng, Y. (2012). Effects of combined nitrogen fertilizer and nano-carbon application on yield and nitrogen use of rice grown on saline-alkali soil. *Journal of Food Agriculture and Environment*, *10*(1): 558-562.

Hagab, R.H., Yousra, H.K. and Doaa, E. (2018). Using nanotechnology for enhancing phosphorus fertilizer use efficiency in peanut bean grown in sandy soils. *J. Adv. Pharm. Edu. Res.*; *8* (3): 59-67.

Jian, L., Zhang, Y.D. and Zhang, Z.M. (2008). Study on application of nanometer biotechnology on the yield and quality of winter wheat. *Journal of Anhui Agricultural Sciences*, *36*: 15578-15580.

Kha, L. Q., Ngo, Q.V., Nguyen, H. C. and Pham, V.B. (2019). The efficacy of micronano particles across NPK doses and densities on maize growth and yield in Vietnam. *Vietnam Journal of Science, Technology and Engineering*, *61* (3).

Kipps, M.S. (1959.) Production of field crops. *Tata McGraw-Hill Publishing Co. Ltd.* Bombay and New Delhi.

Kole, C., Phullara, K., Kelim, M. R. and Poonam, C. (2013). Nanotechnology can boost crop productivity and quality. First evidence from increased plant biomass, fruit yield and phytomedicine content in bitter melon (*Momordica charantia*). *BMC Biotechnology*, *13* (1): 37.

Manikandan, A. and Subramanian, K.S. (2016). Evaluation of Zeolite based Nitrogen Nano-fertilizers on Maize growth, yield and quality. *International Journal of Plant and Soil Science, 9*(4): 1-9.

Maria, C. D., Carlos, M., Morris, S., Ryan, W. and Yaisr, S. (2010). Nanotechnology in fertilizers. *Nature Nanotechnology*, Vol. 5, Macmillan Publishers Limited.

Melika, T., Hania, A.Q., Alimohammad, A.Q. and Mahedieh, Y. (2015). The effect of zinc-oxide nanoparticles on the growth parameters of corn (SC 704). *Stem Fellowship J., 1*(1): 17-20.

Mir, S., Sirousmehr, A. and Shirmohammadi, E. (2015). Effect of nano and biological fertilizers on carbohydrate and chlorophyll content of forage sorghum (Speed feed hybrid). *International Journal of Bioscience*, *6* (4): 157-164.

Morteza, E., Moaveni, P., Farahani, H. A. and Kiyani, M., (2013). Study of photosynthetic pigments changes of maize (*Zea mays* L.) under nano TiO_2 spraying at various growth stages. *Springer Plus, 2*(1): 1-5.

Naderi, M.R. and Danesh-Shahraki, A. (2013). Nanofertilizers and their roles in sustainable agriculture. *Int. J. Agric. Crop Sci.*, *5*(19): 2229-2232.

Nibin, P. M., Ushakumari, K. and Isharat, P. K. (2019). Organic nano NPK formulations on soil microbial and enzymatic activities on post-harvest soil of bhindi. *International Journal of Current Microbiology and Applied Science*, *8*(4): 1814-1819.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical Method for Agricultural Research workers. ICAR., New Delhi.

Prasad, T.N.V.K.V., Sudhakar, P., Sreenivasulu, Y., Latha, P., Munaswamy, V., Reddy, K. R., Sreeprasad, T.S., Sajanlal, P.R. & Pradee, T. (2012). Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. *Journal of Plant Nutrition*, *35*(6): 905-927.

Prihastanti, E., Subagyo, A. and Ngadiwiyana, N. (2018). Effect of combination of NPK and nano silica on the levels of β-carotene and nutritional value of corn (*Zea mays* L.) 3rd Annual Applied Science and Engineering Conference. Indonesia, Series: Materials Science and Engineering 434.

Sharifi, R. S. and Taghizadeh (2016). Response of maize (*Zea mays* L.) cultivars to different levels of nitrogen fertilizer. *J. of Food Agri. Env.*, *7* (3-4): 518-521.

Sharifi, R.S. and Namvar, A. (2016). Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (*Zea mays* L.). *J. Bioscience*, *62*(1): 35-45.

Shebl, A., Hassan, A.A.,Salama, D. M.,*El*-Aziz, M.E. A. and Mohammad S.A. E.(2019). Green synthesis of nanofertilizers and their application as foliar for Cucurbita pepo L. *Hindawi Journal of Nanomaterials*, 2019: 1–11.

Singh, M. D. (2015). Studies on the effect of time of application and concentration of nano zinc sulphide (nZnS) on the growth and yield of sunflower (*Helianthus annus* L.). M. Sc. Agri thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.

Singh, S. B. (1998). Production of specialized maize. *Indian Farming*, *48* (1): 74-75.

Sorooshzadeh, A., Hazrati, S., Orak, H., Govahi, M. and Ramazani, A. (2012). Foliar application of Nano-silver influence growth of saffron under flooding stress. Brno, Czech Republic, EU., *10*: 23-25.

Subramanian, K.S. and Sharmila, R.C. (2009). Synthesis of nano-fertilizers formulation for balanced nutrition. In: proceeding of the Indian Society of soil science. *Platinum Jubilee Celebration*, 22-25 December, IARI Campus, New Delhi.

Suriyaprabha, R., Karunakaran, G., Yuvakkumar, R. and Prabu, P. (2012). Growth and physiological responses of maize (*Zea mays* L.) to porous silica nanoparticles in soil. *Journal of Nanoparticle Research, 14* (12).

Wu, S.C., Cao, Z.H., Li, Z.G., Cheung, K.C., Wong, M.H. (2005). Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Geoderma, *125* (1-2): 155-166.