INFLUENCE OF NANO NITROGEN AND PHOSPHORUS FERTILIZER ON YIELD AND NUTRIENT CONTENT OF MAIZE (*Zea mays* L.)

ABSTRACT:

The study entitled, **"Influence of nano nitrogen and phosphorus fertilizer on yield and nutrient content of maize (*Zea mays* L.)"** was undertaken by conducting a laboratory experiment of synthesis and characterization of nitrogen and phosphorus nano-fertilizer and a field experiment at Regional Research Station, Anand Agricultural University, Anand (Gujarat) during summer and *kharif* seasons of the year 2021. The field experiment was laid out in Randomized Block Design comprising fourteen treatments of T_1[Control(No NPK)], T_2[100 % RDF (150 N-60 P-0 K kg ha^{-1})], T_3[75% RDF + Nano N & P through foliar application (1000 ppm)], T_4[75% RDF + Nano N & P through foliar application (2000 ppm)], T_5[75% RDF + Nano N & P through foliar application (3000 ppm)], T_6[50% RDF + Nano N & P through foliar application (1000 ppm)], T_7[50% RDF + Nano N & P through foliar application (2000 ppm)], T_8[50 % RDF + Nano N & P through foliar application (3000 ppm)], T_9[25% RDF + Nano N & P through foliar application (1000 ppm)] and T_{10}[25% RDF + Nano N & P through foliar application (2000 ppm)], T_{11}[25% RDF + Nano N & P through foliar application (3000 ppm)], T_{12}[Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)], T_{13}[Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)], T_{14}[Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)]. In case of seed treatment with nitrogen and phosphorus NPs, seeds were soaked in nitrogen and phosphorus NPs suspension of 1000 ppm for 2 hours. The foliar application was made during crop growth period with three sprays at 15, 30 and 60 DAS of the crop. The treatments were tested against the control. Signficantly higher grain yield, straw yield, nitrogen and phosphorus content in maize was recorded was achieved under application of T_4- 75% RDF + Nano N & P through foliar application (2000 ppm) during both seasons.

Key word: Nano-fertilizer, yield and Nutrient content

1. **INTRODUCTION**

The concept of nanotechnology is attributed to Nobel laureate Richard Feymen who gave a very famous visionary speech in 1959 during one of his lectures. He said “there is plenty of room at the bottom”. He is known as father of nanotechnology. The term nanotechnology was coined in 1974 by Norio Taniguchi at the University of Tokyo. The word “Nanotechnology” has originated from a Greek word **‘nanos’** which means **“dwarf”**. During the 1950s, Arthour von Hippel proposed the term “molecular engineering” and predicted the feasibility of constructing nano molecular devices (Goel, 2015). In the 1980s, the idea of nanotechnology as a deterministic, rather than stochastic, handling of individual atoms and molecules was conceptually explored in depth by K. Eric Drexler, who promoted the technological significance of nano-scale phenomena. The new variant of fertilizer was developed by Dr. J. C. Tarafdar of the Central Arid Zone Research Institute under the Indian Agriculture Research Institute (IARI). The fertilizer was prepared by developing a methodology to use microbial enzymes for breakdown of the respective salts into nano-form. Dr. Tarafdar told *Indian Science Journal* that the newly developed fertilizer is 2-4 times less expensive compared to chemical fertilizers. The newly developed nano fertilizer will bring down the use of chemical fertilizers by 80-100 times (Patra *et al.*, 2006)

Nanotechnology can reduce the rate of fertilizer nutrients loss through leaching and increase their availability to plants which ultimately leads to reduced water and soil pollution. Present days nano fertilizers are emerging as an alternative to conventional fertilizers, build-up of nutrients in soils and thereby eutrophication and drinking water contamination may be eliminated. Nitrogen stimulates chloroplast in plants, which is responsible for photosynthesis. The development of nitrogen fertilizer began in 1905 with German Chemist Fritz Haber. Haber discovered a way to fix nitrogen from air. He received a noble prize for his work in 1918. Fertilizers have an axial role in enhancing the food production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. Fertilizer N-recovery efficiency by the first crop is 30 to 50%.

This form of P shows low diffusion and high fixation rates in soils through ligand exchange by 1:1 clay minerals, Fe and Al oxides and hydroxides and is thus precipitated as Fe, Al, and Ca phosphates. In addition, application of solid phosphates in agriculture is hindered by the large size of the particles which limits phosphate mobility in the soil and thus prevents phosphate from reaching the root zone and nurturing the crops in a timely fashion.

Maize which is botanically known as *Zea mays* L. is an American Indian term for corn. The term corn comes after wheat and rice which means “to sustain life” that provides nutrients for human and animals worldwide (Elamin and Elagib, 2001). It is cultivated in tropical, temperate and subtropical regions of the world. The nutritional value of maize is high as it contains 72% starch, 10%, 8.5% fiber, 4.8% oil, 3.0% sugar and 1.7%. It is known as a "queen of cereals" because of its maximum yield potential (22 t ha^{-1}) among the cereals.

2. MATERIALS AND METHODS

The experimental field had an even topography with a gentle slope having good drainage. The texture of the soil is loamy sand soils derived from basaltic trap parent materials with medium depth of 30-60 cm which was very deep and fairly moisture retentive. The maize variety GAYMH 3 (Gujarat Anand Yellow Maize Hybrid 3) was used in the present investigation as a test crop which was released by Main Maize Research Station, Anand Agricultural University, Godhra during the year 2018 for middle Gujarat Agro-climatic zone. The minimum temperature ranged from 14.7^0 to 26.3^0 C, while mean maximum temperature ranged from 31.8^0 to 39.5^0 C during the crop summer season 2021 and in *kharif* season 2021 minimum temperature ranged from 29^0 to 35.9^0 C, while mean maximum temperature ranged from 31.8^0 to 39.5^0 C. Full dose of phosphorus (60 kg P_2O_5 ha^{-1}) and 50% of nitrogen in each plot (75 kg nitrogen ha^{-1}) in the form of di-ammonium phosphate and urea were applied in furrows before sowing. Remaining 50% nitrogen (75 kg nitrogen ha^{-1}) was applied in the form of urea in equal three split application at an interval of 15, 30 and 60 days after sowing as per treatment

3. RESULT AND DISCUSSION

3.1 Grain yield

The data on grain yield of maize as influenced by different nitrogen and phosphorus nano-fertilizer treatments during both summer & ~~kharif~~ 2021 seasons as well as in pooled analysis are given in Table 3.1.

Data mentioned in Table 1 showed that different treatments significantly influenced the grain yield of maize during both the seasons (summer and ~~kharif~~ 2021) and in pooled analysis. Among all the treatments tested, treatment T_4 (75% RDF + Nano N & P through foliar application (2000 ppm) at 15, 30 and 60 DAS after sowing of maize) gave significantly higher grain yield of 6037, 6456 and 6247 kg ha^{-1}during summer, ~~kharif~~ and on pooled basis, respectively as compared to all the treatments, except treatments T_2 and T_3. The treatment T_4 produced 66.46, 76.86 and 71.70 % higher grain yield compared to control (T_1) during the summer, *kharif* seasons and in pooled analysis, respectively. The increase over recommended dose (T_4) was 3.2, 3.5 and 3.1 per cent, during summer, *kharif* and on pooled basis, respectively. The increase in grain yield is mainly due to increase in plant height (Tables 2, 3 and 4) and cob length (Table 5) in the treatment T_4 over rest of the treatments.

3.2 Straw yield

Straw yield directly represents the total biological yield (biomass) of the plant excluding economic yield. In Indian condition straw is very useful as livestock feed, as a mulch and composting material. Nutritional value of maize straw is also a good and is a very good source of organic manure.The data pertaining to straw yield (kg ha^{-1}) as influenced by different treatments during the experimentation during both the seasons as well as in pooled analysis are presented in Table 2.

During both the seasons ~~i.e.,~~ summer and *kharif*, the treatment T_4 (75% RDF + Nano N & P through foliar application (2000 ppm) at 15, 30 and 60 DAS after sowing of maize) gave significantly higher straw yield of 8009 and 7948 kg ha^{-1}, respectively than rest of the treatments except T_2 and T_3 treatments. The straw yield of maize was almost 42.88 per cent and 62.96 per cent higher over control during summer and ~~*kharif*~~ seasons, respectively.

In pooled analysis also treatment T_4 registered significantly higher straw yield of 7978 kg ha^{-1} of maize as compared to other treatments, but it remained at par with treatments T_2 and T_3. Treatment T_4 produced 52.22 % higher straw yield than control on pooled basis.

3.3 Nitrogen content in grain

Results presented in the Table 3show significant influence of different treatments of nitrogen and phosphorus on nitrogen content in the grain of maize during both the seasons and on pooled basis. Results revealed that application of 75% RDF + Nano N & P through foliar application (2000 ppm) (T_4) had significantly higher N content (1.94, 1.95 and 1.95 % N content) during summer, ~~*kharif*~~ and in pooled, respectively. However, it was found at par with all the treatments barring T_2, T_3, T_5, T_6 and T_7 during summer. In *kharif* and pooled analysis, it was found to be at par with T_2 and T_3 treatments.

Table 1: Effect of different treatments on grain yield (kg ha^{-1}) of maize

Treatments		Grain yield (kg ha^{-1})		
		Summer	*Kharif*	Pooled
T_1: Control		3627	3651	3639
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		5848	6273	6060
T_3: 75% RDF + Nano N & P through foliar application (1000 ppm)		5789	6010	5899
T_4: 75% RDF + Nano N & P through foliar application (2000 ppm)		6037	6456	6247
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		5228	5648	5438
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		5211	5458	5335
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		5235	5525	5380
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		5040	5208	5124
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		5128	5071	5100
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		5252	5406	5329
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		4965	5285	5125
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		4687	5103	4895
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		4969	5265	5117
T_{14}: Seed treatment Nano N & P Nano N & P through foliar application (3000 ppm)		4918	5036	4977
Mean		5138	5385	5261
S.Em. ±	S			59.36
	T	223.42	220.79	157.05
	S X T			222.1
C. D. at 5 %	S			168.4
	T	649.48	641.83	445.70
	S X T			NS
C.V. %		7.53	7.10	7.31

Table 2: Effect of different treatments on straw yield (kg ha^{-1}) of maize

Treatments		Straw yield (kg ha^{-1})		
		Summer	~~Kharif~~	Pooled
T_1: Control		5606	4877	5241
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		7922	7860	7891
T_3: 75% RDF + Nano N ~~&~~ P through foliar application (1000 ppm)		7780	7261	7521
T_4: 75% RDF + Nano N ~~&~~ P through foliar application (2000 ppm)		8009	7948	7978
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		7548	6829	7188
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		6607	6674	6641
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		6931	6915	6923
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		6739	6780	6759
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		6488	6271	6380
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		7001	6387	6694
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		6967	6338	6653
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		6847	6132	6490
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		7005	6214	6609
T_{14}: Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)		6942	6126	6534
Mean		7028	6615	6821
S.Em. ±	S			61.13
	T	214.3	242.30	161.75
	S ~~X~~ T			228.75
C. D. at 5 %	S			173.49
	T	623.10	704.37	459.03
	S ~~X~~ T			NS
C.V. %		5.28	6.34	5.80

3.4 Nitrogen content in straw

Data given in Table 3.4 revealed that various treatments showed significant effect on nitrogen content in straw during both the seasons as well as on pooled basis. Treatment T_4 (75% RDF + Nano N & P through foliar application (2000 ppm)) significantly resulted in higher nitrogen content of 0.779, 0.831 and 0.805 % in summer, *kharif* and on pooled results, respectively than rest of the treatments, but it remained at par with T_2, T_3, T_5, $T_{6,}$ T_7 and T_8 in summer, in *kharif* and on pooled basis it remained statistical comparable with T_2 and T_3 treatments.

3.5 Phosphorus content in grain

Data pertaining to the influence of different treatments on phosphorus content in grain during both the seasons and on pooled basis are presented in Table 3.5.

An appraisal of data revealed that phosphorus content in grain was significantly affected in summer, *kharif* and pooled analysis. Application of 75% RDF + Nano N & P through foliar application (2000 ppm) at 15, 30 and 60 DAS of maize (T_4) recorded significantly higher P content in grain (0.295, 0.308 and 0.302 %, respectively) in summer, *kharif* and pooled basis than the rest of the treatments, but it remained at par with T_2 and T_5 in summer and pooled results. In *kharif* season T_2, T_3, T_5, T_6, T_7 and T_8 remained at par with T_4.

3.6 Phosphorus content in straw

Data on influence by different treatments on phosphorus content in straw during both the seasons along with pooled results are presented in Table. 3.6.

An appraisal of data showed that phosphorus content in straw was significantly affected during both the seasons and on pooled basis. Higher P_2O_5 content in straw (0.174 and 0.180 % in summer and ~~*kharif*~~, respectively) was observed with the treatment- 4.

Table 3: Effect of different treatments on N content in grain (%) of maize

Treatment		N content in grain (%)		
		Summer	***Kharif***	**Pooled**
T_1: Control		1.44	1.46	1.45
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		1.86	1.89	1.87
T_3: 75% RDF + Nano N & P through foliar application (1000 ppm)		1.84	1.82	1.83
T_4: 75% RDF + Nano N & P through foliar application (2000 ppm)		1.94	1.95	1.95
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		1.80	1.75	1.77
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		1.77	1.73	1.75
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		1.78	1.76	1.77
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		1.73	1.70	1.72
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		1.70	1.66	1.68
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		1.72	1.67	1.70
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		1.69	1.64	1.67
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		1.54	1.53	1.54
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		1.58	1.56	1.57
T_{14}: Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)		1.53	1.55	1.54
Mean		1.70	1.69	1.70
S.Em. ±	**S**			0.015
	T	0.062	0.056	0.042
	S X T			0.059
C. D. at 5 %	**S**			NS
	T	0.181	0.164	0.119
	S X T			NS
C.V. %		6.32	5.79	6.06

Table 4: Effect of different treatments on N content in straw (%) of maize

Treatments		N content in straw (%)		
		Summer	*Kharif*	Pooled
T_1: Control		0.531	0.593	0.562
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		0.755	0.820	0.788
T_3: 75% RDF + Nano N & P through foliar application (1000 ppm)		0.733	0.798	0.766
T_4: 75% RDF + Nano N & P through foliar application (2000 ppm)		0.779	0.831	0.805
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		0.741	0.736	0.739
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		0.717	0.747	0.732
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		0.727	0.762	0.745
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		0.703	0.746	0.725
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		0.671	0.714	0.693
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		0.682	0.728	0.705
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		0.648	0.720	0.684
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		0.558	0.645	0.602
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		0.596	0.683	0.640
T_{14}: Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)		0.549	0.674	0.611
Mean		0.670	0.728	0.699
S.Em. ±	S			0.0063
	T	0.027	0.020	0.0169
	S X T			0.0239
C. D. at 5 %	S			0.0181
	T	0.078	0.058	0.048
	S X T			NS
C.V. %		7.01	4.80	5.92

Table 5: Effect of different treatments on P_2O_5 content in grain (%) of maize

Treatments		P_2O_5 content in grain (%)		
		Summer	*Kharif*	Pooled
T_1: Control		0.184	0.187	0.186
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		0.284	0.303	0.293
T_3: 75% RDF + Nano N & P through foliar application (1000 ppm)		0.264	0.284	0.274
T_4: 75% RDF + Nano N & P through foliar application (2000 ppm)		0.295	0.308	0.302
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		0.268	0.294	0.281
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		0.255	0.287	0.271
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		0.258	0.286	0.272
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		0.249	0.280	0.265
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		0.246	0.259	0.253
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		0.249	0.271	0.260
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		0.238	0.252	0.245
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		0.230	0.236	0.233
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		0.223	0.258	0.240
T_{14}: Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)		0.224	0.229	0.227
Mean		0.247	0.266	0.257
S.Em. ±	S			0.0022
	T	0.0063	0.0097	0.0058
	S X T			0.0081
C. D. at 5 %	S			0.00624
	T	0.0184	0.0283	0.0165
	S X T			NS
C.V. %		4.44	6.32	5.539

Table 6: Effect of different treatments on P_2O_5 content in straw (%) of maize

Treatments		P_2O_5 content in straw (%)		
		Summer	~~Kharif~~	Pooled
T_1: Control		0.133	0.136	0.135
T_2: 100 % RDF (150 N-60 P-0 K kg ha^{-1})		0.171	0.172	0.172
T_3: 75% RDF + Nano N & P through foliar application (1000 ppm)		0.169	0.170	0.170
T_4: 75% RDF + Nano N & P through foliar application (2000 ppm)		0.174	0.180	0.177
T_5: 75% RDF + Nano N & P through foliar application (3000 ppm)		0.168	0.177	0.173
T_6: 50% RDF + Nano N & P through foliar application (1000 ppm)		0.160	0.166	0.163
T_7: 50% RDF + Nano N & P through foliar application (2000 ppm)		0.164	0.168	0.166
T_8: 50% RDF + Nano N & P through foliar application (3000 ppm)		0.159	0.157	0.158
T_9: 25% RDF + Nano N & P through foliar application (1000 ppm)		0.150	0.146	0.148
T_{10}: 25% RDF + Nano N & P through foliar application (2000 ppm)		0.157	0.157	0.157
T_{11}: 25% RDF + Nano N & P through foliar application (3000 ppm)		0.147	0.147	0.147
T_{12}: Seed treatment Nano N & P + Nano N & P through foliar application (1000 ppm)		0.139	0.152	0.146
T_{13}: Seed treatment Nano N & P + Nano N & P through foliar application (2000 ppm)		0.145	0.156	0.151
T_{14}: Seed treatment Nano N & P + Nano N & P through foliar application (3000 ppm)		0.142	0.157	0.149
Mean		0.155	0.160	0.158
S.Em. ±	S			0.0011
	T	0.0039	0.00431	0.0029
	S ~~X~~ T			0.004
C. D. at 5 %	S			0.0031
	T	0.011	0.0125	0.008
	S ~~X~~ T			NS
C.V. %		4.35	4.65	4.51

4. CONCLUSION

Based on two seasons research finding it is concluded that application of of 75 % RDF + Nano N & P through foliar application (2000 ppm) at 15, 30 and 60 days after sowing gave significantly higher yield and nitrogen, phosphorus content of maize. 25 % saving of conventional fertilizers.

5. REFERENCES

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