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RESEARCH PAPER

Effect of nitrogen and sulphur nutrition on growth and yield of maize (*Zea mays* L.) genotypes under eastern plain zone of U.P.

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Abstract : A field trial was carried out at NDUAT Faizabad to find out the effect of nitrogen and sulphur nutrition on growth and yield attributing characters of maize (*Zea mays* L.) genotypes under eastern plain zone of U.P. Nitrogen plays a vital role for the activities of every living cell. Adequate supply of N is associated with dark green colour and vigorous growth. Sulphur is most limiting factor for synthesis of sulphur bearing amino acids *viz.*, cystine, cystein and methionine and lipids. Three nitrogen level and two genotype were kept in main plot while four sulphur levels were allocated into sub plots under Split Plot Design and replicated thrice. Highest net returns of rupees 29134, 28191 and 30420 per hectare and B: C ratio of 2.07, 2.03 and 2.14 were earned with the application of 120 kg ha^{-1} N by Deccan- 103 genotype and nourishment of 20 kg ha^{-1} sulphur, respectively.

Key Words : Maize, Nitrogen, Sulphur, Nutrition, Genotypes, Growth, Yield, Economics

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INTRODUCTION

Maize is an important cereal crop grown all over the world in various agro-climatic conditions ranging from temperate to tropical regions and from sea level to an altitude of 2500 metres throughout the world. USA has highest productivity with 7.25 t ha^{-1} and rank first, trail by China with 4.70 t ha^{-1}. Percentage share of gross cropped area under maize was 4.22 per cent among all crops on all India bases. Where maize was grown in an area of 8.38 million hectares produced 19.78 million tonnes with average productivity of about 2361 kg ha^{-1} during 2012-13. Andhra Pradesh, Karnataka and Bihar ranks first, second and third in production acquiring all India percentage share of about 21.64, 15.43 and 10.48 per cent, respectively during 2012-13. Average annual growth rate of area, production and productivity of maize was about 1.7, 6.3 and 4.4 per cent, respectively during 2012-13 keeping the base year of 2007-08 (Anonymous, 2013).

Maize contains 4.5 per cent oil which is ideal cooking medium for various recipes. About 66 per cent

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of total maize production is used as feed, 25 per cent as food and industrial products while rest is used as seed etc. Industrially maize is used as oil, starch, glucose and fermented products *viz.*, acetaldehyde, acetone, ascorbic acid and confectionary products. While gluten products are used in textile besides paper, pharmaceuticals, poultry industries and cosmetic. Maize serves as staple food for millions of people in Asia, Africa and latin America. Maize is high in carbohydrates, protein and fairly good source of calcium, phosphorus, iron, and vitamin-A, nicotinic acid and riboflavin.

Nitrogen is associated with photosynthetic activities while in excess it can delay crop maturity. Scarcity of nitrogen leads to slow down of photosynthesis which hampers source to sink relationship and translocation of photosynthesis. Sulphur concentration usually range in 0.2-0.5 per cent in vegetative tissues. Sulphur is helpful in synthesis and accumulation of sulphur containing amino acids (cystein, cysteine and methionine), chlorophyll and proteins. Rahman *et al.* (2011) suggested that, sulphur is mainly responsible for availability and supply of nitrogen, hence, with increasing dose of sulphur the availability and uptake of nitrogen is increased. Both nitrogen and sulphur accelerates the yield of maize with ideal genotypes. The 5:1 nitrogen and sulphur ratio is considered as ideal for growth and development of maize (Channabasamma *et al.*, 2013). Proportionate imbalance of nitrogen and sulphur adversely affect protein, carbohydrate and amino acids synthesis. Therefore, a study was conducted to ascertain the optimum and economic doses of nitrogen and sulphur for different maize genotypes under eastern plain zone of Uttar Pradesh.

MATERIAL AND METHODS

A field experiment was conducted during two consecutive years of 2010-11 and 2011-12 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) to study the effect of nitrogen and sulphur nutrition on growth and yield attributing characters of maize (*Zea mays* L.) genotypes under eastern plain zone of U.P. Geographically, experimental site falls under sub-tropical zone in Indo-gangetic plains having alluvial calcareous soils and lies between 26.47^{0}N latitude and 82.12^{0}E longitude at an altitude of 113.0 meters above the mean sea level. The region receives mean annual precipitation of about 1280 mm. Out of which nearly 80 per cent is received from mid June to end of September. The winter season is very cold, whereas summer are hot and dry. Westerly hot winds start from the end of April and continue till the onset of monsoon. The treatment combinations comprised with three nitrogen levels *viz.*, N_1- 60 kg ha^{-1} and N_2- 120 kg ha^{-1}, and 150 kg ha^{-1} and two genotypes namely V_1- Prabhat and V_2- Deccan-103. Four sulphur levels *viz.*, S_1-control, S_1- 20 kg ha^{-1}, S_3- 40 kg ha^{-1} and S_4- 60 kg ha^{-1} were tested under split plot design. Where, nitrogen levels and both genotypes were allocated to main plots while four sulphur levels were assigned to sub plots and replicated thrice. The experimental soil was silty loam [(silt >56 %) delete] in texture with indicating slightly alkaline in reaction with low in organic carbon (0.32-0.37 %), low in available nitrogen (211.50-217.86 kg ha^{-1}) and medium in phosphorus (21.45- 23.68 kg ha^{-1}) and high in available potassium (137.64-140.32 kg ha^{-1}). Maize genotype Prabhat and Deccan- 103 were opted and sown in first fort night of July with aforesaid treatment and their combinations under 60×20 row to row and plant to plant spacing maintaining 6.0×2.4 metre net plot size. Crop was fertilized as per respective treatments where half of inorganic N, full phosphorus, potash and sulphur were applied at the time of sowing and remaining half nitrogen in two instalments one at knee high stage and second at silking stage. Gap filling and thinning were done wherever necessary and harvesting was done when crop was fully matured. Observations on growth characters *viz.*, plant height, number of leaves, dry matter accumulation per plant at different stages and yield attributes *i.e.*, number of cobs/plot, weight of cobs/plot, pith weight, grain yield and stover yield per hectare at harvest stage were recorded. Economics was enumerated after crop was harvested and threshed properly.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Growth and yield attributes :

Data presented in Table 1 depict that the nitrogen and sulphur levels significantly influenced the growth characters. The plant height at harvest and dry matter accumulation per plant at 100 days after sowing stage were obtained significantly higher when crop was nourished with 150 kg ha^{-1} nitrogen which was followed by 120 and 60 kg ha^{-1} application of nitrogen. While

nourishment of plants @ 20 kg ha^{-1} of sulphur has resulted into significantly highest plants and maximum dry matter accumulation at 100 days after sowing stage as compared to rest of the doses of sulphur. Genetic potential might have led to significantly increased plant height and dry matter accumulation per plant by variety Deccan-103 than Prabhat. These results are in close conformity with results reported by Singh *et al.* (2007). Heavy feeding of crop plant with higher doses of nitrogen ought to lead for greater yield attributes. Perusal of data presented in Table 1 revealed that nitrogen and sulphur levels exerted significant effect on yield attributes. Number and weight of cobs per plot was significantly increased with 150 kg ha^{-1} nitrogen followed by 120 and 60 kg ha^{-1} N doses. Lone *et al.* (2013) reported application of 150 per cent higher dose of nitrogen than RDF (225N:90P_2O_5:60K_2O kg ha^{-1}) maximized the yield attributes while number and weight of cobs per plot was significantly maximum with the application of sulphur @ 20 kg ha^{-1} which was trailed by 40, 60 and control treatments. Basal application of sulphur and its mobility within the plant might have restricted the performance behaviour towards the yield attributing characters. Bhatt and Jain (2012) reported significant increase in yield attributes and yields through the application of sulphur. However, genotype Deccan-103 has proven significantly better in acquiring higher number and maximum weight of cobs per plot than Prabhat. This might be due to difference in inbuilt genetic potential of individual genotype. Similar results were reported by Lone *et al.* (2013).

Yields :

Maize genotypes significantly influenced the yields through the application of nitrogen and sulphur (Table 2). Significantly higher plants and greater dry matter accumulation along with more number and weight of cobs per plot might have exerted maximum pith weight, grain and stover yield of maize. Different nitrogen levels revealed that significantly maximum pith weight per plot, grain and stover yields with the application of nitrogen @ 150 kg ha^{-1} as compared to 120 and 60 kg ha^{-1} N doses. Crop nourishment with nitrogen @150 kg ha^{-1} achieved 50.63 q ha^{-1} grain yield hence, it was 2.15 (49.56) per cent and 18.32 (42.79) per cent higher than the doses of 120 and 60 kilogram of nitrogen per hectare. Similarly Ram *et al.* (2003) also found significantly highest grain and stover yield with the application of nitrogen up to 180 kg ha^{-1}. Heredity potential of different genotypes resulted into significant increase in grain yield. Deccan- 103 genotype acquired maximum *i.e.*, 48.83 q ha^{-1} grain yield than obtained by Prabhat (46.56 q ha^{-1}) which was 4.87 per cent higher than later. Similar findings were obtained by Ram *et al.* (2003) also. Significantly greater pith weight might be an indicator for increased

Table 1: Effect of nitrogen and sulphur on drymatter accumulation, number of cobs plot^{-1} and weight of cobs plot^{-1} by maize (*Zea mays* L.) genotypes. (Pooled data)

Treatments	Plant height (cm)	Drymatter accumulation (g plant^{-1}) at 100 DAS	Number of cobs plot^{-1}	Weight of cobs plot^{-1} (kg)
Nitrogen levels (kg ha^{-1})				
60	196.91	149.20	106.62	7.42
120	199.17	152.51	104.99	8.57
150	201.14	154.25	108.87	8.75
S.E. ±	0.05	0.33	0.48	0.06
C.D. (P=0.05)	0.12	0.75	1.07	0.15
Varieties				
Prabhat	198.06	151.07	107.49	8.02
Deccan-103	200.08	152.91	109.49	8.47
S.E. ±	0.04	0.27	0.39	0.05
C.D. (P=0.05)	0.10	0.62	0.87	0.12
Sulphur levels (kg ha^{-1})				
Control	194.32	147.41	104.10	7.62
20	202.84	155.25	112.50	8.68
40	200.79	153.88	110.33	8.63
60	198.34	151.42	107.49	8.06
S.E. ±	0.11	0.20	0.40	0.40
C.D. (P=0.05)	0.24	0.42	0.82	0.81

grain yield naturally. Highest grain yield and pith weight was recorded with the nourishment of sulphur @ 20 kg ha^{-1} followed by 40 and 60 kg sulphur per hectare and control. Application of sulphur @ 20 kg ha^{-1} has achieved the 50.21 q ha^{-1} grain yield which was 7.10 per cent and 15.71 per cent higher than the application of 60 kg sulphur per hectare and control, respectively. Increase in grain yield was at par with the application of 20 and 40 kg ha^{-1} sulphur. Ram *et al*. (2006) also reported significantly higher yields with the application of sulphur @ 30 kg ha^{-1}.

Both the years data revealed that significantly higher stover yield was obtained with the application of nitrogen @ 150 kg ha^{-1} which was trailed by 120 and 60 kg ha^{-1} nitrogen doses which was 2.13 and 18.48 per cent higher than the nourishment of 120 and 60 kg N per hectare. Highest nitrogen dose might have promoted the intermodal elongation, succulence and shoot growth through accelerated photosynthetic activities. Khuram *et al*. (2013) also reported similar results. Heredity potential might be leaded to highest stover yield through the genotype Deccen-103 significantly where the increase in stover yield was 5.80 per cent higher than the genotype Prabhat. Higher growth and yield attributing characters might have caused significantly highest stover yield through the application of 20 kg ha^{-1} sulphur.

Table 2 : Effect of nitrogen and sulphur on pith, grain and stover yields by maize (*Zea mays* L.) genotypes (Pooled data)

Treatments	Pith weight $plot^{-1}$ (kg)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
Nitrogen levels (kg ha^{-1})			
60	1.25	42.79	73.63
120	1.42	49.56	85.42
150	1.45	50.63	87.24
S.E. ±	0.01	0.05	0.10
C.D. (P=0.05)	0.02	0.12	0.22
Varieties			
Prabhat	1.31	46.53	79.78
Deccan-103	1.43	48.83	84.41
S.E. ±	0.008	0.04	0.08
C.D. (P=0.05)	0.019	0.10	0.18
Sulphur levels (kg ha^{-1})			
Control	1.37	43.39	72.01
20	1.44	50.21	87.66
40	1.39	50.24	85.39
60	1.29	46.88	83.32
S.E. ±	0.007	0.04	0.07
C.D. (P=0.05)	0.014	0.09	0.15

Table 3 : Economics of maize (*Zea mays* L.) genotypes as influenced by nitrogen and sulphur nutrition (Pooled data)

Treatments	Gross return (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Cost : Benefit ratio
Nitrogen levels (kg ha^{-1})				
60	48611.00	26191.95	22419.05	1:1.86
120	56309.00	27174.65	29134.35	1:2.07
150	57523.50	29710.68	27812.82	1:1.94
Varieties				
Prabhat	52845.50	28083.84	24761.66	1:1.88
Deccan-103	55492.00	27301.01	28190.99	1:2.03
Sulphur levels (kg ha^{-1})				
Control	49160.00	24665.05	24494.95	1:1.99
20	57103.50	26683.97	30419.53	1:2.14
40	57021.50	28701.83	28319.67	1:1.99
60	53390.00	30721.01	22668.99	1:1.74

Increase in stover yields were 2.65, 5.20 and 21.73 per cent higher than the 40, 60 kg ha^{-1} of sulphur and control, respectively. Similarly Channabasamma *et al*. (2013) found highest grain yield (75 q ha^{-1}) and straw yield (9.30 t ha^{-1}) with the application of 150 kg N and 30 kg S per hectare with an N : S ratio of 5:1.

Economics :

Perusal of data presented in Table 3 revealed that, increasing doses of nitrogen acquired higher gross and net returns. Application of 150 kg ha^{-1} nitrogen exerted highest impact and earned maximum net return of rupees 27,813 and benefit: cost ratio of 1: 1.94. Genotype Deccan- 103 acquired highest net returns of rupees 28,191 and cost: benefit ratio *i.e.*, 1: 2.03. Among different sulphur doses application of 20 kg ha^{-1} proven highly remunerative with regard to gross return, net return and benefits of rupees 57103, 30420 and 1: 2.14, respectively than rest. Gahlout *et al*. (2010) concluded that the combined effects of nitrogen and sulphur were better than their individual effects. Highest returns were reported through the application of nitrogen @ 150 kg ha^{-1} and sulphur @ 30 kg ha^{-1}. Similarly Singh *et al*. (2014) also reported highest net return and B: C ratio with the application of sulphur.

Conclusion :

Application of nitrogen @ 120 kg ha^{-1} was proven economically optimum in combination with application of 20 kg ha^{-1} sulphur. Sowing of Deccan– 103 genotype was proven to be most effective as compared to Prabhat. Highest economic net return of rupees 29134, 28191 and 30420 were earned with the application of 120 kg ha^{-1} N by Deccan- 103 genotype and nourishment of 20 kg ha^{-1} sulphur, respectively. Maximum B: C ratio *i.e.*, 2.07, 2.03 and 2.14 were also obtained through 120 kg ha^{-1} nitrogen, Deccan- 103 genotype and 20 kg ha^{-1} sulphur, respectively during 2010-11 and 2011-12.

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