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Short Note

Influence of Plant Density and Integrated Nutrient Management on N, P and K Contents and Uptake of Quality Protein Maize

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A field experiment was carried out at G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand to find out the effect of different plant densities and integrated nutrient management on N, P and K content and uptake of quality protein maize (QPM) during spring 2010 in factorial randomized block design replicated thrice with three plant densities *viz*., 66,666, 83,333 and 100,000 plants ha^{-1} and five modes of nutrition *viz*., 100% recommended dose of fertilizer (RDF) inorganic, 125 % RDF inorganic, 100 % recommended dose of nitrogen (RDN) through inorganic + 25 % RDN through organic, 75 % RDN through inorganic + 25 % RDN through organic and 50 % RDN through inorganic + 50 % RDN through organic The results revealed that high plant density resulted in reduction of N, P and K content in source as well as sink while fertilizer application either through inorganic alone or in variable combinations with organic did not influence nutrient content neither in source nor in sink.

Key words: Quality protein maize, plant density, INM, organic, inorganic, sink, source
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Maize is a good source of carbohydrates, protein and some important vitamins and minerals, but deficient in two essential amino acids *viz*., lysine and tryptophan. To overcome this problem, quality protein maize (QPM) has been developed by incorporating opaque-2 gene containing twice lysine and tryptophan content compared to normal grain. High yield potential of QPM depends on many factors *viz*., genetic constitution, nutrient availability, nutrient translocation and their assimilation in different plant parts, agronomic practices, environment conditions, etc. In plants, yield is the cumulative function of dry matter production.

Plant density affects plant architecture, alters growth and developmental pattern and influences carbohydrate production and partition (Casal *et al*., 1985). Optimum plant density ensures the plant to grow properly both in aerial and underground parts through differential utilization of growth factors particularly solar radiation, nutrients and space. Plant density beyond optimum level results in severe competition among plants for light above ground and for nutrients below the ground, consequently the nutrients availability and hence nutrient uptake, assimilation and partition between source and sink is severely affected. Thus, maintenance of optimum plant density play a vital role in nutrient absorption and partition in different plant parts.

The uptake of nutrients and their partition to different plant parts have been found to vary primarily with the fertility of soil, amount of fertilizers applied, the growth stage of the plant, the environmental conditions etc. Owing to reduced factor productivity,

the use of even optimum levels of N, P and K failed to maintain yield levels. As a result, more fertilizers have to be applied to sustain the productivity. But continuous use of chemical fertilizers alone has resulted in declining trend in productivity (Nambiar, 1994). Therefore, emphasis should be given on integration of organic source of nutrients. Organic manure provides regulated supply of nutrients by releasing them slowly and thereby increases nutrient availability and use efficiency. Therefore, proper mode of nutrition consisting of a proportionate combination of organic and inorganic source of nutrients is essential. It may help in adequate nutrient supply and proper assimilation in source and sink. Considering above facts this experiment was undertaken to study the effect of plant population and integrated nutrient management on nutrient content and uptake of quality protein maize.

Materials and Methods

A field experiment was conducted during spring 2010. The soil was classified as sandy loam hyperthermic *Aquic Hapludoll* under humid sub – tropical climate. The experimental soil was neutral in reaction (pH - 6.9), rich in organic carbon (1.18 %), low in available nitrogen (212.3 kg ha^{-1}) and medium in available phosphorus (18.14 kg ha^{-1}) and available potassium (258.2 kg ha^{-1}). The treatments consisting of three plant densities *viz*., 66,666, 83,333 and 100,000 plants ha^{-1} maintained through 60 cm × 25 cm, 60 cm × 20 cm and 50 cm × 20 cm, respectively, and five mode of nutrition *viz*.,100% Recommended dose of fertilizer (RDF) inorganic, 125 % RDF inorganic, 100 % Recommended dose of Nitrogen (RDN) through

inorganic + 25 % RDN through organic, 75 % RDN through inorganic + 25 % RDN through organic and 50 % RDN through inorganic + 50 % RDN through organic were tested in factorial randomized block design, replicated thrice. The recommended dose of fertilizers for N, P_2O_5 and K_2O was 120, 60 and 40 kg ha^{-1}, respectively. The source of organic was vermicompost containing 1.8 % N on dry weight basis. Quality protein maize hybrid variety HQPM-1 was sown as per recommended practices. Nitrogen, phosphorus and potassium were applied as per treatment through urea, SSP and MOP, respectively. Full dose of P, K and Zinc as $ZnSO_4$ @ 25 kg ha^{-1} and one third amount of N were applied as basal at sowing and remaining N was top dressed in two equal splits at knee high and tassel emergence stage.

Results and Discussion

Yield

An increase in grain and stover yields of maize was found with increase in plant density (Table 2). High plant density at 1,00,000 plant ha^{-1} produced 4.41 and 12.23 q ha^{-1} more grain and 14.45 and 27.08 q ha^{-1} more stover yields than 83,333 and 66,666 plant ha^{-1}, respectively. Yogananda *et al.* (1999) and Bangarwa *et al.* (1988) also reported increase in grain and stover yield, respectively, with increase in plant density. Nutrient practices failed to bring significant effect on grain and stover yields.

Table 1. N, P and K content in sink and source of maize as influenced by plant density and mode of nutrition

Treatment	N			P			K		
	Sink (%)	Source (%)	Sink/ Source ratio	Sink (%)	Source (%)	Sink/ Source ratio	Sink (%)	Source (%)	Sink/ Source ratio
Plant Density (Plants ha^{-1})									
P_1 : 66,666	1.76	0.74	2.40	0.410	0.202	2.04	0.476	1.16	0.41
P_2 : 83,333	1.72	0.70	2.47	0.372	0.199	1.88	0.435	1.13	0.39
P_3 : 100,000	1.68	0.66	2.54	0.348	0.187	1.86	0.402	1.08	0.38
SEm ±	0.02	0.02	0.05	0.012	0.004	0.08	0.014	0.031	0.02
CD (P = 0.05)	0.05	0.05	NS	0.034	0.012	NS	0.040	NS	NS
INM									
N_1 : 100 % RDF inorganic	1.72	0.70	2.47	0.370	0.189	1.95	0.420	1.08	0.39
N_2 : 125 % RDF inorganic	1.76	0.74	2.38	0.400	0.205	1.96	0.453	1.19	0.38
N_3 : 100% N inorganic + 25 % N organic	1.74	0.72	2.45	0.383	0.203	1.89	0.478	1.17	0.41
N_4 : 75% N inorganic + 25 % N organic	1.70	0.69	2.48	0.370	0.199	1.86	0.431	1.15	0.38
N_5 : 50% N inorganic + 50 % N organic	1.69	0.67	2.56	0.360	0.184	1.96	0.407	1.04	0.40
SEm ±	0.02	0.02	0.07	0.015	0.006	0.10	0.018	0.04	0.02
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

N, P and K content in sink

An increase in plant density led to significant reduction in N, P and K content in sink (Table 1). Crop grown under low plant density (66,666 plants ha^{-1}) accumulated significantly higher N (1.76 %), P (0.410 %) and K (0.476 %) in grain. Very high plant density having 100,000 plants ha^{-1} exhibited the lowest N, P and K content in grain however, was at par with 83,333 plants ha^{-1}. Severe competition among plants for growth factors including nutrients under high plant density might have resulted in less N, P and K content in sink. Zeidan *et al.* (2006) also reported similar findings. Mode of nutrition did not exhibit significant influence on N, P and K content in sink. Adequate supply of nutrients in all mode of nutrition could be ascribed to statistically same NPK content in sink. Malathesh (2005) also found non-significant effect of N substitution through organic on NPK content in maize.

N, P and K content in source

Significant reduction in N and P content in stover occurred due to high plant density stress however, no such effects were observed for K (Table 1). Crop raised with 66,666 plants ha^{-1} had significantly higher N (0.74 %) and P (0.202 %) content. Increase in density from 66,666 to 83,333 plants ha^{-1} resulted in reduction in N and P but significant only in case of N. Further increase in density over 83,333 plants ha^{-1} reduced N and P content significantly. Lowering of N and P content in stover with high plant density might be attributed to interplant competition and thus poor absorption of nutrients from soil. Luxury consumption and sufficient amount of K in soil could be reason for at par content of this nutrient in stover. Nutrient application either through inorganic alone or integration with organic failed to have significant effect on N, P and K content in source plant parts. It indicates proper availability of nutrients in all mode of nutrition.

Sink: Source ratio for N, P and K

Plant density as well as mode of nutrition failed to bring significant differences on source: sink ratio for N, P and K content. In general N and P content in sink was about two times more than that of source (Table 1). In contrast to N and P, K content in source was three times higher compared to sink. It makes clear that N and P have more partitioning in grain while K in stover. Though differences in source: sink ratio for N, P and K content were not significant but increasing plant density showed a trend of wide

Table 2. Effect of plant density and mode of nutrition on N, P and K uptake by sink and source of maize crop

Treatment	N uptake (Kg ha^{-1})			P uptake (Kg ha^{-1})			K uptake (Kg ha^{-1})			Yield (q ha^{-1})	
	Sink	Source	Total	Sink	Source	Total	Sink	Source	Total	Grain	Stover
Plant Density (Plants ha^{-1})											
P_1 : 66,666	101.7	104.6	206.2	23.6	28.8	52.4	27.6	164.7	192.3	57.7	142.0
P_2 : 83,333	113.0	108.8	221.7	24.3	30.8	55.1	28.4	175.5	203.9	65.5	154.6
P_3 :100,000	117.5	112.8	230.3	24.5	31.7	56.2	28.1	183.2	211.3	69.9	169.1
SEm ±	3.7	2.9	4.8	1.1	1.0	1.5	1.2	6.3	6.3	2.0.	2.8.0
CD (P = 0.05)	10.9	NS	13.9	NS	NS	NS	NS	NS	NS	5.0	8.1
INM											
N_1 : 100 % RDF inorganic	110.8	108.2	219.0	23.7	29.5	53.2	27.0	168.4	195.3	64.6	156.0
N_2 : 125 % RDF inorganic	117.4	118.8	236.2	26.6	32.9	59.5	30.1	191.5	221.6	66.9	161.3
N_3 : 100% N inorganic + 25 % N organic	113.6	113.1	226.7	24.9	32.1	56.9	31.1	184.5	215.5	65.3	158.1
N_4 : 75% N inorganic + 25 % N organic	106.1	103.1	209.9	23.2	29.9	53.2	26.5	172.8	199.3	62.6	150.9
N_5 : 50% N inorganic + 50 % N organic	105.1	99.7	205.3	22.3	27.6	49.9	25.5	155.3	180.8	62.5	150.0
SEm ±	4.7	3.8	6.2	1.4	1.3	2.0	1.5	8.1	8.1	2.5	36.0
CD (P = 0.05)	NS	10.9	18.0	NS	NS	5.8	NS	23.6	23.4	NS	NS

ratio for N and narrow for P and K. It reflects more translocation of N in grain while P and K in stover under plant population stress. Plants grown at high density might not properly metabolized N in organic structure of source parts and remained in ionic form and probably translocated to sink. No trend was observed in case of mode of nutrition however, the highest ratio was observed under 50 % N through inorganic and 50 % N through organic.

N, P and K uptake

N, P and K uptake increased with increase in plant density but remained significant only for N. Significant by higher N uptake by grain (117.5 kg ha^{-1}) and total N uptake by crop (230.3 kg ha^{-1}) was noted under high density of 100,000 plants ha^{-1} that was statistically similar to 83,333 plants ha^{-1}. More grain and stover yield under 100,000 plants ha^{-1} resulted in maximum NPK uptake. Similar observations were also made by Singh *et al.* (1997). Nutrient application methods did not affect nutrient uptake by grain significantly, however, N and K uptake by stover (118.8 and 191.5 kg ha^{-1}, respectively) was significantly higher with 125 % RDF inorganic (Table 2). Total uptake (grain + stover) of nutrients was also significantly higher with application of 125 % RDF inorganic but remained at par with integration of 100 % inorganic with 25 % organic. It is noteworthy that both the treatments received 25 % extra nitrogen over recommended dose which produced more yields and thus helped in nutrient uptake. The reduction in nutrient uptake was noticed with increase in the proportion of organic. This suppressing effect of high amount of organic on nutrient uptake might be ascribed to slow release of nutrients during crop life cycle and less grain and stover yield**.** The present findings are in accordance with Thiraporan *et al.* (1992) and Mishra *et al.* (1994).

Conclusion

High plant density reduced N, P and K content in source and sink. Mode of nutrition either through inorganic alone or in variable combination with organic though did not affect nutrient content but more proportion of organic decreased nutrient uptake by plant.

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