ADVANCE RESEARCH JOURNAL OF
C R O P
IMPROVEMENT
Volume 4 | Issue 1 | June, 2013 | 54-58

Influence of integrated nutrient management on productivity and quality of single cross hybrid maize (*Zea mays* L.) cv. HQPM 1

■ MANGAL CHAND BUNKER[1], A.M. PATEL[1], MUKESH KUMAR MAN[1] AND SHAUKAT ALI

ABSTRACT : A field experiment was conducted on loamy soil of Centre of Excellence for Research on Maize, Sardarkrushinagar Dantiwada Agricultural University, Bhiloda, Dist. Sabarkantha (Gujarat) to study the influence of integrated nutrient management on productivity and quality of single cross hybrid maize (*Zea mays* L.) cv. HQPM 1 during *Kharif*, 2011. The experiment comprised of twelve treatments in Randomized Block Design with four replications. Among the different treatments of nutrient management, treatment 100 % NPK + farmyard manure @ 5 t ha^{-1} recorded significantly higher plant height at harvest (228.65 cm), dry matter accumulation at harvest (183.10 g plant^{-1}), weight cob^{-1} (135.56 g), cob length (18.47 cm), weight of grains cob^{-1} (99.90 g), shelling percentage (78.60), 1000- grains weight (211.81 g), grain yield (4292 kg ha^{-1}) and stover yield (5647 kg ha^{-1}). Maize crop when fertilized with 100 % NPK + farmyard manure @ 5 t ha^{-1} observed significantly higher protein (10.43%) and carbohydrate (76.45%) oil per cent (5.49) was observed significantly higher under the application of 100 % NPK + Zn + S over rest of the treatments. The significantly higher nitrogen (329.28 kg ha^{-1}), phosphorus (27.10 kg ha^{-1}) and potassium (309.12 kg ha^{-1}) contents in soil after harvest of maize crop with the application of FYM 10 t ha^{-1} as compared to other treatments. The highest net return (Rs.39526 ha^{-1}) and BCR (2.56) were recorded with the application of 100 % NPK + farmyard manure @ 5 t ha^{-1} followed by application of 125 % NPK (Rs.36462 ha-1) along with BCR value of 2.49. The lowest net return (Rs.6578 ha^{-1}) and benefit cost ratio (1.34) were recorded under the control.

Key Words : FYM, Integrated nutrient management, Maize, Seed yield, Net return

How to cite this paper : Bunker, Mangal Chand, Patel, A.M., Man, Mukesh Kumar and Ali, Shaukat (2013). Influence of integrated nutrient management on productivity and quality of single cross hybrid maize (*Zea mays* L.) cv. HQPM 1, *Adv. Res. J. Crop Improv.*, **4** (1) : 54-58.

Paper History : Received : 23.03.2013; **Revised :** 07.04.2013; **Accepted :** 10.05.2013

AUTHORS' INFO

Associated Co-author :
[1]Department of Agronomy, C. P. College of Agriculture, S.D. Agricultural University, SARDARKRUSHINAGAR (GUJARAT) INDIA

Author for correspondence :
SHAUKAT ALI
Department of Agronomy, C. P. College of Agriculture, S.D. Agricultural University, SARDARKRUSHINAGAR (GUJARAT) INDIA
Email : shaukatagri@gmail.com

Maize (*Zea mays* L.) is an annual plant which belongs to family Gramineae and Genus *Zea*. (*Zea mays* L.) In fact the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Shaw, 1988; Dowswell *et al.*, 1996) and with a growing cycle ranging from 3 to 13 months (CIMMYT, 2000). However, the major maize production areas are located in temperate regions of the globe.

Maize is considered as the "queen of cereals". Being a C_4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity. The nutritional quality of maize is determined by the amino acid makeup of its protein. Maize is deficient in two essential amino acids: lysine and tryptophan, making it a poor protein food. Integrated nutrient management (INM) is a flexible approach to minimize the use of chemical sources of nutrients along with maximization of their efficiency and farmer`s profit. Fertilizers, organic manures and biofertilizer are the main component of INM. The quality parameters of maize like sugar, starch and crude protein content increase by continuous application of NPK + FYM. No manuring, lack of K and use of S free fertilizers decrease these parameters (Singaram and Kumari, 1999). Protein content of maize increases significantly with increase in use of sulphur (Dwivedi *et al.*, 2002). Farm yard manure application to the crops is being practiced for long period. Well decomposed FYM in addition to supplying plant nutrients acts as binding material and improves the soil physical properties (Kale and Bano, 1988).

RESEARCH PROCEDURE

The experiment was laid out to study the influence of integrated nutrient management on productivity and quality of single cross hybrid maize (*Zea mays* L.) cv. HQPM 1 during *Kharif*, 2011 at the of Centre of Excellence for Research on Maize, Sardarkrushinagar Dantiwada Agricultural University, Bhiloda, Dist. Sabarkantha (Gujarat). The soil of the experimental site was loamy with medium available nitrogen (315 kg ha^{-1}) and phosphorus (23 kg ha^{-1}) and high in available potassium (281 kg ha^{-1}). The experiment was laid out in Randomized Block Design with four replications. The experiment comprised of twelve treatments as given in Table 1. The crop was sown in the second week of July with recommended spacing. The seeds were treated with *Azotobacter* culture as per treatment and were dried under shade before sowing. The crop was irrigated as and when needed to maintain the optimum moisture level. Crop was harvested at maturity in the first week of October. Seed and straw yield were recorded and economics was worked out.

RESEARCH ANALYSIS AND REASONING

The results of the present study as well as relevant discussions have been presented under following sub heads:

Effect of treatments on growth attributes :

The maximum plant height was recorded under treatment 100 % NPK + FYM @ 5 t ha^{-1}, with a value of 228.65 cm at harvest being at par with the treatments 125 % NPK and 100 % NPK + Zn + S by recording 224.0 cm and 201.45 cm, respectively (Table 1). The integrated application of 100% NPK + FYM @ 5 t ha^{-1} resulted in maximum dry matter accumulation (183.10 g $plant^{-1}$) which was significantly superior over rest of the treatments.

Effect of treatments on yield and yield attributes :

The combined use of chemical fertilizers and FYM remarkably increased the weight cob^{-1} and cob length. The per cent increase in weight cob^{-1} and cob length under this treatments were 62.93 and 66.39, respectively over control.

The results given in the Table 1 clearly indicate that treatment 100 % NPK +FYM @ 5 t ha^{-1} being at par with the treatments 125% NPK and treatment 100% NPK + Zn + S recorded significantly higher weight of grain per cob (99.90 g). The corresponding value for other at par treatments was 94.20 g and 92.63 g. The lowest weight of grain per cob was recorded under control (48.19 g). Findings of several researchers were same (Pathak *et al.*, 2002) and Singh and Choudhary, 2008).

The results depicted in the Table clearly indicated that treatment T_7 (100 % NPK + FYM @ 5 t ha^{-1}) being at par with treatments T_9 (76.90), T_4 (76.85), T_2 (76.18), T_3 (76.12), T_5 (76.10), T_1 (75.29), T_6 (75.19), T_{10} (74.37) and T_{11} (73.24) recorded significantly higher shelling percentage (78.60) while significantly lowest shelling percentage was recorded under control treatment (54.90).

It was observed from the data that the differences in 1000-seed weight due to integrated nutrient management were found to be significant. Significantly higher 1000-seed weight (211.81 g) was recorded under the treatments T_7 (100 % NPK + FYM

Table 1 : Effect of integrated nutrient management on plant height (cm), dry matter accumulation, weight cob^{-1}, cob length, weight of grains cob^{-1}, shelling percentage and 1000-grains weight of maize

Treatments		Plant height at harvest (cm)	Dry matter/ plant at harvest (g)	Weight cob^{-1} (g)	Cob length (cm)	Weight of grains cob^{-1} (g)	Shelling (%)	1000-grains weight (g)
T_1	100% NPK (RDF)	199.27	141.50	115.90	17.10	85.70	75.29	196.81
T_2	100% NPK + Zn @ 3 kg ha^{-1}	200.07	153.75	118.90	17.54	86.65	76.18	199.41
T_3	100% NPK + S @ 40 kg ha^{-1}	199.95	154.65	115.50	17.41	86.73	76.12	201.25
T_4	100% NPK + Zn @ 3 kg ha^{-1} + S @ 40 kg ha^{-1}	201.45	161.08	121.90	18.15	92.63	76.85	202.55
T_5	100% NPK + Seed treatment with *Azotobacter* @ 30 g kg^{-1} seed	195.05	151.63	114.60	16.82	86.53	76.10	194.95
T_6	FYM @ 5 t ha^{-1} + 100% NPK [-NPK content of FYM] furrow	198.60	152.85	119.47	17.05	84.30	75.19	197.55
T_7	100% NPK + FYM @ 5 t ha^{-1} [furrow]	228.65	183.10	135.56	18.47	99.90	78.60	211.81
T_8	FYM @10 t ha^{-1}	175.85	118.60	98.68	16.00	74.46	68.09	185.17
T_9	125% NPK	224.00	162.85	122.55	18.45	94.20	76.90	203.25
T_{10}	100% NP	192.45	130.25	105.00	15.30	76.89	74.37	192.17
T_{11}	100% N	187.45	119.42	100.19	14.00	69.57	73.24	186.25
T_{12}	Control [N_0 P_0 K_0]	143.45	78.12	83.20	11.10	48.19	54.90	162.19
S.E.±		9.88	6.73	6.27	0.79	4.33	3.65	8.56
C.D. at 5 %		28.35	19.31	17.98	2.28	12.43	10.46	24.54
C.V. %		10.11	9.46	11.13	9.66	10.55	9.92	8.80

@ 5 t ha^{-1}) but it was found to be at par with treatment T_9 (203.25 g), T_4 (202.55 g), T_3 (201.25 g), T_2 (199.41 g), T_6 (197.55 g), T_1 (196.81 g), T_5 (194.95 g) and T_{10} (192.17 g). Significantly lower 1000-seed weight was recorded under control treatment (162.19 g).

Significantly higher grain yield (4292 kg ha^{-1}) was recorded under treatment T_7 (100 % NPK + FYM @ 5 t ha^{-1}) but it was found to be at par with treatment T_9 (125% NPK) and T_4 (100% NPK + Zn + S) by recording 3990 and 3841 (kg ha^{-1}), respectively (Table 2). Significantly the lowest grain yield ha^{-1} (1719 kg) was recorded under control. The highest grain yield ha^{-1} gained under these treatments might due to chemical fertilizer in conjunction with FYM might have provided favourable soil environment for better plant growth resulted in maximum grain

Table 2: Effect of integrated nutrient management on grain yield, stover yield protein (%), oil (%) and carbohydrate (%) of maize

Treatments		Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein (%)	Oil (%)	Carbohydrate (%)
T_1	100% NPK (RDF)	3480	4862	9.51	4.98	70.66
T_2	100% NPK + Zn @ 3 kg ha^{-1}	3670	5016	9.60	5.00	71.33
T_3	100% NPK + S @ 40 kg ha^{-1}	3585	4971	9.56	5.39	71.03
T_4	100% NPK + Zn @ 3 kg ha^{-1} + S @ 40 kg ha^{-1}	3841	5197	9.95	5.49	73.93
T_5	100% NPK + Seed treatment with *Azotobacter* @ 30 g kg^{-1} seed	3593	4979	9.55	4.95	70.96
T_6	FYM @ 5 t ha^{-1} + 100% NPK [-NPK content of FYM] furrow	3540	5011	9.52	5.01	70.73
T_7	100% NPK + FYM @ 5 t ha^{-1} [furrow]	4292	5647	10.43	5.18	76.45
T_8	FYM @10 t ha^{-1}	2690	3530	9.25	4.90	68.73
T_9	125% NPK	3990	5492	10.11	4.97	75.12
T_{10}	100% NP	3089	4331	9.35	4.85	69.47
T_{11}	100% N	2560	3573	9.22	4.84	68.50
T_{12}	Control [N_0 P_0 K_0]	1719	2295	7.90	4.78	68.26
S.E.±		167.41	214.31	0.29	0.15	1.57
C.D. (P=0.05)		480.24	614.79	0.82	0.42	4.50
C.V. %		10.03	9.37	6.03	5.85	4.40

Table 3: Effect of integrated nutrient management on soil fertility status at harvest and economics of maize

Treatments		Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Net realization (Rs ha^{-1})	B:C Ratio
T_1	100% NPK (RDF)	302.00	23.08	278.65	29806	2.27
T_2	100% NPK + Zn @ 3 kg ha^{-1}	305.20	23.16	280.96	32119	2.35
T_3	100% NPK + S @ 40 kg ha^{-1}	308.34	22.09	281.59	31012	2.31
T_4	100% NPK + Zn @ 3 kg ha^{-1} + S @ 40 kg ha^{-1}	306.96	23.32	283.78	34302	2.42
T_5	100% NPK + Seed treatment with *Azotobacter* @ 30 g kg^{-1} seed	302.00	20.54	279.24	31408	2.34
T_6	FYM @ 5 t ha^{-1} + 100% NPK [-NPK content of FYM] furrow	323.75	25.48	292.32	30546	2.29
T_7	100% NPK + FYM @ 5 t ha^{-1} [furrow]	324.56	25.56	300.65	39526	2.56
T_8	FYM @10 t ha^{-1}	329.28	27.10	309.12	17185	1.73
T_9	125% NPK	315.30	23.07	285.78	36462	2.49
T_{10}	100% NP	302.90	22.56	269.89	24931	2.12
T_{11}	100% N	299.50	21.33	266.67	18409	1.89
T_{12}	Control [N_0 P_0 K_0]	295.45	20.12	264.32	6578	1.34
S.E.±		7.15	0.63	6.63	-	
C.D. (P=0.05)		20.52	1.81	19.01	-	
C.V. %		4.62	5.45	4.69	-	

yield ha^{-1}. The results are in close agreements with the findings of Karki *et al.* (2005), Pathak *et al*. (2005) and Haque *et al*. (2010).

The stover yield was significantly higher under the treatment T_7 (100 % NPK + FYM @ 5 t ha^{-1}) (5647 kg ha^{-1}) than rest of the treatments, but it was found to be at par with treatments T_9 125% NPK (5492 kg ha^{-1}) and T_4 100% NPK + Zn + S (5197 kg ha^{-1}). The lowest stover yield was recorded under control treatments T_{12} (2295 kg ha^{-1}). The increased availability of nitrogen under these treatments might have improved the growth attributes which enhanced the photosynthesis and translocation of carbohydrates to sink site which ultimately led to positive increase in stover yield. This finding confirms to those reported by Sharma and Gupta (1998) and Dubey *et al.* (2006).

Effect of treatments on quality parameters :

Protein content of maize seed was variably influenced by the different treatments. From the results, it is observed that significantly higher protein content (10.43%) was recorded under application of (T_7) 100% NPK + FYM @ 5 t ha^{-1}, which was found to be at par with (T_9) 125% NPK (10.11%) and (T_4) 100% NPK + Zn + S (9.95%), significantly lower protein content (7.90 %) in seed was noted under control (Table 2). Higher protein content of grain under organic with inorganic might be due to higher vegetative growth and yield attributing character might have helped to increase uptake of nitrogen and thus increased the protein content of corn significantly. The results are in conformity with the findings of Khadtara *et al.* (2006) and Balai *et al.* (2011).

Significantly higher value of oil content was recorded under treatments (T_4) 100 % NPK + Zn + S (5.49%) which was at par with application of (T_3) 100% NPK + S (5.39%) and (T_7) 100% NPK + FYM @ 5 t ha^{-1} (5.18%). Significantly lower oil content (4.78%) in seed was noted under control. Since sulphur application increased sulphur content of plants and sulphur is known to promote oil synthesis (Tandon and Messic, 2002), it is conceivable that positive response of oil content to balanced level with suphur increased availability of sulphur was possible for bring up about improvement in oil content.

The carbohydrate per cent was significantly higher under the treatments T_7 (100 % NPK + FYM @ 5 t ha^{-1}) (76.45%) it was also found to be at par with T_9 125% NPK (75.12%) and T_4 100% NPK + Zn + S (73.93%). The lowest carbohydrate per cent was recorded under control (68.26%). This might have been instrumental effective regulation of the metabolic functions leading to better synthesis of proximate constituents and consequent improvement in the quality of the produce. The results of combined use of fertilizers and FYM are in close agreement with the findings of Singaram and Kumari (1999) and Singh *et al*. (2008).

Effect of treatments on soil fertility status after harvest :

Treatment T_8 (FYM @ 10 t ha^{-1}) recorded significantly higher nitrogen content in soil (329.28 kg ha^{-1}) than other treatments being at par with T_7 (100% NPK + FYM @ 5 t ha^{-1}), T_6 (FYM @ 5 t ha^{-1} + 100% NPK [-NPK content of FYM] and T_9 (125% NPK) (Table 3). The lowest nitrogen content in soil was registered under the control T_{12} (295.45 kg ha^{-1}). This might be due to continuous use of organic nutrient sources, which accumulated in soil resulting in build up in the soil. Increase in available N might be due to the direct addition of full or partial N through farmyard manure and greater multiplication of soil microbes, which could convert organically bound N to inorganic form. The results are in close agreements with the finding of (Das *et al.*, 2004).

Application FYM @ 10 t ha^{-1} registered significantly higher value of phosphorus (27.10 kg ha^{-1}) in soil which was also found to be at par with 100% NPK + FYM @ 5 t ha^{-1} and FYM @5 t ha^{-1} +100% NPK [-NPK content of FYM]. The control treatment recorded significantly lower amount of phosphorus (20.12 kg ha^{-1}) in soil after harvest of the maize crop.

Treatment T_8 (FYM @ 10 t ha^{-1}) recorded significantly higher potash content in soil (309.12 kg ha^{-1}) than other treatments but it was found at par with (T_7) 100% NPK + FYM @ 5 t ha^{-1} and (T_6) FYM 5 t ha^{-1} + 100% NPK (-NPK content of FYM). The lowest potash content in soil was registered under control (264.32 kg ha^{-1}). The organic manures on decomposition released the organic acids which may mobilize the native or non-exchangeable forms of K and charge the soil solution with K ions, so that it may be readily available. The results are in conformity with these reported by (Shibu, 2002) and (Das *et al.*, 2004).

Effect of treatments on economics :

The highest net realization of (Rs.39526 ha^{-1}) was recorded under (T_7) 100% NPK + FYM @ 5 t ha^{-1} closely followed by treatment T_9 125% NPK (Rs.6462 ha^{-1}) and T_4 100% NPK + Zn + S (Rs.34302 ha^{-1}) (Table). The lowest value net realization of (Rs.6578 ha^{-1}) was recorded under control. The highest benefit: cost ratio (2.56) was obtained with the treatment of (T_7) 100% NPK + FYM @ 5 t ha^{-1} closely followed by treatment T_9 125% NPK (2.49) and T_4 100% NPK + Zn + S (2.42). The lowest value of benefit: cost ratio was recorded under control (1.34).

Conclusion :

On the basis of the results of one year experiment, it is concluded that the maximum grain yield and net return from the maize (*var.* HQPM 1), can be achieved with the application of 100% NPK + FYM @ 5 t ha^{-1} whereas under the shortage or unavailability of FYM crop may be fertilized with 125% of recommended NPK or 100% recommended NPK + Zn @ 3 kg ha^{-1} + S @ 40 kg ha^{-1} under North Gujarat Agro-climatic condition for getting comparable grain yield and net return.

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