International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 964-966

Received: 05-05-2017
Accepted: 06-06-2017

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Response of organic acids and inorganic fertilizers on growth, yield and quality of *Rabi* maize (*Zea mays* L.)

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Abstract
An experiment was conducted at the college Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during *Rabi* season of the year 2015-16 with a view to study the response of organic acids and inorganic fertilizers on growth, yield and quality of *Rabi* maize (*Zea mays* L.). Maize variety HQPM 1 used in experiment. The experiment consisted fifteen treatment combinations comprised of three treatments of inorganic fertilizers *viz.,* F_1: 50 % RDF, F_2: 75 % RDF and F_3: 100 % RDF (150-60-0 NPK kg ha^{-1}) and five treatments of organic acids *viz.* M_1: Control, M_2: Humic acid @ 5 kg ha^{-1}, M_3: Humic acid @ 10 kg ha^{-1}, M_4: Citric acid @ 2.5 kg ha^{-1} and M_5: Citric acid @ 5 kg ha^{-1} were tested in a factorial randomized block design with four replications. Significantly the highest cob length (16.91 cm), number of grain cob^{-1} (499), number of cob plant^{-1} (1.79), stover yield (7776 kg ha^{-1}), protein content of grain and stover (10.43 and 2.87 %, respectively) were observed in case of application of 100 % RDF. While higher plant height at harvest (205.22 cm) and grain yield (5149 kg ha^{-1}) were observed in case of application of 100 % RDF and it was remained at par with treatment 75% RDF. Among $^{-1}$ (M_5), humic acid 5 kg ha^{-1} (M_2) and citric acid @ 2.5 kg ha^{-1} (M_5). Higher level of organic acids treatments, significantly higher cob length (16.24 cm), number of grain cob^{-1} (486), grain yield (5103 kg ha^{-1}) and protein content in grain (10.36 %) were observed under the application of 10 kg ha^{-1} humic acid and it was remained at par with application of citric acid @ 5 kg ha^{-1} (M_5) and humic acid 5 kg ha^{-1} (M_2). Plant height (204.78 cm) was observed in case of application of 10 kg ha^{-1} (M_3) humic acid and it was remained at par with application of citric acid @ 5 kg hacob plant^{-1} (1.73) and stover yield (7507 kg ha^{-1}) were observed in application of 10 kg ha^{-1} (M_3) humic acid and it was remained at par with application of citric acid @ 5 kg ha^{-1} (M_5). The highest protein content in stover (2.77 %) was observed in case of application of 10 kg ha^{-1} humic acid (M_3). Higher net realization of 51101 ha^{-1} and higher B.C.R. value of 2.57 were recorded in 100 % RDF. Among organic acids resulted in to higher net realization 55449 ha^{-1} with B.C.R. of 3.03.

Keywords: organic acids, inorganic fertilizers, *Rabi*, *Zea mays*

Introduction
Maize (*Zea mays* L.) the "Queen of Cereals", popularly known as corn, is one of the most important cereals of the world, ranking third among the food crops, next to rice and wheat, both in respect of area and production. In India, maize is the third most important food crop after rice and wheat.

Important maize growing states in India are Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Karnataka, Gujarat, Punjab, Rajasthan and West Bengal. Globally maize is cultivated in area of 177 Million hectares with the production of 967 million metric tonnes of grain with 5.5 metric tonnes hectare^{-1} productivity (Anonymous, 2014) [1]. In India, maize is grown over an area of 9.4 million hectares with an annual production of about 23 Million metric tonnes with 2.5 metric tonnes hectares^{-1} productivity.

Organic acids are produced in different ways in soils either from plant roots, microorganism or during the degradation of soil organic matter and make it available for plant uptake. Organic substances have no harmful threat to the quality of the environment and have excellent beneficial synergy with nutrients and compost (Pollhamer, 1993) [8].

Fertilizers have been and will continue to be the key input for achieving the estimated food grain production goals of the country. As increase in food grain production is possible only through the increased productivity per unit land that a needed to all effort is needed to increase the crop response to fertilizers.

The purpose of investigation was to study the response of organic acids and inorganic fertilizers on growth, yield and quality of *Rabi* maize (*Zea mays* L.).

Materials & Methods

A field experiment was conducted at the college Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during *Rabi* season of the year 2015-16 with a view to study the response of organic acids and inorganic fertilizers on growth, yield and quality of *Rabi* maize (*Zea mays* L.). The experiment consist fifteen treatment combinations comprised of three treatments inorganic fertilizers *viz.* F_1: 50 % RDF, F_2: 75 % RDF and F_3: 100 % RDF (150-60-00 NPK kg ha^{-1}) and five treatments of organic acids *viz.* M_1: Control, M_2: Humic acid @ 5 kg ha^{-1}, M_3: Humic acid @ 10 kg ha^{-1}, M_4: Citric acid @ 2.5 kg ha^{-1} and M_5: Citric acid @ 5 kg ha^{-1} were tested in a factorial randomized block design with four replications. The experiment was laid out in Randomized Block Design (Factorial experiment) with three replications. The soil of experimental plot was loamy sand in texture. The soil was low in organic carbon (0.40 %), available nitrogen (230.02 kg ha^{-1}) and medium in available phosphorous (30 kg ha^{-1}) and higher in potash (310.40 kg ha^{-1}). The maize varieties were sown with seed rate of 20 kg ha^{-1}. The economics was workout on current market price basis. Nitrogen was applied in three splits in the form of urea as per treatment combinations. Half of the nitrogen applied as basal, first one fourth dose of nitrogen as top dressing at knee height stage and second one fourth dose of nitrogen was applied at tasseling stage in the form of urea. Phosphorus was applied as basal application in the form of diammonium phosphate as per treatment. Zinc sulphate was applied basal @ 20 kg ha^{-1}. Humic acid and citric acid treatment were applied as basal application. Basal application was done in previously opened furrows. After fertilizer application, the furrows were covered with soil in such a way that the furrows remained partly opened for seed sowing. Total nitrogen percentage was multiplied by 6.25 to get protein percentage. The values off "F'' was worked out and compared with the values of table F at 5 per cent level of significance. The value of S. Em. $\pm$, C.D. and C.V. per cent were also calculated (Cochran and cox, 1957) [2].

Result & Discussion

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

Effect of inorganic fertilizers

The data presented in Table 1 showed that, among the inorganic fertilizers, Significantly the highest cob length (16.91 cm), number of grain cob^{-1} (499), number of cob plant^{-1} (1.79), stover yield (7776 kg ha^{-1}), protein content of grain and stover (10.43 and 2.87 %, respectively) were observed in case of application of 100 % RDF. While higher plant height at harvest (205.22 cm) and grain yield (5149 kg ha^{-1}) were observed in case of application of 100 % RDF and it was at par with treatment 75% RDF.

Increase in plant height, cob length, number of grain cob^{-1} and number of cob plant^{-1} with higher dose of 100 % RDF was probably due to stimulatory effect of N and P on cytokines synthesis and rapid conversion of synthesized carbohydrates into protein, consequent to increase in the number and size of growing cells, resulting ultimately into more number of grains cob^{-1}.

Application of nitrogen increased plant height and vigourus growth of plant has resulted in to higher stver yield. Phosphorus plays a vital role in the soil to accelerate the nutrient uptake and improved overall growth and development of the floral to primordial.

The higher grain yield attributes under application of 100 % RDF (F_1) and 75 % RDF (F_2) might be due to fact that of nitrogen might have hastened vigorous vegetative growth of the maize which might have stimulated the rate of photosynthesis and resulted into higher diversification of photosynthesis from vegetative to reproductive sink. Increased the dose of nitrogen increased the synthesis of amino acids, which constitute buildings block of protein and might have resulted in higher protein content in the grains and stover.

The results are conformity with findings of Pathan (2005) [7], Gomma *et al.* (2014) [3], Kumawat (2016) [5], Wadie *et al.* (2016) [9].

Effect of organic acids

Organic acids treatments, significantly higher cob length (16.24 cm), number of grain cob^{-1} (486), grain yield (5103 kg ha^{-1}) and protein content in grain (10.36 %) were observed in case of application of 10 kg ha^{-1} humic acid and it was at par with application of citric acid @ 5 kg ha^{-1} (M_5) and humic acid 5 kg ha^{-1} (M_2). Pant height (204.78 cm) was observed in case of application of 10 kg ha^{-1} (M_3) humic acid and it was at par with application of citric acid @ 5 kg hacob plant^{-1} (1.73) and stover yield (7507 kg ha^{-1}) were observed in application of 10 kg ha^{-1} (M_3) humic acid and it was at par with application of citric acid @ 5 kg ha^{-1} (M_5). The highest protein content in stover (2.77 %) was observed in case of application of 10 kg ha^{-1} humic acid (M_3).

Organic acids are helpful for nutrient availability increased in plant and they accelerated the growth and metabolite activity of the plants. So plant growth accelerated and they also help to increase the plant height, cob length, number of grain cob^{-1} and number of cob plant^{-1}. Application of organic acids showed better results, because of addition of organic acids increased the availability of both the native and applied nutrients in the soil and substantially their uptake by the plant which leads to overall improvement in growth of stover, thereby increased the grain and stover yield. Organic acids more accumulation of nitrogen, which leads the increased protein content in grain and stover.

These results are in line with findings of Zekeriya (2004) [10], Gomma *et al.* (2014) [3], Moghadam *et al.* (2014) [6] and Kim *et al.* (2016) [4].

Table 1: Growth, yield, quality attributes and economics of *Rabi* maize as influence by inorganic fertilizers and organic acids

Treatments	Plant height (cm)	Cob length (cm)	No. of grain cob^{-1}	No. of cob plant^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	protein content in grain (%)	protein content in stover (%)	Net realization (ha^{-1})	B. C. R.
Inorganic fertilizers (F)										
F_1: 50 % RDF	193.91	14.85	451	1.48	4180	5590	9.80	2.16	37011	2.24
F_2: 75 % RDF	202.40	15.62	470	1.67	4916	6777	10.02	2.64	47719	2.53
F_3: 100 % RDF	205.22	16.91	499	1.79	5149	7776	10.43	2.87	51101	2.57
S. Em. ±	1.94	0.15	6.26	0.02	124.03	175.31	0.09	0.03	-	-
C.D. (P=0.05)	5.55	0.43	18	0.06	354	500	0.28	0.08	-	-
Organic acids (M)										
M_1: Control	193.97	15.31	455	1.53	4352	6224	9.81	2.38	44094	2.69
M_2: HA @ 5 kg ha^{-1}	200.60	15.87	479	1.65	4766	6803	10.10	2.55	50059	2.86
M_3: HA @ 5 kg ha^{-1}	204.78	16.24	486	1.73	5103	7507	10.36	2.77	55449	3.03
M_4: CA @ 5 kg ha^{-1}	198.98	15.55	463	1.62	4640	6666	9.96	2.49	48333	2.82
M_5: CA @ 5 kg ha^{-1}	202.57	15.98	483	1.69	4878	7037	10.20	2.59	52085	2.95
S. Em. ±	2.51	0.19	8.09	0.03	160.12	226.33	0.13	0.04	-	-
C.D. (P=0.05)	7.16	0.55	23	0.08	457	646	0.36	0.10	-	-
Interaction										
V x M	NS	NS	NS	NS	NS	NS	NS	NS	-	-
C.V. %	4.34	4.21	5.92	6.05	11.68	11.45	4.38	4.82	-	-

Economics of different treatments

Economics play important role in deciding the adoption of particular treatment by the farmers. Therefore, the gross realization, net realization and benefit cost ratio (B.C.R.) were calculated for inorganic fertilizers and organic acids.

Effect of inorganic fertilizers

The data on economics (Table 1) revealed that 100 % RDF (F3) recorded maximum gross and net realization of 83744 and 51101 ha-1, respectively. 100 % RDF (F3) recorded maximum B.C.R. of 2.57.

Effect of organic acids

The data on economics (Table 1) revealed that HA @ 10 kg ha-1 (M3) recorded maximum gross and net realization of 82702 and 55449 ha-1, respectively. HA @ 10 kg ha-1 (M3) recorded maximum B.C.R. of 3.03.

Conclusion

From the results, it can be concluded that in order to obtain remunerative higher grain yield of Rabi maize variety HQPM 1, the crop should be fertilized either with 100 % (150:60:00 N:P:K kg ha-1) or 75 % (112.5:45:00 N:P:K kg ha-1) recommended dose of fertilizer (RDF) Common dose of zinc sulphate @ 20 kg ha-1 should be applied as basal. In substitute of inorganic fertilizers, maize crop should be nourished either with application of humic acid @ 10 or 5 kg ha-1 or citric acid @ 5 kg ha-1.

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