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Influence of Organic and Inorganic Sources of Fertilizers on Growth and Yield of Maize (*Zea mays* L.) in Fiji

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ABSTRACT

Background: Maize is used both as green cobs and for grains and it is in increasing demand throughout Fiji. Maize productivity is low and could be attributed primarily to climate, low soil fertility and inappropriate agronomic practices.

Methods: The experiment was laid out on maize variety Nirala in a randomized block design with three replications and six treatments comprising NPK, poultry manure and its combinations. Parameters on plant height (cm), number of leaves per plant, leaf length, leaf width, stem girth, grain yield were recorded and collected data was analyzed statistically applying the analysis of variance technique.

Result: Results reveled that among the all combinations, 100% NPK (300 kg/ha) along with PM @ 10 t ha^{-1} recorded higher plant height (204.00 cm), number of leaves per plant (12.87), maximum production efficiency (20.93 Kg/day/ha) and significantly superior (2511 kg/ha) grain yield and was most effective for improving growth and yield of maize.

Key words: Inorganic fertilizers, Maize, Organic fertilizers, Poultry manure.

INTRODUCTION

Maize is used both as green cobs and for grains and it is in increasing demand throughout Fiji. A total of 402 ha area was harvested under maize with production of 1208 tons with a productivity of 3 t/ha (FAOSTAT, 2018). The value of imports of Maize to Fiji totaled US$ 181 thousand in 2018. Besides climate, soil fertility plays a critical role in crop production. The low maize yields being recorded could be attributed primarily to climatic factors, especially rainfall distribution, low soil fertility and inappropriate agronomic practices. In addition, since climatic factors are not easy to manipulate, it would be prudent to concentrate efforts on improving soil fertility.

Due to continuous degradation in our natural resources, sustained agriculture production systems are the most crucial issue. Furthermore, the possibility of mixing maize with wheat for bread making has also increased the demand of maize. The increasing population and food demand have forced farmers to use high doses of chemical fertilizers. The unscientific use of fertilizers (nutrient imbalances, incorrect amount) is a serious threat to the sustainable agriculture production system (Kumar *et al*., 2014).

The use of both organic and inorganic fertilizer by farmers has been reported to increase yield, sustain productivity and improved soil chemical properties (Oyedeji, 2016). Application of mineral fertilizer in combination with locally available organic fertilizer is important to maintain soil fertility that achieve balance nutrient supply in order to increase crop yield. It is one of the best practices for plant nutrient management to optimize social, economic and environmental benefits of crop production. Integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints. Combined organic/ inorganic fertilization both enhanced carbon storage in soils and reduced emissions from nitrogen fertilizer use while contributing to high crop productivity in agriculture (Abbasi and Yousra, 2012). Afe *et al.* (2015) and Abdelzaher *et al*. (2017) witnessed a combination of organic and inorganic fertilizer improved the growth and yield of maize than sole application of any of the fertilizer. Intensive agriculture practice caused undesirable changes in soil environment in the past which include loss of soil organic matter, soil erosion and water pollution.

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MATERIALS AND METHODS

A field investigation on maize was conducted at Instructional Agriculture Farm Complex, College of Agriculture, Fisheries and Forestry, Koronivia Campus, Fiji National University, Fiji during February to July 2019. The geographical reference of the study area is 18°2′ 30″-18°3′ 36″ S, 178°31′ 17″-178°33′ 10″ E and elevation ranges from 6 to 23 m above mean sea level. The climate is tropical and the temperature was moderate (21°C-26°C). Soil of experimental area was sandy clay loam with pH value of 5.8; organic carbon (1.9%), total nitrogen (0.15%), available phosphorus (16 kg ha^{-1}) and potassium (133 kg ha^{-1}). Composition analysis reported 21.2 per cent total organic carbon,1.75 per cent nitrogen,

0.65 per cent phosphorus and 1.07 per cent of potassium in poultry manure. The experiment was laid out with maize variety Nirala in a randomized block design (RBD) with three replications and six treatments comprising sole and combinations of inorganic fertilizers and poultry manure (PM) as (T1: 100% NPK, T2: 100%NPK+PM @5t/ha, T3: 100% NPK+PM @10 t/ha, T4: PM@10t/ha, T5: PM @5t/ha and T6: Control. N, P and K were applied @300 kg/ha by NPK (13:13:21) as basal during planting. As per the treatments 15 days prior sowing poultry manure was applied and mixed in soil of respective plots and NPK fertilizer was applied and mixed thoroughly in each plot in accordance with treatment assigned.

Gap filling and thinning were done wherever necessary to maintain optimum plant population. Plant protection measures were taken to prevent infestation of insects, weeds and diseases. From each plot five maize plants were selected at random and tagged for growth measurements. Growth parameters like plant height (cm), number of leaves per plant (cm), leaf length (cm), leaf width (cm), stem girth (cm) were recorded. Leaf area (cm^2) was calculated by formula, Leaf area = 0.75 (length × width), where 0.75 being a constant (Foncha, 2019).

At harvesting, all plants of plots were harvested at ground level. A sub-sample of 5 plants were randomly selected and weighed. The plants were then separated into ears and stover. The ears were further separated into cobs and grains by shelling. From each experimental plots grain and stover yields was recorded. The data was converted and reported as grain yield (kg ha^{-1}) at 13% moisture. Production efficiency was calculated as per the formula adopted by (Kumawat *et al*., 2012).

Collected data was analyzed statistically applying the analysis of variance technique and CD (5% level of probability) was calculated for comparing treatment means for those where effect was significant in F-test.

RESULTS AND DISCUSSION

Growth parameters

Results from experiment showed that among nutrient management treatments, 100%NPK+PM@ 10t/ha (204.00 cm), PM @10t/ha (199.30 cm) and 100%NPK+PM @5t/ha (193.68 cm) gave the taller maize plants followed by 100%NPK (186.90 cm) and PM @5t/ha (185.60 cm) while the smallest plant (156.67 cm) was recorded in control (Table 1). Control plots recorded shortest maize plants due to limited nutrients supply in these plots. Superior plant height was recognized due to gradual release of essential plant nutrients in a combination of NPK and poultry manure as required by the plant.

Among nutrient management treatments, 100% NPK+ PM@10t/ha, PM @10t/ha and 100% NPK+PM @5t/ha recorded higher number of leaves per plant (12.87, 12.80, 12.45 per plant) followed by 100% NPK (12.13 per plant) and PM @5t/ha (11.07 per plant) while the minimum (9.97 per plant) was described in control. Leaves in each plant was inhibited due to restricted nutrients supply in the control plots. Similar trends were recorded in leaf length of the maize plant where by T3 recorded highest leaf length (89.93 cm) and control recorded the lowest (69.80 cm) (Table 1).

Analysis of variance showed significant differences for leaf width (cm), stem girth (cm) and leaf area (cm^2) amongst various inorganic and organic nutrient sole and combined application combinations. The significantly different treatments indicate positive responses of various treatments used on these growth parameters. Among sole and combined nutrient management treatments 100%NPK+PM @10t/ha recorded highest leaf width, stem girth and leaf area (9.3 cm,7.5 cm,839.80 cm^2) which was followed by PM @10t/ha, 100%NPK+PM @5t/ha, PM @5t/ha, 100% NPK and while the minimum leaf width, stem girth and leaf area (7.10 cm, 4.53 cm, 496.70 cm^2) was recorded in control plots. Stem girth and leaf area were inhibited due to restricted nutrients supply in the control plots (Table 1).

Production potential of maize

Combined application of organic and inorganic sources of fertilization had a significant result of maize grain yield. Maximum grain yield of 2511 kg/ha obtained from 100% NPK+PM @10t/ha followed by 100%NPK+PM @5t/ha and 100% NPK (2267 kg/ha and 2185 kg/ha, respectively). Minimum grain yield of 1033 kg/ha obtained in control.

Results obtained are in agreement with those of Fanuel and Gifole (2013); Afe *et al*., (2015) and Magda *et al*., (2015). They found that higher grain yield might be due to better growth, development and dry matter buildup by proper supply of nutrients in plant and increased availability of other plant nutrients with the corresponding nitrogen application source. Treatment 100%NPK+PM @10t/ha gave the highest values of growth components (Table 1) which were consequently reflected on grain yield.

Under the influence of sole and combined application of organic and inorganic sources of fertilization, maize stover yield varied significantly. Maximum stover yield of 4776 kg/ha was recorded by 100%NPK+PM @10t/ha followed by 100% NPK+PM @5t/ha and 100% NPK, 4310 and 4149 kg/ha, respectively. Minimum stover yield of 1966 kg/ha was obtained in control.

Biological yield was significantly affected by the investigated sole and combined treatments (Table 2). The highest biological yield of 7287 kg/ha was recorded in 100%NPK+PM @10t/ha, while, minimum was produced by Control. Dilshad *et al*., (2010) and Khan *et al*., (2016) found that combined use of organic and inorganic nutrients sources produced highest maize biological yield.

Production efficiency

Treatment 100%NPK+PM @10t/ha recorded maximum production efficiency (20.93 kg/day/ha) which was significantly higher among all other treatments. Minimum production efficiency of 13.53 kg/day/ha was recorded in treatment control (Table 2). This might be because of increase in grain yield under 100%NPK+PM @10t/ha which

Table 1: Growth parameters of maize as influenced by sole and combined organic and inorganic fertilizers.

Treatments	Plant height (cm)	No. of leaves /plant	Leaf length (cm)	Leaf width (cm)	Stem girth (cm)	Leaf area (cm^2)
100% NPK	186.90	12.13	85.87	8.13	6.44	695.37
100% NPK+PM @5t/ha	193.68	12.45	89.20	8.90	7.09	785.23
100% NPK+PM @10t/ha	204.00	12.87	89.93	9.30	7.50	839.81
PM @10t/ha	199.30	12.80	89.07	9.03	7.33	804.59
PM @5t/ha	185.60	11.07	85.30	8.87	6.63	726.29
Control	156.67	9.97	69.80	7.10	4.53	496.70
SE±	14.35	0.83	4.44	0.36	0.56	60.80
C.D. (0.05)	NS	NS	NS	1.16	1.80	194.06

Table 2: Maize yields and production efficiency of maize as influenced by sole and combined organic and inorganic fertilizers combinations.

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Production efficiency (kg/day/ha)
100% NPK	2,185	4,149	6,334	18.21
100% NPK+PM @5t/ha	2,267	4,310	6,577	18.89
100% NPK+PM @10t/ha	2,511	4,776	7,287	20.93
PM @10t/ha	1,746	3,316	5,062	14.55
PM @5t/ha	1,702	3,108	4,938	13.53
Control	1,033	1,966	2,999	08.61
SE±	49.73	64.23	141.58	0.18
C.D. (0.05)	158.73	205.01	451.90	0.56

also enhanced production efficiency per day. Combination of inorganic fertilizer with organic manure enhance the efficacy of inorganic fertilizers. Superior plant growth might have aided in synthesis of larger quantity of food material which was later translocated into developing cobs with increasing cob length and diameter.

Treatment 100% NPK+PM @10t/ha recorded significantly superior (2511 kg/ha) grain yield than inorganic fertilizers or organic manure alone tested for growth and yield of maize. This was followed by 100%NPK+PM @5 t/ha, 100% NPK, PM @10t/ha, PM @5t/ha and control.

CONCLUSION

Combined application of organic and inorganic sources of fertilizers were found more effective over inorganic fertilizers or organic manure alone in influencing growth and yield of maize. Among all the combinations, 100%NPK (300 kg/ha) along with 10 tons per hectare poultry manure was found most effective for enhancing growth and yield.

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