Use of Fertilizers and Lime for Enhancing Productivity of Maize Genotypes in Western Hill of Nepal

Bishnu H. Adhikary[1] and Krishna B. Karki[2]

[1] National Maize Research Program (NMRP)-NARC, Rampur, Chitwan
[2] Soil Science Division-NARC, Khumaltar, Lalitpur Nepal

ABSTRACT

Farmers' field experiment was conducted at Outreach sites in Tanahun and Palpa districts of Western Nepal with the objectives of evaluating the effects of fertilizers and agricultural lime on grain production of the local and improved (Manakamana-1) maize varieties during summer season of year 2003 and 2004. Farmer's practice (without fertilizers) and with fertilizer 60: 30: 30 kg (N: P_2O_5: K_2O) per hectare with or without agricultural lime (4 t ha^{-1}), were the treatments in experimental study that was conducted in factorial RCB design with four farmers as replications. The results revealed that response of fertilizers and agricultural lime was observed significant plant growth and kernels production including varieties in both sites of Palpa and Tanahun districts. The highest grain yield of 5.1 t ha^{-1} was produced by the local variety when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} along with 4 t ha^{-1} of agricultural lime in Tanahun. Manakamana-1 variety produced the maximum grain yield (4.45 t ha^{-1}) with the same level of fertilization. The two district mean grain yield result indicated that the highest grain yield of 3.9 t ha^{-1} was produced when the crop was supplied with 60: 30: 30 kg N, P_2O_5 and K_2O ha^{-1} with agri-lime. Hence it is suggested that to increase maize productivity in the hills irrespective of the maize variety application of fertilizers (60: 30: 30) with agricultural lime (4 t ha^{-1}) is needed.

Key words: Agriculture lime, farmer's practice, yield increase, *Zea mays*

INTRODUCTION

Maize (*Zea mays* L.) is a principle staple food crop for over 55% of people in the hills of Nepal. Traditionally, farmers have been applying ample amount of organic manures to sustain maize production and maintain soil fertility. Because of low content of plant nutrients in organic manure the amount of nutrient supplied through FYM/compost is not sufficient to explore the genetic potential of improved maize varieties. Soil analysis data revealed wide variation in fertility status across the hills of Nepal that differed in land type, altitude and soil type (Bennett 1995).

Increased use of high yielding maize varieties in intensive cropping system has led to increased demand of plant nutrients. Depletion of organic matter (OM) has been a key factor in overall decline of soil fertility in hills. Therefore, there is an increasing trend towards reduced nutrient balance in these soils (Ghani and Brown 1997). Much higher response to fertilizer is expected from crops when micronutrients are included in the treatments (Karki et al 2000, Karki 2003).

Soil acidification is one of the major factors contributing soil fertility decline in the hills of Nepal (Karki and Dacayo 1990, Turton et al 1996). Since lime is the cheapest and widely used materials to ameliorate acid soils, Karki (1986), studied lime requirement and recommended 4 to 9 t ha^{-1} of agricultural lime to strong to extreme acidic soils. Similar results were also obtained by Isherwood (1978), Tripathi (2002), Adhikary and Ranabhat (2004). To increase efficiency crop production soil amelioration is not enough. Nitrogen is another limiting nutrient in Nepalese soils. Nitrogen application practiced by farmers' is not responsive as expected. So split application of nitrogen with lime in upland condition has been found more effective (Joshy and Shrestha 1979). These treatments on both local and improved maize varieties responded well (NMRP 2005). Local maize varieties have been found performing well in soil acidity and low nutrients status and improved crop varieties are scarce in remote areas with the objective of promoting local maize variety that could be

comparable to improved one under similar condition and nutrient supply rate in western hills of Nepal this study was carried out.

MATERIALS AND METHODS

Series of experiments on maize genotypes using fertilizers and agricultural lime were conducted during the year 2004 and 2005 in the peri-urban areas of Tansen and Vyash municipalities to evaluate their effect on the grain production of maize (*Zea mays* L.). Four experiments were conducted in each site with local and improved maize varieties. Same local variety was used in the study with the four farmers that were available on the area and improved variety was Manakamana-1. Experimentation was carried out in the summer season (last week of April) on both sites. The experiment was designed in factorial RCB with four replications (farmers as replicates) in each site. Farmer's practice was used as control. Chemical fertilizers were applied with or without agricultural lime. The plot size taken in the experiments were (4-m × 3-m) with the line spacing of 75-cm × 25-cm. Plant growth and yield parameters were recorded and analyzed manually following Gomez and Gomez (1984). The following treatments were used in the experiment.

Treatment

Manakamana-1

T1 (V1F1) = (V1) Farmers practice/FP (F1).
T2 (V1F2) = (V1) 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (F2).
T3 (V1F3) = (V1) 4 t ha^{-1} of agricultural lime (F3).
T4 (V1F4) = (V1) 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} plus 4 t ha^{-1} agri.-lime.

Local variety

T5 (V2F1) = (V2) Farmers practice/FP (F1).
T6 (V2F2) = (V2) 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (F2).
T7 (V2F3) = (V2) 4 t ha^{-1} of agricultural lime (F3).
T8 (V2F4) = Local variety (V2) 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} plus 4 t ha^{-1} agri.-lime (F4)

RESULTS AND DISCUSSION

Fertilizer and agricultural lime significantly affected by the plant and ear head growth on both sites in Palpa and Tanahun districts (Table 1 and Table 2). Tallest plant height of 221.0 cm was observed in Tanahun district in Manakamana-1 when crop was fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1}. Shortest plant height of 189.2 cm was recorded with this variety in farmer's practice (T1 in Table 1). Longest ear height (123 cm) was observed in Manakamana-1 fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} along with 4 t of agricultural lime application (T4) and shortest (95.7 cm) also with this variety in farmers' practice condition (T1) in Tanahun district (Table 1).

Effect of lime and fertilizer looks positive. Farmers' practice looks inferior to all the treatments in both the varieties as indicated by straw and biomass yield (Figure 1). In both the varieties response of lime is apparent which is obvious and the results resemble the finding of Karki (1986). Fertilizer alone has given positive response and lime with fertilizer in Manakamana-1. Highest result is clearly observed with the T4 in Manakamana-1 and T6 in local varieties. Grain yield local variety did not result better grain yield with fertilizer application but performed well when fertilizers is combined with lime (T8). But the grain yield in T6 is decreased as compared to other treatments.

Table 1. Response of fertilizers and agri-lime on the plant growth and kernel production in Tanahun district

Treatment	Plant height, cm	Ear site height, cm	Ear length, cm	Kernel rows ear^{-1}	Kernels row^{-1}	Stover yield, t ha^{-1}	Grain yield, t ha^{-1}
T1	189.2	95.7	11.3	11.0	23.5	4.29	1.78
T2	221.0	116.7	13.7	11.5	27.7	7.29	4.10
T3	206.2	108.5	11.7	11.7	24.4	6.16	2.83
T4	220.5	123.0	13.4	11.7	26.0	6.91	4.45
T5	200.5	109.7	11.9	12.0	22.5	5.08	2.66
T6	208.0	110.0	14.3	12.5	26.2	6.79	4.55
T7	191.7	102.7	12.3	11.7	23.5	6.08	3.70
T8	213.5	114.7	14.0	12.0	27.3	8.00	5.10
Mean	206.3	110.2	12.8	11.7	25.1	6.32	3.65
CV, %	8.8	9.3	11.9	6.8	10.3	13.93	23.82
F-test	*	*	*	ns	*	**	**
LSD 0.05	26.9	15.1	2.2	-	3.8	1.29.	1.27

**, *Highly significant*. *, *Significant*. n*s, Non significant.*

In this experiment treatments T1 to T4 are similar to T5 to T8. The same treatments were applied to other variety. In Tanahun site, response of the two varieties to fertilizers and lime are compared. There was highly significant difference in the yield response. The local varieties performed significantly better than the improved one (Manakamana-1). In straw yield with T2 (application of mineral fertilizer alone) yielded much higher than T1 (farmers practice) and T3 (lime alone) but lime along with mineral fertilizer yielded highest irrespective of varieties (Figure 1). The longest ear length of 14.3 cm was observed in Tanahun district when the local maize crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T6, Table 1) whereas the shortest ear length (11.3 cm) was observed in this district in Mana-1 variety in farmer's practice condition (T1, Table 1). The effect of fertilizers and lime in kernel row production was observed to be non significant in Tanahun but significant in Palpa district. The number of kernel rows were to be highest (12.5 rows) in the local variety fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} in Tanahun district (T6, Table 1) and lowest (11.0 rows) with the farmer's practice condition in Manakamana-1 variety (T1), however, non significant difference in kernel rows was observed among the treatments in Tanahun district (Table 1). The number of kernel rows were to be highest (12.5 rows) in the local variety fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} in Tanahun district (T6, Table 1) and lowest (11.0 rows) with the farmer's practice condition in Manakamana-1 variety (T1), however, non significant difference in kernel rows was observed among the treatments in Tanahun district (Table 1).

The highest kernel numbers (27.7 kernels row^{-1}) were produced in Manakamana-1 variety when the crop was fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T2) followed by the local variety fertilized at this level of fertilizers applied along with 4 t ha^{-1} of agri-lime, and the lowest (22.5 kernel/row) in the local variety in farmer's practice condition in Tanahun district (T1, Table 1).

In Palpa district the results was little deviated from the results of Tanahun. Tallest plant height (245.2 cm) was observed in local variety fertilized at the same level of fertilizers whereas shortest plant height (171.2 cm) was observed in Manakamana-1 variety fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T2, Table 2). Longest ear length (138.2 cm) was observed in local variety when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T6) and the effect were significant. But the cob length (12.3 cm) was longest when lime is applied along with mineral fertilizer (T8). Likewise, the shortest length (9.1 cm) was observed in the same variety (local) when the crop was not supplied with fertilizers (T5), however, the effect of fertilizers and lime was found to be significant. Lime helped amelioration of soil pH and enhanced nutrients uptake (Maskey et al 2004). Since nitrogen is one of the limiting elements lime induced microbial activities and applied nitrogen in organic and mineral form is mineralized and hence biomass is increased with the application of lime and fertilizer in T8, which is similar to the finding of Joshy and Shrestha (1979).

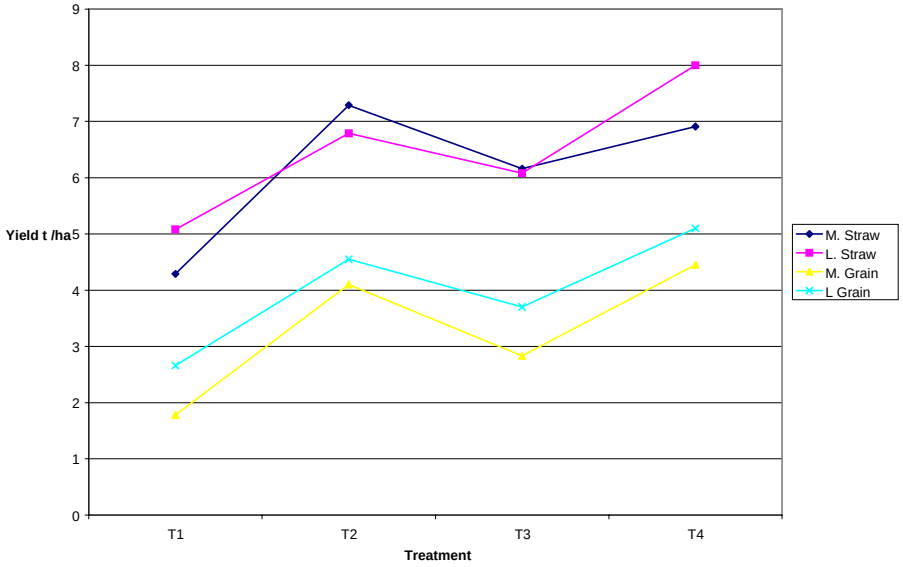

Figure 1. Response of lime and fertilizers on the yield of local and improved maize varieties in Tanahun district.

The numbers of kernels rows^{-1} the cobs were also significant indicating 21 as grand mean. The kernels number varies from 17.3 to 23.2 kernels row^{-1}. Highest numbers (23.2) were found in T2 and T8 both local and Manakamana. Effect of treatments on the kernel rows production was found to be significantly affected (Table 2). The highest kernel rows number (13.0 rows ear^{-1}) was produced by the Manakamana-1 variety when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T2). Besides these, kernel rows number ear^{-1}, production of kernels in the rows was found to be significantly affected. Similarly, the highest kernel numbers (24.5 kernels row^{-1}) were produced by Manakamana-1 variety when the crop was supplied with 60:30: 30 kg N, P_2O_5 and K_2O and 4 t ha $^{-1}$of agri-lime in Palpa district (T4, Table 2). The lowest kernels (17.3 kernels /row) were produced by the local variety in farmer's practice condition (T5).

The effect of fertilizers and lime on stover production was observed to be highly significant in both districts. The highest stover yield (8.0 t ha^{-1}) was produced by the local variety fertilized with 60:30:30 kg N, P_2O_5 and K_2O and 4 t ha^{-1} of agri-lime in Tanahun district (T8) and lowest stover yield (4.29 t ha^{-1}) with the Mana-1 variety in farmer's practice condition (T1, Table 1). The production of stover yield was almost double (15. 41 t ha^{-1}) in Palpa district when the crop was fertilized with 60:30:30 kg N, P_2O_5 and K2O ha^{-1} and 4 t ha^{-1} of agri-lime (T8, Table 2). The lowest stover yield (6.08 t ha^{-1}) was produced by both varieties, one supplied with agri-lime in farmer's practice condition (T3) and another without lime but farmer's practice (T5). The second highest stover yield (12.41 t ha^{-1}) was produced in Palpa district when the local maize crop was supplied only with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime (T6, Table 2).

Table 2. Response of fertilizers and agri-lime on the plant growth and kernel production in Palpa district

Treatment	Plant height, cm	Ear height, cm	Ear length, cm	Kernel rows ear^{-1}, n	Kernels row^{-1}, n	Stover yield, t ha^{-1}	Grain yield, t ha^{-1}
T1	190.2	89.7	10.2	11.0	19.7	6.43	1.49
T2	171.2	98.0	11.4	13.0	23.2	8.45	2.43
T3	180.2	88.4	9.6	11.5	17.5	6.08	1.63
T4	208.0	119.5	12.2	12.7	24.5	11.12	2.96
T5	206.5	113.7	9.1	9.7	17.3	6.08	1.47
T6	246.2	138.2	11.1	10.8	22.8	12.41	1.97
T7	194.2	117.5	9.2	10.5	19.1	6.62	1.35
T8	267.0	162.5	12.3	11.5	23.2	15.41	2.71
Mean	207.96	115.95	10.62	11.36	20.92	9.08	2.00
CV, %	18.79	19.29	10.54	11.80	13.09	27.03	36.00
F-test	*	*	**	*	**	**	**
LSD 0.05	57.45	32.89	1.64	1.97	4.02	3.61	1.06

***, Highly significant. *, Significant. ns, Non significant.*

Effect of fertilizers and agricultural lime on the maize grain production

A positive response of fertilizer and agri-lime on grain production of both maize genotypes was observed. Highly significant effect of treatments on the grain production was observed in both districts (Table 3). The highest grain yield (5.1 t ha^{-1}) was recorded in Tanahun district when the local variety was fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime (T8) followed by the same variety fertilized only with 60:30:30 kg N, P_2O_5 and K_2O /ha (T6). Non significant difference was observed in grain production between the Manakamana-1 (4.1 t ha^{-1}) and local variety (4.55 t ha^{-1}) at the same level of fertilization at 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} (T2 and T6, Table 3) in Tanahun. Similarly, non significant difference in grain yield was observed among the Manakamana-1 variety either in farmer's practice condition (1.78 t ha^{-1}) or with farmers practice fertilized with 4 t ha^{-1} of agri-lime (T3) in Tanahun. The response of treatments on grain production in Palpa district was found almost similar to Tanahun district but the quantity of production in an area of land was almost half to that of Tanahun district (Table 3). A maximum of 2.96 t ha^{-1} of grains were recorded by the Mana-1 variety when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime in Palpa district (T4, Table 3) followed by the local variety (2.71 t ha^{-1}) at the same level of fertilization (T8); however, non-significant differences in grain production was observed between them. The lowest grain yield of 1.35 t ha^{-1} was observed in local variety in farmer's practice condition when crop was fertilized with 4 t ha^{-1} of agri-lime (T7), which was less than the Mana-1 variety at farmer's practice condition (1.49 t ha^{-1}) in Palpa district.

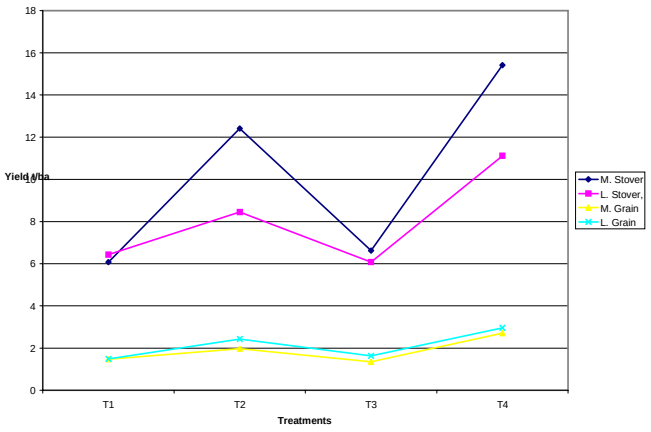

Figure 2. Yield response to local and Manakamana-1 maize varieties in Palpa.

Table 3. Response of fertilizers and agri-lime on the grain production of maize genotypes tested in Palpa and Tanahun districts

Treatment	Grain yield, t ha^{-1}		Two-districts mean, t ha^{-1}	Increment over the check, %
	Tanahun	Palpa		
T1	1.78	1.49	1.63	(-) 20.8
T2	4.10	2.43	3.26	58.2
T3	2.83	1.63	1.96	(-) 4.8
T4	4.45	2.96	3.70	79.6
T5 (Check)	2.66	1.47	2.06	00.0
T6	4.55	1.97	3.26	58.2
T7	3.70	1.35	2.52	22.3
T8	5.10	2.71	3.90	89.3
Mean	3.65	2.00	2.82	
CV, %	23.82	36.00	29.91	
F-test	**	**	**	
LSD 0.05	1.27	1.06	1.16	

**, *Highly significant*.

Table 4. Two-way table of means of grain yield at Palpa and Tanahun districts

Treatment (Fertilizer), F	Palpa district, yield, t ha^{-1}			Tanahun district, yield, t ha^{-1}		
	Variety I, V1	Variety II, V2	Mean, t ha^{-1}	Variety I, V1	Variety II, V2	Mean, t ha^{-1}
F1	1.49	1.47	1.48	1.78	2.66	2.22
F2	2.43	1.97	2.20	4.10	4.55	4.32
F3	1.63	1.35	1.49	2.83	3.70	3.26
F4	2.96	2.71	2.83	4.45	5.10	4.78
V-mean	2.13	1.87		3.29	4.00	
F-test, V		ns			*	
F-test F		**			**	
F-test, VxF		ns			ns	
SEM, V		0.1805			o.2174	
SEM, F		o.2553			0.3074	
SEM, VxF		0.3610			0.4347	
CV, %		36.02			23.82	

***, Highly significant. *, Significant. ns, Non significant.*

Two sites mean response revealed that highest grain yield (3.9t ha^{-1}) was recorded in the local maize variety when fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime (T8, Table 3). The highest yield of 3.7 t ha^{-1} was produced by the Mana-1 variety at this level of fertilization (T4, Table 3) in Palpa district. Manakamana-1 variety produced less grain yield (1.63 t ha^{-1}) by 20.8% to that of the local check at farmer's practice (T5, Table 3). The crop yield was increased by 89.3% over the local check crop (T5) when fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime (T8). The second highest increment (79.6%) was recorded in Mana-1 variety at this level of fertilization (T4, Table 3).

The mean grain yield results as shown in the two-way table (Table 4) revealed that higher grain production (2.13 t ha^{-1}) was produced by the Mana-1 variety as compared to that of the local variety. Similarly, nitrogen mean effect on grain production was observed to be highest (2.83 t ha^{-1}) in Palpa district when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime (F4, Table 4). The lowest grain yield of 1.48 t ha^{-1} was recorded in the farmer's practice condition in Palpa district (F1, Table 4). The effect of variety, as shown in Table 4, was observed to be non significant, whereas the effect of fertilizer application on grain yield was observed to be highly significant. On the contrary, the effect of variety was observed to be non significant on the grain production in Tanahun district. However, the effect of nitrogen was found to be highly significant. The interaction effect on the grain production was observed to be non significant in both sites (Table 4). The mean grain yield as shown in Table 4, indicated that increased grains (4.78 t ha^{-1}) could be produced when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} applied along with 4 t ha^{-1} of lime (F4, Table 4) followed by the crop (2.22 t ha^{-1}) supplied only with fertilizers at 60: 30:30 kg N, P_2O_5 and K_2O ha^{-1} (F1) in Tanahun district. Mean results also indicated that higher grain production was obtained (4.0 t ha^{-1}) from local variety (V2) compared to that of the Manakamana-1 variety (3.29 t/ha) in Tanahun district. This increment of grain yield should be release of nutrients especially P, Ca and Mg due to amelioration of soil pH due to addition of agricultural lime and application of fertilizer. Joshy and Shrestha (1979) and Karki (1986) obtained similar results.

Table 5. **Soil test results before crop planting (BCP) and after crop harvesting (ACH) of the experimental plots in Tanahun and Palpa districts**

Treatment	Tanahun district						Palpa district					
	Soil pH		OM, %		Total N, %		Soil pH		OM, %		Total N, %	
	BCP	ACH	BCP	ACH	BCP	ACH	BCP	ACH	BCP	ACH	BCP	ACH
T1	5.67	5.22	2.22	2.5	0.187	0.822	5.4	5.4	2.2	3.7	0.152	0.822
T2	5.78	6.00	2.35	2.4	0.227	0.647	5.5	6.0	2.6	2.8	0.153	1.015
T3	6.12	6.40	2.42	2.2	0.212	0.400	5.4	5.9	2.5	2.5	0.145	1.067
T4	5.83	6.78	2.37	2.3	0.185	0.770	5.4	6.0	2.8	2.9	0.177	0.717
T5	5.86	5.12	1.84	2.3	0.210	1.225	5.6	5.4	2.3	2.5	0.132	0.770
T6	5.88	5.93	2.38	2.3	0.265	0.690	5.3	5.7	2.5	2.8	0.191	0.700
T7	5.85	6.01	2.15	2.3	0.192	1.025	5.4	6.1	2.2	2.3	0.146	0.757
T8	5.83	6.16	2.03	2.2	0.190	0.762	5.4	6.0	2.6	2.7	0.173	0.735
Mean			2.22		0.208				2.46		0.158	

Soil samples were analyzed at the soil laboratory of National Maize Research Programme (NMRP), Rampur, Chitwan, Nepal during the year 2005.

Effects on the nutrient status of the soil

Soil samples were collected and analyzed for the pH, organic matter (OM) and nitrogen (N) content before the crop planting (BCP) and after the crop harvesting (ACH) in both sites. The results revealed that soil pH was observed to be increased with the application of fertilizers and agricultural lime in both districts (Table 5). Similarly the OM and N content was found increased after crop harvest with the application of fertilizers in the experimental plots in both districts. The mean OM and N content of 2.31% and 0.208% was observed before crop planting in Tanahun district. The N content was increased drastically in all the treated plots in Tanahun (Table 5). The highest N content of soil (1.025%) was observed in the Farmer's practice plot that received probably only farmyard manures (T5). The lowest increment of N content (0.400%) was observed in the plot supplied with 4 t ha^{-1} of agricultural lime in Farmer's practice condition (T3) in Tanahun district. Similarly, the mean OM content of 2.46% was observed before crop planting in Palpa district. The OM content was increased in all the plots after crop harvest (ACH) irrespective of the treatments used in the experiment (Table 5). The mean of total N content of 0.158% was observed before crop planting and its content was also increased after the application of fertilizers and agricultural lime in all the treated plots after crop harvesting (Table 5). Soil analysis results show increment in soil pH, soil organic matter and also nitrogen content of soil after crop harvest. Increment of 1 unit of soil pH after harvest of crop that is two year consecutive experiment on the same plot is not worthy. This increment enhances nutrients availability especially Ca^{++} and Mg^{++} and PO_4^{-}. This result is similar to the finding of Karki (1986).

CONCLUSION

It is noticed that the effect of fertilizers and agricultural lime was found to be significant on the plant growth and grain production on both local and improved (Mana-1) varieties in both districts. The tallest plant height (267.0 cm) was observed in the local maize variety with the application of 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime in Palpa district. The highest number of kernels (27.7 kernels row^{-1}) in a kernel row was observed in Tanahun district when the Mana-1 variety was supplied with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1}. The highest grain yield (5.1 t ha^{-1}) was recorded in Tanahun district in the local variety when fertilized with 60:30:30 kg N, P_2O_5 and K_2O ha^{-1} and 4 t ha^{-1} of agri-lime. Two districts mean grain yield of 3.9 t ha^{-1} was observed in this variety at this level of fertilization. A maximum of 4.45 t ha^{-1} of grains were produced by the manakamana-1 variety when the crop was supplied with 60:30:30 kg N, P_2O_5 and K_2O and 4 t ha^{-1} of agri-lime and was observed to be non significantly different to that of local variety at this level of fertilization. The productivity of maize crop was observed to be less in Palpa (lowest 1.35 t and highest 2.96 t ha^{-1}) as compared to that of Tanahun district (lowest 1.78 t and highest 5.1 t ha^{-1}). Farmers are suggested to grow not only improved maize varieties but also local varieties in acidic and marginal fertility soils in the hills of Nepal. It is recommended to apply 60:30:30 kg N, P_2O_5 and K_2O and 4 t ha^{-1} of agri-lime for increased grain production irrespective of maize genotypes.

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