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EFFECTS OF MICRONUTRIETNS ON GROWTH AND PRODUCTIVITY OF MAIZE IN ACIDIC SOIL

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Abstract: Micronutrients are trace elements which are needed by the maize crop in small amounts and play an active role in the plant metabolic functions in shortage of which show deficiency symptoms and crop yields are reduced, they are therefore to be added into the soil before crop planting or applied directly to the crop to increase maize productivity. In order to evaluate the effects of micronutrients (B, Zn, Mo, S and Mn) on the grain production of maize (var. Rampur Composite), series of field experiments were conducted during the winter season of three consecutive years (2007 to 2009) in the acidic soil condition (5.1 pH) at National maize Research Programme (NMRP), Rampur. Plant growth and yield parameters were studied. Results of the experiments revealed that the treatments had significant effect on studied parameters. Three years yield data following combined analysis indicated a sharp response of treatments on grain production and was observed to be highly significant, however, the response on the maize grain production among the micronutrient treated plots was observed small (5.43-5.99 t/ha of grains) except with the crop that lacked sulphur nutrient (4.71 t/ha). The highest grain yield (5.99 t/ha) was recorded with the crop which was supplied with all micronutrients (B, Zn, S, Mn and Mo applied in combination with NPK fertilizers at 120:60 40 kg /ha which produced almost 171 % higher grain yield than those with control plot (2.21 t/ha) and 1.48 t/ha of additional grains over NPK treated crop. It is suggested to apply micronutrients along with recommended dose of fertilizers in the acidic soils of Chitwan.

Key words: Combined analysis, correlation, grain yield, significant effect and *Zea mays* L.

INTRODUCTION

Micronutrients play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity and nitrogen fixation and reduction. Micronutrient requirements of the maize (*Zea mays*) crops are relatively small and ranges between their deficiencies and toxicities in plants and soils are rather narrow. Expectation of higher maize productivity through the use of adequate amount of fertilizer nutrients may lead to become limiting to some micronutrients in the soil and most times due to their overmining by the crops and shortage of which often show the deficiency symptoms and yields are reduced. The decreased amount of micronutrient in soils and their uptake by plants to such critical level which shows their deficiency symptoms (Das, 2000) to different crops and in shortage of which produce low yields. The importance of essential micronutrients in Nepal was realized about 2 decades ago when wheat sterility problems were encountered in the eastern part of the country. At that time the micronutrient identified was boron. In areas where intensive cultivation is practiced application of Zn has become a regular feature in rice cultivation. Khatri-Chhetri and Schulte (1984) found B and Zn were the most limiting nutrients for the soils of the Chitwan valley. Further, Khatri-Chhetri and Schulte (1985) reported that maize respond to the application of N and P, secondary nutrients and micronutrients. Joshy (1997) reported the critical limit of some micronutrients on maize. He mentioned the critical limit for sulphur was 14 ppm, boron 95 ppm, zinc 82 ppm and for manganese 0 ppm for maize crop.These limits were obtained from plant samples which were grown on the soils which were below critical limit values. Micronutrients are becoming increasingly important to world agriculture as crop removal of these essential element increases. Soil and plant tissue tests confirm that these elements are limiting crop production over wide areas and suggest that attention to them is likely increase in the future. Micronutrient deficiencies are due to not only to low contents of these elements in the soil but more often to their unavailability to growing plants (Brady and Weil, 2002). The micronutrient cations are most soluble and available under acid conditions. Boron is one of the most commonly deficient in the soil. The availability of B is related to the soil pH, this element being most available in acid soils. Soil pH is most important factor influencing the availability of plant uptake of Molybdenum (Mo). Liming of the acids soils usually increases the availability of Mo (Sillanpaa, 1982; Yermiyahu *et al.*, 1995). The results of experiments conducted at NMRP farmland using micronutrients on maize for both summer and winter seasons during the year 2003 and 2004 revealed that all micronutrients demonstrated a response except for sulphur.The crop yield was decreased in the absence of B. In the winter season, there was an indication of S deficiency only and there was no response to other micronutrients (Sherchan *et al.*, 2004). Adhikari *et al.* (2004) conducted experiments on Toria to study the response of different micronutrients in farmer's field and in NMRP research farmland, Rampur, Chitwan and concluded that application of micronutrients, especially S, B and Zn, are essential for achieving higher yields in Chitwan soils. In another study Adhikary and Pandey (2007) suggested to apply 20 kg of S/ha to increase grain production of maize in acidic soils of Chitwan valley. Tuladhar *et al.* (2004) reported that Chitwan soils were deficient in B and Zn but sufficient in cupper (Cu), Fe and Mn. The soils of Rampur agriculture farm has the typical composition of soils in the Chitwan valley, these have been recognized as young alluvium soils that are strongly acidic and very light textured. These soils need good management practices to increase soil productivity. The most commonly used practice to ameliorate the deficiencies is to add micronutrients into the soil or to spray them on crop foliage. In this context, an experiment was designed to identify the limiting micronutrients and to evaluate their effect on maize production and to recommend the micronutrients that could improve the productivity of maize.

MATERIALS AND METHODS

Field experiments were conducted during the winter seasons of the year 2007/08, 2008/09 and 2009/10 in a randomized complete block design (RCBD) with 3 replications in the acidic soils (pH 5.1) of NMRP farmland, Rampur, Chitwan. Some plots received only compost or NPK fertilizer and some do not (control plots) while most of the plots were treated with micronutrients along with NPK fertilizers as indicated in the treatment details, below. The experimental plot size was 4.5 m x 5 m (22.5 m^2) and net harvest area was only 15 m^2 for yield estimation. The row to row and plant to plant spacing was 75 cm and 25 cm, respectively. The maize variety used in the experiment was Rampur Composite and seed rate was 20 kg /ha. Seeds were seeded in the month of September in all years. There were 9 treatments with various combination of micronutrients (B, Mn, S, Zn and Mo), manures and fertilizers. The source of fertilizers were urea, DAP, MOP, ammonium molybdate, zinc sulphate, borax, manganese oxide and elemental sulphur. All required micronutrients, compost, P and K were applied according to the treatments as a basal application but N was splitted into two. The half N was applied as basal and the remaining half amount was side-dressed when the maize crop was at knee high stage. The crop was harvested in the month of February. Composite soil and plant samples were collected and analyzed for their nutrient content Total nitrogen (N) was analyzed by Micro-Kjeldahl method, and available phosphorus was extracted and analyzed by using 0.1N HCL+0.03N NH4F (Bray II) and diluted in 500 ml of distilled water. The filtrate along with blank sample was read by Spectrometer at the wavelength of 882 nm (Bray and Kurtz, 1945). Similarly, available potassium was extracted by using ammonium acetate and the filtrate was read by Flame photometer. Micronutrients (Zn, Mn, Cu and Fe) were extracted with DTPA extraction method. Growth and grain production parameters were taken into observation, and studied and analyzed statistically. Details of the treatments applied in the experiment are given below.

Treatments combination

T1= $N_0P_0K_0B_0Zn_0Mo_0S_0Mn_0$ (Control)
T2 = $N_{120}P_{60}K_{40}$ (120:60:40 kg N: P_2O_5 :K_2O/ha).
T3= $N_{120}P_{60}K_{40}$+ $B_5Zn_5Mo_{0.5}S_{20}Mn_{12}$ (T2+5 kg B/ha+ 5 kg Zn/ha + 0.5 kg Mo/ha + 20 kg S/ha + 12 kg Mn/ha).
T4= $N_{120}P_{60}K_{40}$+ $B_0Zn_5Mo_{0.5}S_{20}Mn_{12}$ (T3 but no boron).
T5= $N_{120}P_{60}K_{40}$+ $B_5Zn_0Mo_{0.5}S_{20}Mn_{12}$ (T3 but no Zinc).
T6= $N_{120}P_{60}K_{40}$+ B_5 Zn_5 $Mo_{0.5}$ S_0 Mn_{12} (T3 but no sulphur).
T7= $N_{120}P_{60}K_{40}$+ B_5 Zn_5 $Mo_{0.5}$ S_{20} Mn_0 (T3 but no manganese).
T8= $N_{120}P_{60}K_{40}$+ B_5 Zn_5 Mo_0 S_{20} Mn_{12} (T3 but no molybdenum).
T9= C_{20} (Compost @ 20 ton/ha)

RESULTS AND DISCUSSION

Response of micronutrients on maize growth characters

Three years results revealed that the growth of maize was significantly affected by the application of NPK and micronutrients over the nontreated control plot. Maize plant height, ear height, ear length and stover yield were observed significantly affected in all the years (Table 1, 2 and 3). The 1st year result indicated that tallest plant height (183.66 cm) was recorded when the crop was supplied with recommended dose of NPK fertilizers along with micronutrients (B, Mn, S and Zn). This plot did not receive Molybdenum element (T8, Table1) followed by the crop (180.33 cm) supplied with B, S, Mn and Mo at the similar NPK level (T5, Table 1). Tallest ear height (86.66 cm) and longest ear length (12.86 cm) was recorded in plots treated with all of the micronutrients except molybdenum at the NPK level of 120:60:40 kg/ha (T8) and with NPK alone (T2), respectively. Application of 20 t /ha of compost alone produced only 9.13 cm long ear length (T9) whereas the shortest was produced (6.60 cm) in the control plot in the 1st year (Table 1).

Table 1. Response of different micronutrients on maize growth and yield components for the year 2007/08.

Treatments	Plant ht. (cm)	Ear ht. (cm)	Ear length (cm)	Ker rows/ear (nos.)	Ker per row (nos)	1000 grain wt (g)	Stover yield (t/ha)
T1 (control)	89.33	34.00	06.60	10.40	12.26	315.66	1.66
T2 (N_{120}:P_{60}:K_{40})	172.00	78.66	12.86	13.46	23.13	401.00	4.39
T3 (T2+B+Zn+Mo+S+Mn)	175.33	82.66	12.40	13.73	24.73	394.66	6.54
T4 (T3+no B)	171.00	79.66	12.46	13.33	23.93	407.66	5.61
T5 (T3+no Zn)	180.33	79.66	12.60	13.86	23.46	385.33	5.40
T6 (T3+no S)	161.33	70.33	12.40	12.53	22.40	411.00	5.08
T7 (T3+no Mn)	162.00	80.00	11.93	12.93	21.80	389.33	5.68
T8 (T3+no Mo)	183.66	86.66	12.73	14.00	24.80	412.66	5.90
T9 ($compost_{20}$ alone)	102.66	37.33	09.13	11.86	17.40	385.00	2.47
Grand mean	155.29	69.88	11.45	12.90	21.54	389.14	4.74
CV (%)	6.57	9.45	8.77	6.45	12.14	5.62	17.29
F-test	**	**	**	**	*	*	*
LSD (0.05)	17.66	11.43	5.49	1.43	4.52	37.89	1.41

**= Highly significant at 0.01 level, *=Significant at 0.05 level and ns= non-significant.

Similarly, tallest plant height (213 cm) was recorded in T5 followed by T4 (207 cm) in the 2nd year. The tallest ear height (110 cm) was recorded in the crop supplied with all micronutrients except zinc (Zn) at the NPK dose of 120:60:40 kg/ha. Likewise, longest ear length (15 cm) was recorded in the crop fertilized with all micronutrients along with NPK fertilizers (T3). It can be concluded that there was no significant effect of treatments among the micronutrients applied crops on plant height, ear height and ear length in the 2nd year (Table 2). In the 3rd year, the effect of treatments was observed to be significant

On plant height, ear height and ear length but significant response among micronutrient treated plots was not observed (Table 3). The tallest plant height (188.33 cm) was recorded only with the application of NPK fertilizers (T2) without application of any micronutrients. The trend was found quite similar to ear height production. This level of NPK application produced tallest ear height (97.0 cm) which lacked any micronutrients (T2, Table 3). Longest ear length (15.0 cm) was recorded in the crop which was supplied with NPK fertilizers along with zinc, molybdenum, sulphur and manganese but lacked boron application (T4). Application of compost alone produced only 9.13 cm long ear length and shortest (8.40 cm) by control plots in the 3rd year (Table 3).

Table 2. Response of different micronutrients on maize growth and yield components for the year 2008/09.

Treatments	Plant ht. (cm)	Ear ht. (cm)	Ear length (cm)	Ker rows/ear (nos.)	Ker per row (nos)	1000 grain wt (g)	Stover yield (t/ha)
T1 (control)	107	057	09.6	11.7	18.4	448.6	3.36
T2 (N_{120}:P_{60}:K_{40})	198	095	14.8	13.7	29.2	447.8	5.29
T3 (T2+B+Zn+Mo+S+Mn)	202	101	15.0	13.4	29.7	532.9	6.91
T4 (T3+no B)	207	102	14.4	14.5	29.2	508.4	7.37
T5 (T3+no Zn)	213	110	14.8	14.6	27.6	477.5	6.77
T6 (T3+no S)	199	103	14.9	14.6	29.2	518.8	6.26
T7 (T3+no Mn)	204	106	14.3	13.8	28.4	510.5	6.51
T8 (T3+no Mo)	206	109	14.3	14.4	27.5	545.8	7.00
T9 ($compost_{20}$ alone)	126	064	12.0	12.2	25.2	476.9	4.36
Grand mean	184	94.2	13.8	13.7	27.1	496.3	5.98
CV (%)	4.82	8.37	7.18	7.09	8.24	5.41	7.57
F-test	**	**	**	**	**	*	**
LSD (0.05)	15.41	13.65	1.72	1.68	3.87	46.5	0.784

**= Highly significant at 0.01 level, *=Significant at 0.05 level and ns= non-significant.

Table 3. Response of different micronutrients on maize growth and yield components for the year 2009/10.

Treatments	Plant ht. (cm)	Ear ht. (cm)	Ear length (cm)	Ker rows/ear (nos.)	Ker per row (nos)	1000 grain wt (g)	Stover yield (t/ha)
T1 (control)	117.66	59.00	08.40	10.53	16.06	300.20	3.23
T2 (N_{120}:P_{60}:K_{40})	188.33	97.00	13.73	13.60	24.00	361.80	7.16
T3 (T2+B+Zn+Mo+S+Mn)	181.00	92.00	14.06	14.40	25.20	341.50	7.80
T4 (T3+no B)	187.00	91.33	15.00	13.90	25.86	373.56	7.16
T5 (T3+no Zn)	188.00	91.33	14.13	13.73	22.73	371.80	6.90
T6 (T3+no S)	182.00	87.00	13.80	13.20	25.53	355.90	7.33
T7 (T3+no Mn)	174.66	92.00	14.13	14.00	22.26	379.86	6.83
T8 (T3+no Mo)	186.66	92.33	14.73	13.856	23.26	426.73	7.36
T9 ($compost_{20}$ alone)	160.33	73.00	10.46	11.13	19.13	359.00	5.56
Grand mean	173.96	86.11	13.16	13.15	22.67	363.37	6.59
CV (%)	9.91	14.17	10.79	5.71	12.34	5.52	6.86
F-test	**	*	**	**	**	**	**
LSD (0.05)	29.83	21.11	2.45	1.30	4.84	34.74	0.783

**= Highly significant at 0.01 level, *=Significant at 0.05 level and ns= non-significant.

Response of micronutrients on maize yield components

Effects of treatments on kernel production in a kernel row and 1000 grain weight were observed to be significant in all years. Highest number of kernel rows/ear were produced (14.0 rows /ear) when the crop was supplied with NPK at 120:60:40 kg along with B, S, Zn and Mn but lacked Mo application (T8, Table 1) followed by T5 which produced 13.86 kernel rows /ear when the crop was supplied with B, Mo, Mn and S applied along with NPK fertilizers (T5) in the 1st year. On the contrary, highest kernel rows were produced by maize (14.6 rows /ear) when the crop was supplied either with B, S, Mn and Mo which lacked Zn (T5) or with B, Mn, Mo and Zn but lacked sulphur (T6) at the same level of NPK fertilization at 120:60:40 kg/ha in the 2nd year. Application of compost alone produced only 12.2 rows /ear (Table 2). Similarly, highest kernel rows/ear were produced (14.4 rows/ear) when the crop received all micronutrients and NPK fertilizers (T3) followed by T7 (14 rows/ear) in the 3rd year (Table 3). The control plot produced only 10.53 rows and 11.13 rows with compost alone (T9) in this year. However, significant response among the micronutrient treated plots was not observed on the rows production (Table 3). The highest number of kernels (24.8 kernels /row) was recorded in the T8 plot followed by T3 plot (24.73 kernels /row) in the 1st year whereas highest kernels (29.7 kernels /row) were produced by the T3 plot when all micronutrients along with NPK fertilizers were applied in the 2nd year (Table 2). Compost applied plot produced only 25.2 kernels/row in this year. No significant response was observed between micronutrient treated plots in the kernel production (Table 2). On the contrary, highest kernels were recorded in plots that do not received boron but all other micronutrients and NPK fertilizers (T4, Table 3) followed by T6 (25.53 kernels /row). Lowest kernels (16.06 kernels /row) were produced by control plot followed by the crops which received only compost (19.13 kernels /row) in the 3rd year. On the other hand, highest 1000 grain weight (412.66 g) was recorded in the crop supplied with B, Zn, S and Mn but no molybdenum (T8) followed by T6 (411.0 g) at the same level of NPK fertilizers in the 1st year (Table 1). The trend was quite similar to the 2nd year (545.8 g) and 3rd year (426.73 g) at the same level of NPK and micronutrients. Lowest 1000 grain weight of 315.6 g and 300.2 g were recorded by the control plots in the 1st and 3rd year, respectively (Table 1 and 3) whereas in the 2nd year lowest was produced by T2 (447.8 g). Highest grain yield of 545.8 g and 426.7 g were produced by T8 in the 2nd year and 3rd year, respectively.

Effects of micronutrients on maize grain production

Crop responded significantly to the application of micronutrient on the grain production of maize in all years. The highest grain yield (5.84 t/ha) was produced in the 1st year (2007/08) when all micronutrients (B, S, Mn, Mo and Zn) were applied in combination with NPK fertilizers at 120:60:40 kg/ha (T3) followed by T8 which did not receive molybdenum (Mo) at the same level of fertilizers (5.26 t/ha) (Figure 1). But in the 2nd year (2008/09), highest grain yield (7.35 t/ha) were produced by the application of Zn, Mn, Mo and sulphur (S) but lacked boron (B) , which were applied along with NPK fertilizers (T4) followed by the crop (7.30 t/ha) that lacked Mo but all other micronutrients and fertilizers (T8, Figure 1). The highest grain yield production trend in the 3rd year was observed quite similar to the 2nd year which produced 5.18 t of grains when all micronutrients except boron was applied (T4). Lowest grain yield (1.99 t/ha) was produced by the control plot (T1) followed by the crop treated with the compost alone (T9) in the year 2009/10 (Figure 1). Three years pooled results (combined analysis) indicated that highest grain yield (5.99 t/ha) was produced when the crop was supplied with all micronutrients and NPK fertilizers (T3) followed by the crop supplied with micronutrients except Mo (5.9 t/ha) at the NPK level of 120:60:40 kg/ha (T8, Table 4). The LSD value obtained from the analysis report (LSD 0.05= 0.486 t/ha) indicated that no significant response on grain production was observed among the micronutrient treated plots except with sulphur application but the responses were observed significant between the non-treated control plots, compost treated plots and fertilizer (NPK) applied plots. Sherchan *et al*. (2004) reported that response of boron application on maize grain production was found not significant at NMRP soil. Khatri-Chhetri and Schulte (1985) found an increase in the yield of maize due to application of Cu, S and Mg in a multilocation trial. In his experiment omission of S, B or Cu did not affect the yield. In this experiment, the highest yield increment of 1.48 t/ha of additional grains due to the effect of micronutrients over the NPK treated plot was recorded. Similarly, 171.04 % higher yield was observed over the control plot when the crop was supplied with all micronutrients in combination with NPK fertilizers (T3, Table 4). It is noted that correlation between kernel numbers per row and grain yield was observed to be highly significantly correlated (r=0.837) as shown in Figure 2.

Physicochemical properties of the soil at NMRP farmland (trial sites)

Soil and plant samples were collected and analyzed for NPK and micronutrient contents.

Micronutrients such as Zn, Mn, Cu and Fe content of leaf and grains of maize from the micronutrient experimentation plots at NMRP, Rampur were analysed at SSD, Khumaltar, Lalitpur as shown in Table 5 (Sherchan *et al*., 2004). NPK and Boron content of soil was analyzed at Soil Science laboratory, SSD, Khumaltar during the period of experimentation. Soils was found to be acidic (5.1 pH) while P and K content were observed to be high as indicated in Table 5.The nitrogen (N) and boron (B) content of soil was found to be as low as 0.09 % and 0.6 ppm, respectively.

Table 4. Response of different micronutrients on maize grain production for 3 Consecutive years (2007/08 - 2009/10) at NMRP farmland, Rampur.

Treatments	Maize grain yield after Combined analysis over 3 years (t/ha)	Yield increase over control (t/ha)	Yield increase Over control (%)	Yield increase over NPK (t/ha)
T1 (control)	2.21 e	0.00	0.00	0.00
T2 (N_{120}:P_{60}:K_{40})	4.51 c	2.30	104.07	0.00
T3 (T2+B+Zn+Mo+S+Mn)	5.99 a	3.78	171.04	1.48
T4 (T3+no B)	5.85 ab	3.64	164.70	1.34
T5 (T3+no Zn)	5.50 b	3.29	148.86	0.99
T6 (T3+no S)	4.71 c	2.50	113.12	0.20
T7 (T3+no Mn)	5.43 b	3.22	145.70	0.92
T8 (T3+no Mo)	5.90 ab	3.69	166.96	1.39
T9 ($compost_{20}$ alone)	3.05 d	0.84	38.00	0.00
Grand mean	04.86			
CV (%)	10.69			
F-test	**			
LSD (0.05)	0.486			

**= Highly significant at 0.01 level, *=Significant at 0.05 level and ns= non-significant.

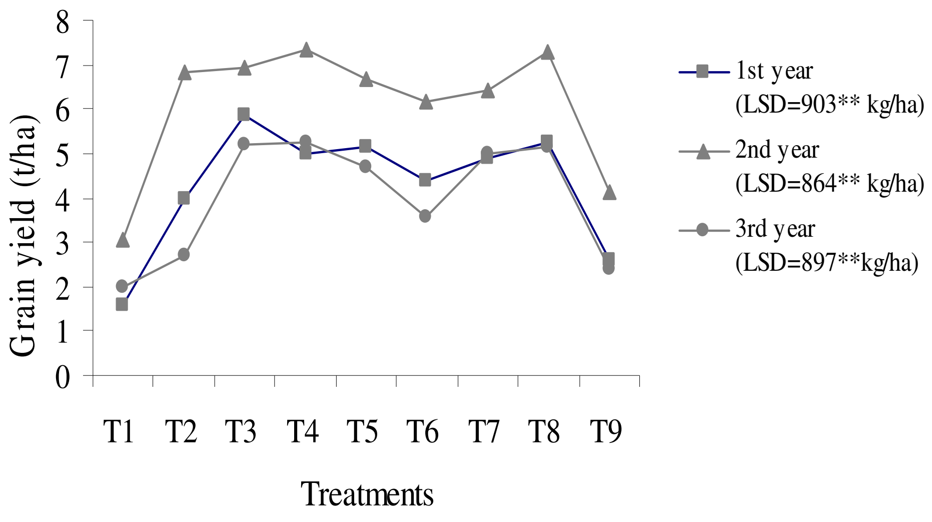

Figure 1. Diagrammatic sketch of the effects of different micronutrients on maize grain production for 3 consecutive years

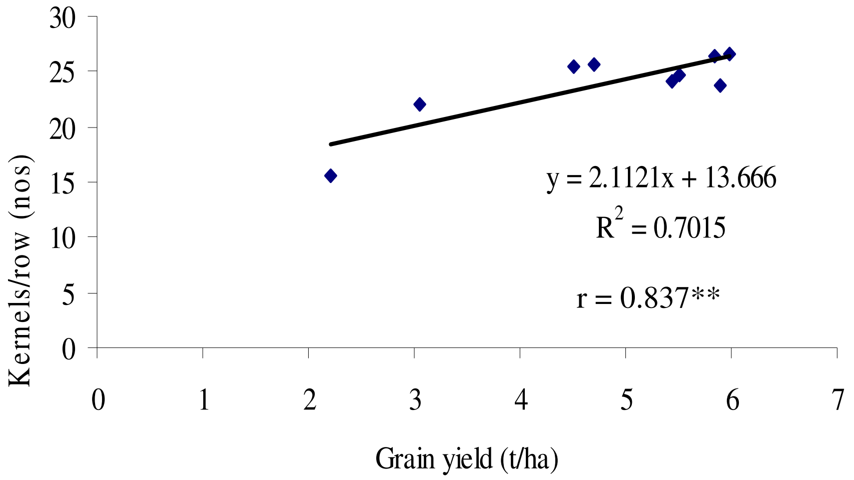

Figure 2. Relationship between kernel numbers in the ear rows and grain yield (t/ha) of maize for 3 consecutive years (t /ha) of maize for 3 consecutive years

Table 5. Physicochemical properties of soil and plant samples at NMRP farmland at Rampur Chitwan.

Samples	Zinc (Zn)(ppm)	Manganese (Mn) (ppm)	Cupper (Cu) (ppm)	Iron (Fe) (ppm)	Remarks
[a]**Plant samples** (ear leaf)					Sampled before heading
Sample 1.	14.2	151	7.9	9387	
Sample 2.	10.9	205	8.3	10121	
[a]**Plant sample** (grains)					
Sample 1.	15.2	532	10.7	26768	Sampled after harvest.
Sample 2.	14.4	535	11.2	26951	
[a]**Soil sample- A**					
Sample 1.	0.154	29.52	NA	111.6	sampled before planting.
Sample 2.	0.332	30.40	NA	109.0	
[b]**Soil sample-B**	N (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Boron (ppm)	pH and OM
Composite	0.090	369.0	134.0	0.60	5.1 pH and 1.83 %

[a]Micronutrient analysis results obtained from Sherchan et al.(2004). [b]NPK, OM, pH and boron was analysed and reported by Soil Science Division NARC, Khumaltar and NMRP, Rampur, Chitwan.

CONCLUSION

Response of treatments on the growth and yield parameters of maize were found significantly affected in all 3 years. The highest 1000 grain weight (545.8 g) was observed in the second year when the crop was supplied with boron , zinc, sulphur and manganese applied in combination with 120:60:40 kg N, P_2O_5 and K_2O /ha. This level of micronutrient application produced highest 1000 grain yield in the 1st year (412.66 g) and 3rd year (426.73 g) at the same level of NPK fertilization. The highest numbers of kernels per row (29.7 kernels/row) were produced in the 2nd year (2008/09) when all of the micronutrients (B,Mo,Zn, Mn and S) were applied along with NPK fertilizers. Lowest number of Kernels (12.26 kernels /row) were produced in the 1st year followed by the 3rd year (16.06 kernels/row) by the control plots.Three years mean result (combined analysis) revealed that highest grain yield (5.99 t/ha) was produced when the crop was supplied with all micronutrients(B, Mo, Zn, Mn and S) were applied along with NPK fertilizers at 120: 60:40 kg/ha followed by the crop (5.9 t/ha) that received all micronutrients except Mo at the same level of NPK application.

The derived LSD value (0.486 t/ha at 0.05 level) indicated that significant response was observed between the micronutrient treated plots (range 5.43- 5.99 t/ha) and with the crop that did not receive sulphur nutrient (4.71 t/ha). A yield increase of 171.07 % (3.78 t/ha) was observed over the control plot when the crop was fertilized with all micronutrients applied in combination with recommended dose of fertilizers. Application of NPK alone at 120:60: 40 kg/ha produced the yield increase of 2.3 t/ha over control plots as shown in Table 4, above. The correlation between kernel numbers and grain production was found highly significant. It can be concluded that application of micronutrients in combination with NPK fertilizers could help increase maize productivity.

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