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OMISSION PLOT EXPERIMENT IN WHEAT TO DETERMINE THE NATIVE NUTRIENT SUPPLYING CAPACITY OF SOIL IN BHAIRAHAWA, NEPAL

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Abstract. A field experiment was conducted with an objective to estimate the native nutrient supplying capacity of soil on the alkaline and silty loam soils of National Wheat Research Program, Bhairahawa, Nepal during 2013/14 and 2014/15. The experiments were laid out in a completely randomized block design (RCBD) with six treatments, each with four replications. Among the six treatments, -N, -P, -K, –Zn and –B were set to estimate the inherent N, P, K, Zn and B supplying capacity of soil respectively. The highest grain yield of wheat (3449kg/ha) was measured from fully fertilized plots and the lowest (1684kg/ha) was found in case of nitrogen mission plots in the first year; whereas fully fertilized plots had the highest grain yield (3001 kg/ha) and potassium mission plots had the lowest 990 kg/ha) in the second year of the experiment. Nitrogen and potassium were found to be most limiting nutrient for wheat production followed by potassium and phosphorous in the site. Based on the results from two years, it was concluded that the inherent N and K supplying capacity of soil is very low. Therefore, use of optimum dose of nitrogen and potassium should be used for efficient nutrient uptake which ultimately increases wheat productivity.

Keywords: *wheat: N, P, K, Zn, B, omission plot.*

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1. Introduction

The gap between maximum observed and national average yield of wheat in Nepal, as well as declining yield trend, required urgent research to determine fertilizer use in the wheat fields (Regmi et al., 2002). Stagnation and even decline in yields in wheat has been shown by some long-term experiments of Nepal (Regmi et al., 2002). Due to conventional blanket and imbalanced fertilizer application, nutrient use efficiency in wheat is very low. Determination of soil capacity to supply major nutrients N, P, K, Zn and B is the pre-requisite regarding increasing wheat yield and nutrient use efficiency. A large variability in soil nutrient supplying capacity exists among field and recommended doses of fertilizer will not be suitable in all fields. The omission plot technique is a useful tool to quantify soil nutrient supply (Regmi et al., 2002). To determine the indigenous supply of given major nutrient in an omission trial, all the other major nutrients are supplied other than the nutrient in question.

Attainable yield can be estimated from field or station experiments that use crop management practices designed to eliminate yield limiting and yield reducing factors (Mueller et al., 2002; Yengoh, 2014). Indigenous nutrient supply is defined as the total amount of a particular nutrient that is available to the crop from the soil during a cropping cycle, when other nutrients are non-limiting and can be measured in nutrient omission plots. The yield response is related to indigenous nutrient supply which determines the yield in omission plots (Dobermann, 2003). Yield Response (YR) can be used to evaluate the soil nutrient supply capacity (Xu, 2014). Knowing soil nutrient condition is the premise of the optimized fertilization. Soil indigenous nutrient supply can reflect the soil nutrient condition or soil fertility and can be developed as guidelines for fertilizer recommendation. The higher indigenous nutrient supply means the higher grain yield in the nutrient omission plots (Mueller et al., 2012). Nutrient use efficiency was affected by grain yield, soil indigenous nutrient supply, amount of fertilizer application and the overall timeliness and quantiy of other crop management operations (Dobermann, 2007). Native soil fertility may be determined effectively by the nutrient omission plot technique (Chowdhury et al., 2007;Khatun and Saleque, 2010).

Quantification of soil capacity to supply major nutrients N, P, K, etc. is the pre-requisite for increasing yield and nutrient use efficiency. A large variability in soil nutrient supplying capacity exists among field and recommended doses of fertilizer may not be suitable in all fields (Regmi, 2002). Determination of the indigenous supply of nutrients can be carried out with omission plot trials to compare the productivity of rice in optimum fertilizer condition without giving on nutrient such as N, P, K, etc (Abduracman et al., 2002; 2003; Center for Food Crops Research and Development, 2003)

The existing fertilizer recommendation is based on blanket recommendation which assumes that the need of a crop for nutrients is constant over time and large areas. However, the need for supplemental nutrients vary greatly among fields, seasons and years (Ladha et al., 1999) and a blanket dose of fertilizer will not fit to all fields. Therefore, quantification of indigenous nutrient supply (INS) of soil for major nutrients like N, P, K, etc. is a prerequisite to increase nutrient use efficiency and wheat yield. Imbalanced fertilizer application during wheat cultivation will make depletion of soil nutrients leading to production decline as well as to deterioration of soil physical and chemical properties. In order to sustain agricultural production, it is important to maintain these soil properties by applying optimum dose of fertilizer. Individual field has to be assessed for their nutrient supplying capacity so that fertilizer required for certain targeted yield can be developed based on inherent nutrient supplying capacity of soil. Therefore, this study was an attempt made to quantify indigenous nutrient supplying capacity of soil and yield responses of wheat in Bhairahawa, Nepal.

2. Materials and methods

A field experiment was conducted to estimate the native nutrient supplying capacity of soil on the alkaline and silty loam soils of National Wheat Research Program (NWRP), in Bhairahawa, Nepal during 2013/14 and 2014/15. The experimental site was situated at Bhairahawa in the western Terai region of Nepal at the latitude of 27°32’ and the longitude of 83°28’ with an elevation of 120 m of sea level. Temperature ranged from a minimum of 7°C in winter to the maximum of 45^0C in summer. In general, the site received ample rainfall during the rainy season, which started from June and continues up to September. The mean annual rainfall was 1800 mm. The soil of the experiment plot was silty loam with a pH of 8.0, organic matter (OM) of 1.35 %, olsen P of 45.59 kg/ha, exchangeable K of 119.42 kg/ha soil and bulk density of 1.61 $gmcm^{-3}$ and there was a hard pan just below the plow layer. The soils in the experiment area were classified as Typic Heplaquepts.

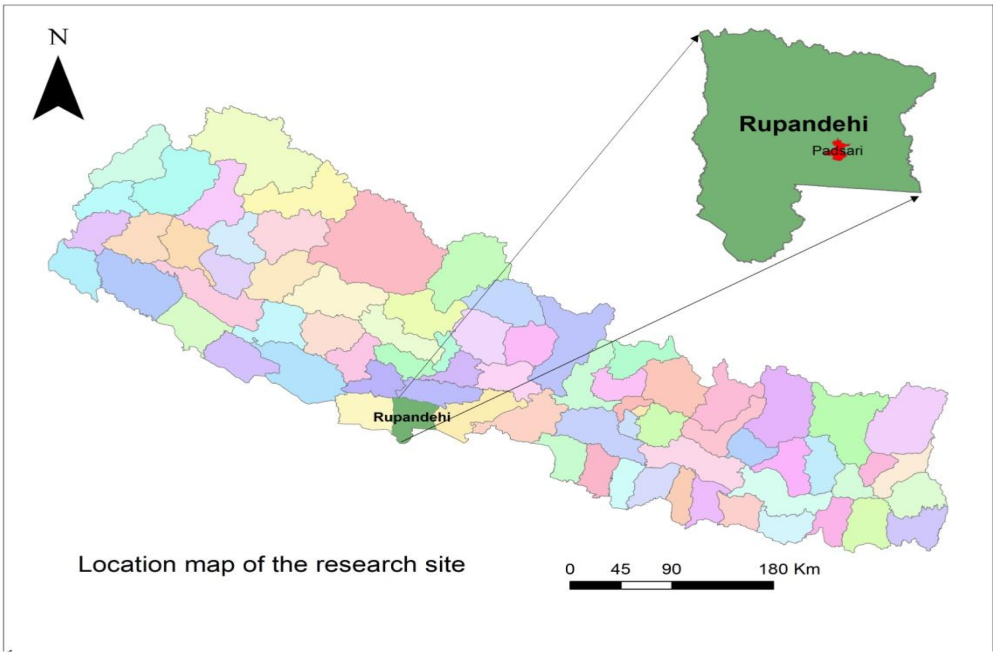

Figure 1. Location map of the experiment plot.

The experiment was laid out in a completely randomized block design (RCBD) with six treatments, each with four replications and was 5 x 5 m^2. There was 1 m spacing between plots and each replication was separated by 1.5 m space.

Table 1. Treatments of omission plot experiment

Treatments	Purpose of treatment
-N, +PK, Boron, $ZnSO_4$	To determine the indigenous N supply ensuring that no other nutrients are limiting (minus N plot)
-P, +NK, Boron, $ZnSO_4$	To determine the indigenous P supply ensuring that no other nutrients are limiting (minus P plot)
-K, +NP, Boron, $ZnSO_4$	To determine the indigenous K supply ensuring that no other nutrients are limiting (minus K plot)
+NPK but – $ZnSO_4$	To determine the indigenous Zn supply ensuring that no other nutrients are limiting (minus Zn plot)
+NPK but –boron	To determine the indigenous B supply ensuring that no other nutrients are limiting (minus B plot)
+NPK, Boron, $ZnSO_4$	To determine the maximum attainable yield with full NPK, Boron and $ZnSO_4$ (‘Sufficiency+’)

Gautam variety of wheat was used as test crop and NPK was applied 50% more than the recommended dose (i.e. 150:75:75: 25: 2= N: P_2O_5: K_2O: B: $ZnSO_4$ Kgha-1) in which half of N and full doses of other fertilizers in respective treatments were applied as basal dose and remaining 25% N was applied at 25 DAS and 25% N at heading stage (approximately 60 DAS). Urea, Single super phosphate (SSP) and Muriate of Potash (MOP), $ZnSO_4$ and borax were used as sources of fertilizer for supplying N, P, K, Zn and B respectively.

Measurement of Crop Parameters

Data were recorded on days to heading, days to maturity, spikes m^{-2}, grains $spike^{-1}$, spike length, 1000 grain weight, biological yield, grain yield and harvest index. Number of spikes in one meter square area at four different places were counted in each subplot and converted into number of spikes m^{-2}. Number of grains $spike^{-1}$ was recorded by counting the number of grains of ten randomly selected spikes from each subplot and average number of grains $spike^{-1}$ was calculated. A random sample of 1000 grains from each treatment was collected and weighed with digital balance for 1000 grain weight. For biological yield, 10 m^2 area from each plot was harvested, sun dried, and weighed into $kgha^{-1}$. For grain yield, the biomass of 10 m^2 area from each plot was sun dried, threshed, cleaned and grains were weighed into $kgha^{-1}$.

Statistical Analysis

Recorded data were compiled and tabulated in Ms-Excel. Data for each parameter over two year period was subjected to analysis of variance using RCBD according to MSTATC (Steel and Torrie, 1980) and GENSTAT. Treatment means were compared using least significant difference (LSD) test at $P \leq 0.05$.

3. Results and discussion

There was significant effect (at 5 % level) of nutrient omission on plant height, grains per spike, biological yield, harvest index and grain yield but was non significant (at 5 % level) on productive tillers/m^2, thousand grain weight and spike length in NWRP, Bhairahawa (Table 2). Maximum spike length (12.5 cm), grain per spike (46), biological yield (8467 kg/ha) and harvest index (40.7 %) was found from fully fertilized plots while lowest was obtained from nitrogen missing plots in the first year of the experiment.

Effect of nutrients omission on grain yield was highly significant. Among all the treatments, the highest grain yield was obtained from fully fertilized plots (3449 kg/ha) which was at par with zinc missing plots (3363 kg/ha) and the lowest grain yield was found from nitrogen missing plots (1684 kg/ha). Lowest yield in 0 N plots indicates N application cannot be substituted and has highest contribution in rice yield. It could be due effect of N on chlorophyll formation, photosynthesis and assimilated production because nitrogen stress reduces crop photosynthesis by reducing leaf area development and leaf photosynthesis rate by accelerating the leaf senescence (Diallo et al., 1996). Moreover, under N deficiencies, a considerably large proportion of dry matter is partitioned to roots than shoots, leading to reduced shoot/root dry weight ratio (Rufty et al., 1988) and consequently the grain yield.

Similarly, in the second year, there was significant effect of nutrient omission on plant height, productive tillers/m^2, grain per spike, spike length, thousand grain weight, biological yield and grain yield.

Table 2. Summary of means of variables of omission plot experiment at NWRP, Bhairahawa, 2013/14

Treatments	PH (cm)	Spm^{-2}	SpL (cm)	Gr/Sp	TGW (gm)	BY (kg/ha)	Grain yield (kg/ha)	HI (%)
-N	83.90	255	11.05	24	43.80	4417	1684	38.28
-P	93.45	228	10.90	45	42.70	7400	3062	40.43
-K	93.80	227	12.05	44	36.60	7250	2723	37.55
-Zn	98.45	269	12.50	42	44.10	8357	3363	40.24
-B	97.85	272	11.85	45	39.45	7783	3084	39.71
+all	97.35	266	12.50	46	40.05	8467	3449	40.73
F test	***	Ns	Ns	*	Ns	***	***	*
LSD (0.05)	5.54	35.82	1.36	13.59	6.12	790.5	322.4	2.45
CV (%)	3.9	9.5	7.6	22.1	9.9	7.3	7.4	4.1

*** and * denotes significant at 0.1 % and 5 % level of significance respectively and Ns stands for non significant

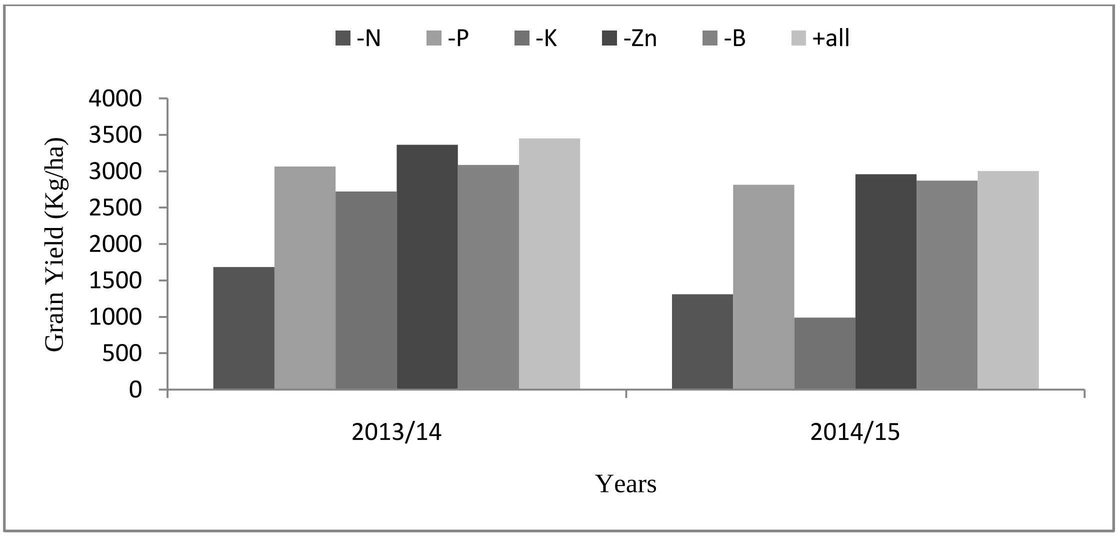

Figure 2. Effects of nutrient omission on grain yield of wheat at NWRP, Bhairahawa, Nepal, in 2013/14-2014/15

Table 3. Summary of means of variables of omission plot experiment at NWRP, Bhairahawa, Nepal in 2014/15

Treatments	PH (cm)	Spm^{-2}	SpL (cm)	Gr/Sp	TGW (gm)	BY (kg/ha)	Grain yield (kg/ha)
-N	81.05	181	10.3	25	43.55	2975	1308
-P	82.35	207	11.48	40	42.25	6050	2813
-K	68.3	180	10.65	36	25.65	2350	990
-Zn	84.3	214	11.25	39	42.95	6525	2960
-B	87.45	226	11.65	42	42.9	6075	2869
+all	87.8	229	12.43	43	44.6	5875	3001
F test	***	**	*	***	***	***	***
LSD (0.05)	6.82	29.11	1.13	5.57	4.08	1252.2	327.9
CV (%)	5.5	9.4	6.6	9.9	6.7	16.7	9.4

***, ** and * denotes significant at 0.1%, 1 % and 5% level of significance respectively

Maximum productive tillers per m^2 (229), plant height (87.80 cm), spike length (12.43 cm), grain per spike (43) and thousand grain weight (44.6 gm) was found from fully fertilized plots while lowest was obtained from potassium missing plots followed by nitrogen missing plots. Among all the treatments, the highest grain yield was obtained from fully fertilized plots (3001 kg/ha) followed by zinc missing plots and the lowest grain yield was found from potassium missing plots (990 kg/ha) followed by nitrogen missing plots (1308/ha). K application also significantly helps in uptake of N in straw as well as wheat grain (Saifullah et al., 2002). Results of the study Liu et al. (2005) also reported that N fertilization application on wheat significantly increased total N, ammonium-N and nitrate-N contents in crop field, resulting in high indigenous N supply of soil (INS). Higher soil P and K from –N plot might be due to significantly low biomass production severely restricted by nitrogen omission which n turn resulted in low P and K uptake. This result was in accordance with the findings of Tendon and Sekhon (1988). The cost of N fertilizer can be saved around 12% on the same level of yield if N fertilizer recommendation was based on soil fertility status and the value of N indigenous supply (Wang et al., 2012).

4. Conclusion

From two years of studies, it was concluded that inherent N and K supplying capacity of soil is very low. The highest grain yield of 3449 kg/ha and 3001 kg/ha was measured from fully fertilized plots in 2013/14 and 2014/15 respectively and the lowest grain yield of wheat was obtained from nitrogen missing plots in first year (1684 kg/ha) and potassium missing plots in the second year (990 kg/ha). Therefore, use of optimum dose of nitrogen and potassium should be used for efficient nutrient uptake which ultimately increases wheat productivity.

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