DETERMINATION OF INDIGENOUS NUTRIENT SUPPLYING CAPACITY OF SOIL THROUGH OMISSION PLOT EXPERIMENT FOR WHEAT IN WESTERN TERAI OF NEPAL

N. Rawal*, N. Khatri, C.B. GC and B.P. Chaurasiya
Nepal Agricultural Research Council, Nepal
*nabin_rawal@yahoo.com

ABSTRACT

The field experiment was conducted to estimate the native nutrient supplying capacity of soil in western terai of Nepal during 2013/14 and 2014/15. The experimental site consisted three areas: Pakadi VDC ward no.-3, Barrohiya of Kapilvastu district; Ramgram municipality ward no.-1, Sanda of Nawalparasi district and Tukuligadh VDC ward no.-1, Rehara of Rupandehi district. The indigenous nutrients supplying capacity of the soil was determined by establishing omission plots for wheat cultivation with six treatments each of 50 m^2 and 4 farmers from each site was taken assuming one farmer as one replication. 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. From two years of experiment, it has been clear that inherent N and K supplying capacity of soil in selected areas is very low. The highest grain yield of 3.33 t/ha and 2.75 t/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 both years (1.74 t/ha and 1.51 ton/ha) followed by potassium missing plots (1.74t/ha). Farmers manage their field in a different way, so large variation was seen even in small area. Nitrogen was found to be most limiting nutrient for wheat growth followed by potassium and phosphorous in all sites. Therefore, use of optimum dose of nitrogen, phosphorus and potassium should be used for efficient nutrient uptake which ultimately increases wheat productivity.

Keywords: Omission plot, wheat, nitrogen and potassium, nutrient supplying capacity

INTRODUCTION

The gap between maximum observed and national average yield as well as declining yield trend requires utmost research attention. Stagnation and even decline in yields in wheat has been shown by long-term experiment of National Wheat Research Program, Bhairahawa, Nepal (Rawal *et al*., 2017). Due to conventional blanket and imbalanced fertilizer application, nutrient use efficiency in wheat is very low (Regmi *et al*., 2002). 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*., 2012). The yield response is related to indigenous nutrient supply which determines the yield in omission plots (Dobermann *et al.,* 2003). 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.

Yield response 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 quantity 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). A large variability in soil nutrient supplying capacity exists among field and recommended doses of fertilizer may not be suitable in all fields (Regmi *et al*., 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.,* 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.,* 2000) 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 deplete soil nutrients leading to decline in production as well as deterioration of soil physical and chemical properties. In order to sustain agricultural production, it is important to maintain the soil properties by applying optimum dose of fertilizer. In this regard, 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 outreach sites of Bhairahawa.

MATERIALS AND METHODS

Site description

The field experiment was conducted to estimate the native nutrient supplying capacity of soil in western terai of Nepal during 2013/14 and 2014/15. The experimental site was selected in three areas viz. Pakadi VDC ward no.-3, Barrohiya of Kapilvastu district; Ramgram municipality ward no.-1, Sanda of Nawalparasi district and Tukuligadh VDC ward no.-1, Rehara of Rupandehi district whose altitude range from 80-120 masl and were the outreach sites of National Wheat Research Program, Bhairahawa, Nepal.

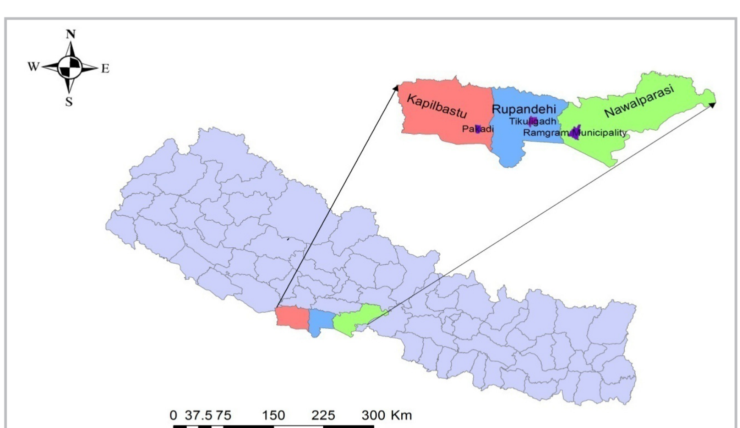

Figure 1: Location map of experiment sites

Farmers' fields were selected and study was done in winter season in which rice-wheat cropping system was practiced. The indigenous nutrients supplying capacity of the soil was determined by establishing omission plots with six treatments each of 50 m^2 and 4 farmers from each site was taken assuming one farmer as one replication.

Table 1: Treatments details

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}) so that growth of the wheat will not be limited by other primary nutrients. 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 with aspects of 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 from each farmers plot 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 plot 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, 4 m^2 area from each farmers plot was harvested, sun dried and weighed into kgha^{-1}. Similarly, for grain yield, the biomass of 4 m^2 area from each plot was sun dried, threshed, cleaned and grains were weighed into kgha^{-1}.

Soil sampling and analysis

Soil samples were collected from each of the selected farmer's fields. Soil samples from each site were randomly collected from the 0 to 20 cm deep plough layer using an auger. For analysis, the air-dried samples were crushed and passed through a 2mm sieve. Soil pH was determined by a pH meter after extraction from a soil: water ratio of 1:2. Organic matter was determined using the Walkley and Black dichromate method (Nelson and Sommers, 1982) and total N using Kjeldhal's method (Bremner and Mulvaney, 1982) For available P determination, modified Olsen's (Olson and

Sommers, 1982); exchangeable K (Knudsen *et al.,* 1982) was estimated by 1M ammonium acetate extraction followed by flame photometric determination.

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 Completely Randomized Block Design (RCBD) according to MSTAT-C (Steel and Torrie, 1980) and GENSTAT. Treatment means were compared using least significant difference (LSD) test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Soil fertility status of farmers' field in the study areas

The soil of study areas was found to be alkaline with low organic matter, low total nitrogen, medium available phosphorus and medium available potassium. In Barrohiya (Kapilvastu), pH was slightly alkaline with an average of 7.6 (ranges from 6.7 to 8.7), organic matter range from 0.28 to 1.73 (very low) with an average of 0.98.

Table 2: Soil fertility status of farmers' field in the study areas, 2014

Treats	pH	Organic Matter (%)	Nitrogen (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1}
		Kapilvastu			
Lowest	6.7	0.28	0.05	36.7	108.3
Highest	8.7	1.73	0.09	101.1	320.1
Average	7.6	0.98	0.07	74.1	195.9
Rating	Slightly alkaline	Very low	Low	Medium	Medium
		Nawalparasi			
Lowest	7.3	0.35	0.05	24.7	103.1
Highest	8.6	3.12	0.13	103.0	294.6
Average	7.6	1.37	0.08	64.9	124.9
Rating	Slightly alkaline	Low	Low	Medium	Medium
		Rupandehi			
Lowest	7.2	0.55	0.06	20	90.7
Highest	8.6	3.12	0.13	81	230.6
Average	8.0	1.66	0.09	44.3	103.4
Rating	Alkanline	Low	Low	Medium	Low

Similarly, nitrogen content of the soil was very low with an average of 0.07 whereas available phosphorus and potasium was medium with average of 74.1 kg/ha and 195.9 kg/ha, respectively. Similarly, in Sanda (Nawalparasi), pH was slightly alkaline with an average of 7.6, organic matter range from 0.35 to 3.12 (low) with an average of 1.37.

Similarly, nitrogen content of the soil was very low with an average of 0.08 whereas available phosphorus and potasium was medium with average of 64.9 kg/ha and 124.9 kg/ha, respectively. The soil of Rehara (Rupandehi) was found to be alkaline with low organic matter (1.66), low total nitrogen (0.09), medium available phosphorus (44.3 kg/ha) and medium available potassium (103.4 kg/ha).

Crop Parameters Measurement

The results showed significant differences of nutrient omission on plant height, grains per spike, thousand grain weight (in second year) and biological yield but was non significant on productive tillers/m^2(in first year) and spike length (in both years) in Barrohiya, Kapilvastu (Table 3). Significantly higher plant height (103.4 cm and 93.76 cm), productive tillers per square meter (216 and 240), spike length (14.8 cm and 11.1 cm), grain/spike (56 and 39) and biological yield (8.02kg $ha^{-1}$and 7.01kg ha^{-1}) were recorded from fully fertilized plot in 2014 and 2015 respectively.

Table 3: Summary of means of variables of omission plot experiment at Barrohiya, Kapilvastu, 2013/14 and 2014/15

Treatments	PH (cm)		Spm^{-2}		SpL (cm)		Gr/Sp		TGW (gm)		BY (kg/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
-N	94.9	85.9	196	144	13.1	9.3	38	35	47.0	39.4	5750	3360
-P	100.3	85.0	214	205	12.8	10.2	54	35	44.0	40.3	7250	6200
-K	84.4	84.6	207	186	12.5	10.6	44	33	37.8	31.7	4688	5533
-Zn	100.0	89.0	210	222	12.6	10.7	50	37	44.8	39.9	7688	6200
-B	104.4	89.3	218	238	14.0	10.8	48	38	44.9	40.8	7688	6267
+all	103.4	93.8	216	240	14.8	11.1	56	39	43.7	40.4	8019	7013
F test	*	*	Ns	***	Ns	Ns	*	Ns	**	Ns	*	**
LSD (0.05)	10.9	5.78	28.11	40.92	1.73	1.33	11.69	9.17	4.34	6.95	2167.4	1642.3
CV (%)	7.4	5	8.9	15.1	8.6	9.6	16.1	19.1	6.6	13.6	21	21.6

****, ** and * denotes significant at 0.1%, 1 % and 5% level of significance respectively and Ns stands for non significant*

Similarly, at Sanda, Nawalparasi, the effect of nutrient omission was significant on plant height, spike length, grains per spike, biological yield and grain yield but was non significant on productive tillers/m^2 and thousand grain weight in the first year of the experiment. Plant height (104 cm and 91.5 cm), productive spike per square meter (244 and 213), grain/spike (56 and 42), thousand grain weight (44gm and 41.8 gm) and biological yield (8.65 kg ha^{-1} and 6.93 kg ha^{-1}) were recorded respectively the highest in 2014 and 2015) from fully fertilized plots of Sanda (Table 4).

Table 4: Summary of means of variables of omission plot experiment at Sanda, Nawalparasi, 2013/14 and 2014/15

Treatments	PH (cm)		Spm^{-2}		SpL (cm)		Gr/Sp		TGW (gm)		BY (kg/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
-N	83.7	83.9	207	135	10.6	10.5	35	33	44.8	41.9	5188	4027
-P	95.5	82.7	232	192	12.2	10.9	42	36	42.6	41.1	6125	5067
-K	96.8	84.8	234	179	12.7	11.7	47	36	37.7	34.5	6750	4947
-Zn	101.9	88.9	232	206	13.6	12.0	53	40	42.2	42.0	8425	6040
-B	104.0	91.0	271	195	12.6	11.9	52	43	42.1	37.4	8000	6027
+all	104.0	91.5	244	213	13.1	12.7	56	42	44.0	41.8	8650	6933
F test	***	***	Ns	**	**	**	*	**	Ns	*	**	***
LSD (0.05)	7.6	3.34	46.21	39.75	1.67	1.01	11.7	5.68	5.6	5.51	1611.2	995.4
CV (%)	5.2	2.9	13	16.1	8.9	6.6	16.4	11.3	8.9	10.5	14.9	13.7

****, ** and * denotes significant at 0.1 %, 1 % and 5 % level of significance respectively and Ns stands for non significant*

Similarly, the results showed significant differences of nutrient omission on plant height, productive tillers/m^2, grain per spike and biological yield but was non significant on spike length and thousand grain weight in Rehara, Rupandehi (Table 5). Significantly higher productive tillers per square meter (274), grain per spike (34), plant height (87 cm) and biological yield (7.1 ton ha^{-1}) were recorded from fully fertilized plot.

Table 5: Summary of means of variables of omission plot experiment, Rehara, Rupandehi, 2014/15

Treatments	PH (cm)	Spm^{-2}	SpL (cm)	Gr/Sp	TGW (gm)	BY (kg/ha)
-N	79.5	199	11.2	25	40.9	4400
-P	77.0	197	10.1	27	37.4	5413
-K	74.3	209	10.2	28	35.0	4293
-Zn	83.4	238	11.6	33	39.5	6680
-B	80.2	242	11.1	32	39.0	7107
+all	87.0	274	11.4	34	41.5	7133
F test	*	**	Ns	*	Ns	***
LSD (0.05)	7.22	43.52	1.23	5.85	6.17	1270.5
CV (%)	6.8	14.6	8.5	14.9	12	16.5

****, ** and * denotes significant at 0.1 %, 1 % and 5 % level of significance respectively and Ns stands for non significant*

Effect of nutrients omission on grain yield was highly significant in Sanda, Rehara and Barrohiya (Table 6). Among all the treatments, the highest grain yield was obtained from fully fertilized plots in Barrohiya (3.19 t/ha and 2.98 t/ha), Sanda (3.42 t/ha and 2.57 t/ha) and Rehara (3.38 t/ha and 2.41 t/ha) respectively in the year 2014 and 2015. Similarly, the lowest grain yield was found from nitrogen missing plots (2.16 t/ha, 1.31 t/ha and 1.77 t/ha, respectively) in the first year in all three experiment sites but in the second year of the experiment, the grain yield was found lowest from nitrogen missing plots in Barrohiya and Sanda (1.49 t/ha, 1.44 t/ha, respectively) and from potassium missing plots in Rehara (1.41 t/ha).

Table 6: Summary of means of grain yield (ka/ha) of omission plot experimentat three locations (Barrohiya, Sanda and Rehara), 2013/14 and 2014/15

	Grain yield (Kg/ha)							
Treatments	Barrohiya		Sanda		Rehara		Combined	
	2014	2015	2014	2015	2014	2015	2014	2015
-N	2160	1488	1306	1437	1766	1608	1744	1511
-P	2927	2257	2688	2089	2293	1781	2636	2042
-K	2615	1832	2747	1996	2561	1411	2641	1746
-Zn	3035	2397	3225	2407	3065	2197	3108	2334
-B	3110	2425	3385	2473	3298	2304	3264	2401
+all	3189	2979	3422	2567	3379	2407	3330	2651
F test	*	**	***	***	***	**	***	***
LSD (0.05)	625.3	659.2	710.1	412.4	331.5	486.1	256.7	445
CV (%)	14.6	22.4	16.9	14.5	8	18.9	12.9	28.9

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

The combined analysis of all three locations showed highly significant effect on grain yield of wheat. The highest grain yield of 3.33 t/ha and 2.65 t/ha in 2014 and 2015 respectively was measured from fully fertilized plots. Similarly, the lowest grain yield of 1.74 t/ha and 1.51 t/ha respectively in 2014 and 2015 was obtained from nitrogen mission plots followed by potassium omission plot (1.75 t/ha). Lowest yield in 0 N plots indicates N application cannot be substituted and has highest contribution in wheat 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. 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 Tandon 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).

CONCLUSION

From two years of experiment, it has been clear that inherent N and K supplying capacity of soil is very low. The highest grain yield of 3.33 t/ha and 2.75 t/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 both years (1.74 t/ha and 1.51 ton/ha) followed by potassium missing plots (1.74t/ha). Farmers manage their field differently, so large variation was seen even in small area. Nitrogen was found to be most limiting nutrient for wheat growth followed by potassium and phosphorous in all sites. Overall it can be concluded that spatial variability for soil nutrient supplying exist across the farmer's field so it is necessary to estimate that variability for efficient nutrient uptake and to increase wheat productivity.

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