

Research Article**ASSESSMENT OF SITE SPECIFIC NUTRIENT MANAGEMENT ON THE PRODUCTIVITY OF WHEAT AT BHAIRAHAWA, NEPAL****M. Yadav^{1*}, S. K. Sah¹, A. P. Regmi², and S. Marahatta¹**¹Agriculture and Forestry University, Rampur, Chitwan, Nepal²Nepal Agricultural Research Council, Nepal

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ABSTRACT

Low and unbalanced fertilizer application rate are the major factors contributing to the poor yield of wheat in Nepal. The Site Specific Nutrient Management (SSNM) provides the field specific recommendations in a cost effective and precise manner. A field experiment was done at National Wheat Research Program (NWRP), Bhairahawa, Rupandehi, Nepal during 2019-20 to evaluate the site specific nutrient management approaches in order to enhance wheat productivity. The SSNM dose was determined at NWRP by using omission plot techniques. The calculated SSNM dose (148:65:71 N: P₂O₅:K₂O kg ha⁻¹), was compared with SSNM + Zn + B, (148:65:71:5:1 N: P₂O₅:K₂O Zn : B kg ha⁻¹), Research recommended dose (RRD, 150:50:50 N: P₂O₅:K₂O kg ha⁻¹); National recommended dose (NRD, 100:50:25 N: P₂O₅:K₂O kg ha⁻¹), Nutrients expert dose (NED, 110:50:73 N: P₂O₅:K₂O kg ha⁻¹), and farmers dose (FD, 80: 40:15 N: P₂O₅:K₂O kg ha⁻¹) in a RCB design with four replications. The data on growth, yield attributes and yield were collected and analyzed using Genstat Statistical package. Results showed that research recommended dose (RRD) along with SSNM dose and SSNM +Zn +B were statistically similar (p>0.05), but these treatments were comparatively superior over rest of the treatments for yield attributes and yield. Hence it can be concluded that wheat yield can be improved through adoption of SSNM and RRD of fertilizers at Bhairahawa condition.

Key words: Site specific nutrient management, wheat productivity, fertilizer, micro-nutrient**INTRODUCTION**

Wheat (*Triticum aestivum* L) is the third important cereal after rice and maize in Nepal. It plays an important role in national food security (Devkota et al., 2019). It is grown in the Terai, mid hill and high hills during the winter season. Wheat crop covers nearly 0.703 million hectare in Nepal (MoALD, 2019) with total production of 2.005 million t, and 2.848 t ha⁻¹ average productivity. Among various factors responsible for low yield of wheat crop, nutrient management is of key importance. Inadequate and unbalanced use of fertilizers is found associated with decreasing efficiency of nutrient use (Devkota et al., 2016; Sapkota et al., 2014). This scenario equally enforce the concern authorities and researchers to work towards maximizing wheat yield through the adoption of optimum nutrient rate (Becker et al., 2007) and site-specific nutrient management (Dobermann, 2007).

The blanket nutrient recommendation over large areas of small-scale farming systems fails to meet the nutrient requirement of crops. Due to high field to field variability, the possibility of over or under-application of nutrients are very high with its economic and environmental consequences. This leads to inefficient use of added nutrients, as application rates do not consider the spatial variability in nutrient requirements among the fields (Buresh et al., 2010).

Nutrient use efficiency can be improved through the use of site-specific fertilizer recommendation (IPNI, 2017). Findings of the research carried out in Indo-Gangetic Plains (IGP) of Bangladesh, India, Nepal, and Pakistan of South Asia, suggests that further improvement in nutrient use efficiency is possible through the balanced application of nitrogen (N), phosphorus (P), and potassium (K) fertilizers, and by rational use of organic manures in the systems (Jat et al., 2014). A balanced application of the primary nutrients (N, P, K), secondary nutrient (S) and some other micronutrients (Zn, B) are needed to enhance wheat production (Pandey et al., 2020).

Site-specific nutrient management (SSNM) provides an approach to “feeding” crops with nutrients as and when they are needed. It ensures that all the required nutrients are applied at the proper rate and in proper ratio based on the crop’s nutrient needs. SSNM based nutrient management is advantageous over existing practices for grain yield and nutrient use efficiency in wheat (Sharma & Tiwari, 2004). Therefore, this study was done to assess the impact of SSNM based nutrient management in enhancing wheat productivity.

MATERIAL AND METHODS**Experimental site:**

A field experiment was done during winter season of 2019/020 in “C” block of National Wheat Research

Program (NWRP), Bhairahawa, Rupandehi, Nepal. Geographically the site is located at 27° 32' North latitude and 83° 25' East longitudes with the elevation of 104 masl. The climate is of sub-tropical type.

The experimental soil pH was near to neutral (7.11); low in organic matter (2.25%), medium in total nitrogen (0.1 %); high in available phosphorus (74.7 kg ha⁻¹); and medium in available potassium (103.04 kg ha⁻¹). Soil texture was silty clay loam. The total rainfall during the research period was recorded as 333.9 mm, and weekly maximum and minimum temperature ranged from 15.2 to 36°C and 7.3 to 21°C respectively.

Experimental details

The experiment was done by using Randomized Block design with the arrangements of four replications for each treatment. Treatments comprised of six nutrient management approaches, viz. farmers' dose (FD; 80:40:15 N: P₂O₅:K₂O kg ha⁻¹); SSNM dose (148:65:71 N: P₂O₅:K₂O kg ha⁻¹); SSNM dose + Zn + B (148:65:71:5:1 N: P₂O₅:K₂O Zn:B kg ha⁻¹); national recommended dose (NRD, 100:50:25 N: P₂O₅:K₂O kg ha⁻¹); Nutrient expert dose (NED, 110:50:73 N: P₂O₅:K₂O kg ha⁻¹), and research recommended dose (RRD, 150:50:50 N: P₂O₅:K₂O kg ha⁻¹). The size of individual plot was (4 m × 3 m) 12 m². 12 rows of 4 meter length were sown in each plot. Popular wheat variety Vijay was used for the experiment. The seeding was done on 27th November, 2019. Sulfosulfuron @ 30 g a.i. ha⁻¹ was applied to control weed populations in all experimental plots at 35 days after sowing (DAS).

The plant samples from 40 cm row length were collected from crop rows earmarked for destructive sampling. The roots were clipped off from each selected plant; the remainder was cleaned, transferred to properly label brown paper bags, and then partially dried in the sun. Later on they were subjected to oven drying at 65 ± 2°C until constant weight was recorded, and expressed as dry matter production (g m⁻²). The plants harvested for dry matter were used to measure leaf area. The leaf area was measured by using automatic leaf area meter, and it was expressed as leaf area index (LAI); by dividing the leaf area with ground area occupied by it. The ten selected plants were used to measure plant height from ground to tip of spike excluding awn. The average data of ten plants height was used as plant height, expressed in cm. Physiological maturity data was taken when 75% peduncle of plants in the plots turned yellowish. Effective tiller per m² was recorded from net plot area of individual plot. Grains per spike data was taken from 20 randomly selected spikes. Thousand grains was counted from each net plot yield and weighted with in automatic electronic balance. The total biomass yield for each net plot was recorded at harvest. Grain yield was recorded from net plot area of 7.0 m², and expressed in kg ha⁻¹ at 12 % moisture content. Harvest index was calculated by dividing grain yield with total biological yield and multiplied by hundred to express in percent at 12 % moisture content. All the collected data were analyzed using Genstat statistical package. Analysis of variance was done for all the variables and Duncan's multiple range test (DMRT) was used for mean separations at p<0.05.

Nutrient management approaches

Farmers dose (FD)

A survey was conducted at adjoining villages of NWRP/Bhairahawa, Rupandehi to know the dose of fertilizers used by the farmers. A Focus Group Discussion (FGD) was made with farmers on different categories of farm holdings regarding the information of current fertilizer source, rate, time and method of their application in wheat crops, and majority of the farmers following the same fertilizer practices was considered as FD.

At present situation, farmers are managing the fertilizer dose in wheat as 80:40:15 N: P₂O₅:K₂O kg ha⁻¹ where 40 kg N and complete dose of P and K has been applied as basal and remaining quantity nitrogen is applied at 30 DAS and 55 DAS.

SSNM dose

An experiment comprised of N, P, K omission and adequate N,P,K, treatments was conducted in A, B, C, D and E blocks of National Wheat Research Program, Bhairahawa, Rupandehi during 2018/019. Based on omission plot techniques, the SSNM dose was calculated as (148:65:71 N: P₂O₅:K₂O kg ha⁻¹); 50% N and full dose of P and K was applied as basal dose. Remaining nitrogen; 25%; applied at 30 DAS, and 25% N was applied at 55 DAS.

SNM dose +Zn+B

5 kg Zn and 1 kg ha⁻¹ Boron was added in SSNM dose Nitrogen @ 50% as basal, whereas 25 % at 30 DAS, and another 25% at 55 DAS was applied through urea . Full dose of P, K, Zn, and B were applied as basal.

National recommended dose (NRD)

National recommended dose (NRD) for irrigated condition of wheat in Nepal is 100:50:25 N: P₂O₅:K₂O kg ha⁻¹ (MoALD, 2019). Nitrogen @ 50 % as basal and remaining 25% at 30 DAS, and another 25 % at 55 DAS

was applied through urea. Full dose of phosphorus and potassium is applied at the time of planting.

Nutrient expert dose (NED)

An innovative, information and communications technology (ICT)-based decision support systems (DSS) tool Nutrient Expert (NE) for maize, rice, and wheat has been developed by International Plant Nutrition Institute (IPNI) and International Maize and Wheat Improvement Centre (CIMMYT) (Pampolino et al., 2012). The NE is an easy-to-use, simple computer based DSS, or delivery tool that can rapidly provide nutrient recommendations for N, P and K for above crops for individual farmer's fields in presence or absence of soil testing results. NED was calculated based on existing soil status of NWRP/ Bahiarahawa. NED was as 110:50:73 N: P₂O₅:K₂O kg ha⁻¹ where, nitrogen @ 50% as basal; 25 % at 30 DAS, and 25% N at 55 DAS was applied through urea. Full dose of P and K was applied as basal.

Research recommended dose (RRD)

Different nutrient management trials and long term fertility trials has been conducted in wheat at National Wheat Research Program, Bhairahawa, Rupandehi. Based on those research findings, recommended dose was considered as 150:50:50 N: P₂O₅:K₂O kg ha⁻¹ for irrigated wheat cultivation (NWRP, 2016). Nitrogen @ 50% as basal; 25 % N at 30 DAS and another 25% N at 55 DAS was applied through urea. Full dose of P and K was applied as basal dose.

RESULTS AND DISCUSSION

Phenology and growth of wheat

All the major variables considered in this study in various SSNM treatments were significantly different ($p < 0.05$), except days to flowering, days to physiological maturity, plant height, dry matter production, and leaf area index (Table 1). Research recommended dose treatment took longer days (121 days) to reach at physiological maturity, but it was at par with SSNM dose and SSNM +Zn +B ($p > 0.05$). Days to physiological maturity of wheat was statistically similar ($p > 0.05$) for NRD and NED. Farmers dose (FD) fertilized treatment had attained physiological maturity earlier than rest of the treatments. Nitrogen levels affected crop phenological phases from flowering to maturity. Low N content, or deficiency can speed up time, the plant require reaching maturity and thus can decrease the grain filling period (Marschner, 1995). Grain filling period is important because longer grain filling period leads to higher yields and better quality (Yau, 2007). A higher nutrient, especially N supply, stimulates the synthesis of cytokinins and its supply to leaves and ears, therefore, delayed the maturation process (Forster, 1973). Plant height affected significantly in different treatments. RRD, SSNM +Zn + B and SSNM treatments had similar plant heights but significantly taller than FD and NRD (Table1). Wheat crop is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization (Mattas et al., 2011). Hence, higher amount of N applied in these treatments might have stimulated increased activity of meristematic cells and cell elongation of internodes, resulting in higher growth rate of stem promoting the plant height of wheat. Singh et al. (2003), Singh & Yadav (2006) and Mukherjee (2008) also had reported taller plant height with increased application of nitrogen.

Significantly ($p < 0.05$) higher dry matter production was recorded in SSNM dose fertilized treatment, but it was significantly similar ($p > 0.05$) to RRD, SSNM + Zn + B. The dry matter production in SSNM + Zn + B was also at par with NED ($p > 0.05$). The lowest dry matter was produced in FD followed by NRD. Improved dry matter production at higher levels of nutrients, is attributed to the fact that these nutrients being important constituent of nucleotides, proteins, chlorophyll and enzymes, involves in various metabolic processes which have a direct impact on vegetative and reproductive phase of wheat plants. Beneficial effects of higher levels of nutrients application on dry matter production were also reported by Kumar et al. (1998); Kataria et al. (1999), and Singh & Yadav (2006). SSNM dose, RRD, SSNM + Zn + B treatments were statistically similar ($p > 0.05$), but had produced higher leaf area index than FD, NRD and NED treatments. Leaf area index is the efficiency of photosynthetic process, and is expressed on the extent of photosynthetic surface (Lockhart & Wiseman, 1988). Thus wheat plants grown with an adequate supply of nutrients made rapid growth due to stimulation of leaf and stem growth enhancing tiller production contributing to higher LAI.

Yield attributes and yield

All the variables studied, viz, grains per spike, 1000 grains weight, tillers production, above ground total biological yield, and grain yield, except harvest index were significantly ($p < 0.05$) different among treatments (Table 2). SSNM dose produced higher grains per spike than FD and NRD, but it was at par ($p > 0.05$) with SSNM + Zn +B, NED, and RRD treatments. Similarly, NRD and NED were also at par ($p > 0.05$) in grains per spike. An adequate leaf area index and dry matter production during ear formation might have contributed to produce more number of grains ear⁻¹. Beneficial effects of N fertilization rates on grains ear⁻¹ were also reported by Singh (1996), and Bellido et al. (2006). 1000 grains weight was affected in different treatments. Thousand grain weight was the highest in FD and it was

significantly higher than SSNM dose, SSNM+ Zn +B, RRD and NRD. Higher dose of fertilizers, especially nitrogen reduced 1000 grains weight due to increased number of tillers per unit area hence competition among the plants is more for growth factors, resulting in reduction in size and yield of plant (Reddy & Reddi, 1992). Behera & Ghosh (2009) also reported that 1000 grains weight increased with increasing levels of N from 0 to 30 kg ha⁻¹; thereafter, it showed a decreasing trend even up to 120 kg ha⁻¹. RRD, SSNM and SSNM +Zn +B treatments were at par ($p>0.05$) for tillers production in per unit area in our experiment, but these three treatments were superior over FD and NRD (Table 2). Similarly the performance of NRD was also at par ($p>0.05$) with NED.

Above ground total biological yield and grain yields were significantly different ($p<0.05$) for different treatments (Table 2). Above ground total biological yields in RRD, SSNM and SSNM +Zn +B were not significant ($p>0.05$) among each other, but these three nutrients levels had significantly higher ($p<0.05$) above ground total biological yield than FD and NRD treatments. The above ground total biological yield produced between SSNM +Zn + B and NED was at par ($p>0.05$). More tillers, taller plant height, and grain yield in higher nutrients levels in RRD and SSNM treatments contributed to more above ground total biological yield. RRD, SSNM and SSNM +Zn +B treatments produced similar grain yield ($p>0.05$), but grain yields produced in these nutrients levels were significantly higher ($p<0.05$) than FD, NRD and NED treatments. Whereas NRD and NED produced similar grain yield ($p>0.05$). Grain yield is a function of effective tillers, grains per spike, and weight of individual grain. Since yield attributes, effective tillers and grains per spike were higher in RRD, SSNM dose and SSNM +Zn +B treatment that contributed to higher grain yields in these three treatments than others treatments. Devkota et al. (2018) also had reported higher wheat yield at 180:50:50 N: P₂O₅:K₂O kg ha⁻¹ than others treatments.

Table 1. Growth and phenology of wheat as influenced by different Fertilizer management practices at NWRP, Bhairahawa, in 2019/2020

| Treatments | Days to 50% flowering | Days to physiological maturity (Days) | Plant height (cm) | Dry matter production (g m ⁻²) | Leaf area index (LAI) |
|---------------------|-----------------------|---------------------------------------|-------------------|--|-----------------------|
| FD | 79.0 | 116.5c | 88.6d | 585c | 0.99c |
| SSNM dose | 80.0 | 120.2a | 93.3ab | 749.9a | 1.84a |
| SSNM +Zn +B | 79.7 | 120.2a | 93.5a | 745.5a | 1.79a |
| NRD | 79.2 | 118.2b | 91.1c | 643.6bc | 1.12bc |
| NED | 79.5 | 119.0b | 91.8bc | 699.8ab | 1.32b |
| RRD | 79.7 | 121.0a | 93.8a | 748.8a | 1.83a |
| F-test | NS | ** | ** | ** | ** |
| LSD _{0.05} | 0.93 | 0.79 | 1.51 | 70.27 | 0.21 |
| CV% | 0.8 | 0.4 | 1.1 | 6.7 | 9.3 |

Table 2. Yield attributes and yields of wheat as influenced by different Fertilizer management practices at NWRP, Bhairahawa in 2019/2020

| Treatments | Effective tillers m ⁻² | Grains/spike | 1000 grains weight (g) | Above ground total biological yield (kg ha ⁻¹) | Grain yield (kg ha ⁻¹) | HI (%) |
|---------------------|-----------------------------------|--------------|------------------------|--|------------------------------------|--------|
| FD | 234d | 33.75c | 47.42a | 6351d | 3050c | 47.96 |
| SSNM dose | 302ab | 38.06a | 45.15b | 8469a | 4154a | 49.05 |
| SSNM + Zn+B | 299ab | 36.67ab | 45.07b | 8158ab | 4077a | 48.96 |
| NRD | 266c | 34.16bc | 45.9ab | 7320c | 3509b | 48.52 |
| NED | 281bc | 36abc | 46.12ab | 7568bc | 3758b | 48.46 |
| RRD | 313a | 36.49ab | 44.76b | 8480a | 4159a | 49.04 |
| F-test | ** | ** | * | ** | ** | NS |
| LSD _{0.05} | 24.65 | 2.39 | 1.64 | 909.3 | 313.9 | 1.38 |
| CV% | 5.8 | 4.4 | 2.4 | 7.9 | 5.5 | 1.9 |

CONCLUSION

Research recommended dose (RRD); SSNM dose, and SSNM +Zn +B treatments were statistically at par for grain yield. But these nutrients levels had higher grain yield than FD, NRD and NED, and grain yields obtained in NRD and NED were also similar. Hence it can be concluded that wheat yield can be improved through adoption of SSNM and RRD of fertilizers at Bhairahawa condition.

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