2. Response of Wheat (*Triticum aestivum* L.) to Nutrient Omission under Irrigation in Sekota District of Amhara Region, Ethiopia

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Abstract

The Ethiopian governmenthas imported multinutrient fertilizers and distributed them to farmers recently. Hence, the selection of appropriate types of fertilizer based on the actual limiting plant nutrients is timely to give policy direction to import only fertilizers that could limit crop yield. A field study was carried out to identify the yield-limiting plant nutrients

Amhara region of Ethiopia in the 2022 irrigation season. A total of nine treatments, including control, NPSKZnB (all), NPSKZn (all-B), NPSKB (all-Zn), NPKZnB (all-S), NPSZnB (all-K), NKSZnB (all-P), PKSZnB (all-N), and RNP (all-KSZnB), were arranged in a randomized complete block design (RCRD) with three replications. The Kekeba wheat variety was used as a test crop. The collected grain and biomass yield data were analized by SAS software following the procedure. The analysis of result showed that the application of fertilizer had a significant effect on wheat grain yield. The highest grain yield (4443.5 Kgha^{-1}) was obtained from NPKZnB (All-S). While the lowest grain yield was obtained from the control and Nitrogen omission. There was no significant difference between and among the treatments except Control, All-N, and All-P. The grain yield was reduced by 3181.6 Kgha^{-1} when N was omitted and 1817.8 Kgha^{-1} when P was omitted over All-S (NPKZnB). This clearly showed that Nitrogen and Phosphorous are the most yield-limiting plant nutrients for wheat under irrigation in the study area. Therefore, the government should give emphasis to Nitrogen- and Phosphorous-containing fertilizers to increase wheat yield.

Key words: Nitrogen, nutrient, omission, Phosphorous, wheat,

Introduction

Wheat is the second most important staple crop in Ethiopia and a major pillar for food security (CIMMYT, 2022). It is one of the strategic crops for food security and the supply of raw materials for the agro-processing industry (Endalew *et al.,* 2020). Due to rapid population growth, massive urbanization and increasing disposable incomes, the consumption of refined wheat breads is rapidly increasing and displacing traditional meals (Noort *et al.,* 2022). But average wheat productivity in Ethiopia is much lower than the world average and far below research yield (CSA 2021). To meet the demand of ever-increasing population growth the yield of wheat should be increased by double.

Irrigated agriculture is a prime sector to ensure food security, alleviate poverty, and promote economic development in the developing world (Fraiture *et al.,* 2010). It is one of the best options to increase production. Nowadays, irrigated wheat farming has expanded into all regions of Ethiopia. It is a new scenario fo Mer wheat under irrigation and it needs some sort of improvement in agronomic, breeding and irrigation efficiency. Even the areas of wheat irrigation farming should also be the lowland and large-scale irrigation schemes.

Mineral fertilizers are considered to be one of the most reliable and readily available inputs for increasing crop yields. They have a positive impact on the yield and yield components of the crop. The type of fertilizer, time of application and amount to apply are the major constraints for production. Understanding the principles of soil fertility is vital to efficient nutrient management, crop production, as well as environmental protection (Pagani *et al.,* 2013). Therefore, identification of limiting plant nutrients in the soil, and providing them to the crops is very important and possible to increase production and reduce costs and environmental pollution. Hence, targeting that liming nutrient is a means of solution to boost the production and productivity of the crops.

In the last 10 years, fertilizer use in Ethiopia has changed from urea and DAP to a multi-nutrient approach. But research conducted on omission trials shows that Nitrogen and Phosphorous are the most yield-limiting nutrients (Amare *et al.,* 2021; Alemayehu *et al.,* 2022). Similarly, Teshome *et al.,* (2022) and Getinet *et al.,* (2022) reported that Nitrogen is the most yield-limiting nutrient for sorghum and maize yields. There is limited research on

omission trials under irrigation of wheat in the study areas. Therefore, the objective of the study was to identify the yield-limiting nutrients for wheat under irrigation in the Woleh irrigation scheme.

Materials and Methods

Study Area: The study was conducted at the Woleh irrigation scheme in two farmer fields (Figuer. 1). The scheme has an area of 137.75 ha. In the irrigation season, farmers produce horticultural crops and cereals like Tef wheat and maize. Currently, wheat is the major irrigation crop in all irrigation schemes in the country, including the Woleh irrigation scheme.

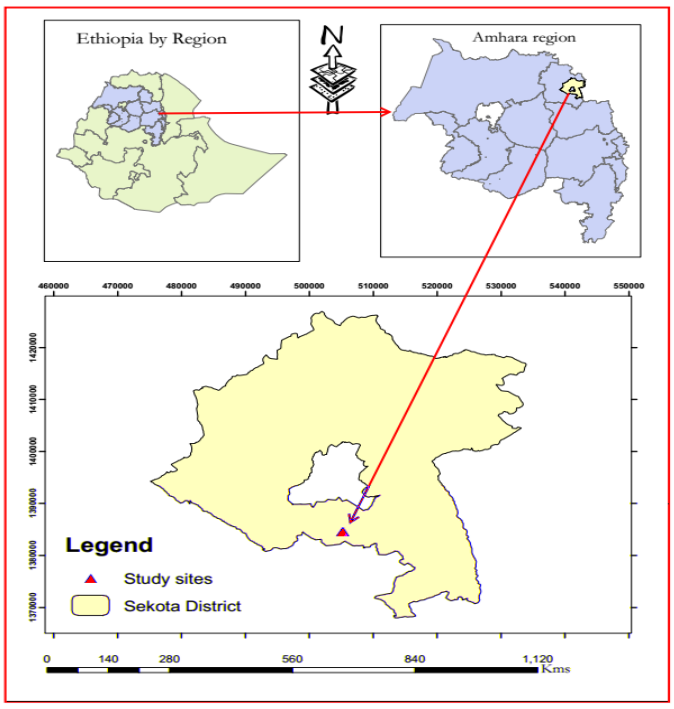

Figure 1 study area map

Experimental Design: The experiment consisted of ten treatments, as described in Table 1 and arranged in a randomized complete block design (RCBD) with three replications. The test crop wheat Kekeba variety was used and planted on a 2.4m x 6 m plot size. The spacing between rows, plots and blocks were 0.2, 0.5 and 1m respectively. The source of nutrients were triple super phosphate for Phosphorous, urea for Nitrogen, *Muriate of potash* for

Potassium, borax for Boron, Zn-EDTA (granular) for Zinc and $MgSO_4$ for Sulphur applied at planting except urea. Urea was applied half at planting and half at 35 days after planting.

Table 1 Treatment setup

Treatment	Treatment description	Applied nutrient $Kgha^{-1}$					
		N	P	S	K	Zn	B
Control	No fertilizer	0	0	0	0	0	0
NPSKZnB (All)	All nutrients						

Results and Discussion

Soil Nutrient Status of the Experimental Site: The results of the soil analysis shows that the soil pH of the experimental sites was 8. The soil organic carbon content of the soil from farms 1 and 2 was 0.7 and 1.2%, respectively. The average total Nitrogen was 0.1, and the available Phosphorous of the experimental sites ranged from 10.9 to 16.7 ppm. The available Zinc of the respective sites was also 0.7 to 1.8 ppm, and the available Boron of the experimental site was 0.5 ppm (Table 2).

The pH of the soil was moderately alkaline (Jones, 2003), implying that wheat yield could be maximized by fertilizer applications. Hence, alkalinity could not be considered a yield-limiting factor. The SOC contents of the study site were very low; it required activities that increased SOC to increase crop yield and improve the use efficacy of the fertilizer, as the critical value is 2% (Murphy, 2014). This SOC showed that the yield of wheat is impractical without the application of mineral fertilizer. The lab report also showed that the total Nitrogen content of the experimental site was 0.1 (poor) because the critical values of soil TN are above 0.2%; this amount of soil Nitrogen limits the productivity of wheat (Landon, 1991). In addition to the application of NP-containing fertilizer, the application of other soil management practices that increase total Nitrogen content in the soil should be prevalent. The available P of the experimental site was above the critical value, which was 16.7. This amount of Phosphorus is ideal for the wheat crop (Zamuner *et al.*, 2006) when other factors like soil pH and moisture are in good condition. The range of available Zn content at the experimental site was 0.7 to 1.8, grouped from low to high levels for wheat crops (Cakmak, 2008).

Table 2. Soil nutrient satus of experimental farms

Sites	TN*	SOC	Av. P	Zn	B
	%	%	ppm	ppm	ppm
Farm 1	0.1	0.7	10.9	0.7	0.5
Farm 2	0.1	1.2	16.7	1.8	0.5

**TN: total Nitrogen, SOC: soil organic carbon, Av.P: available phosphorous, Zn: Zinc and B: Boron.*

Effects of Applied Nutrients on Grain Yield of Wheat: The analysis revealed that the application of various fertilizer nutrient sources significantly influenced the grain yields of wheat (Table 3). The highest grain yield was achieved with the application of NPKZnB (-S) nutrients, while the lowest yields were observed in the Nitrogen-omitted, control, and Phosphorous-omitted treatments. The grain yield from the positive control (All-KSZnB) or RNP was comparable to other nutrient-applied treatments, as indicated in Fig. 2. Interestingly, the yield from RNP fertilizer was superior to all treatments except the NPKZnB (-S) treatment. By applying NPKZnB (-S) nutrients, the yield increased by 150.9 $Kgha^{-1}$ compared to the RNP received treatment, but statistically at par. This showed that Nitrogen and Phosphorous are the major yield-limiting nutrients. The highest grain yield reduction occurred when Nitrogen was omitted, followed by Phosphorous omission. Omitting other nutrients (Boron, Zinc, Sulphur, and Potassium) did not significantly affect the grain yield compared to the recommended NP, underscoring the crucial role of Nitrogen and Phosphorous in wheat yield. This suggested that the application of other nutrients without the application of N and P together has less effect on wheat grain yield. Hence, optimizing Nitrogen and Phosphorous in fertilizer formulations can be key to maximizing wheat yields. The results align with previous studies by Abebe *et al.*, (2020), Rawal *et al.,* (2018), Singh (2018), and Teshome *et al*., (2023), who reported that the highest yield reduction was observed from the N-omitted treatment. Similarly, a study conducted on maize and tef in north-western Ethiopia by Amare *et al.*, (2022), Getinet *et al.*, (2022), and Alemayehu *et al.,* (2022) confirmed that Nitrogen and Phosphorous are the most yield-limiting plant nutrients among others. The yield reduction due to Nitrogen and Phosphorous omission is associated with the fertility status of the study farmland soils (Table 2), and it

confirms that nutrient depletion is a common and serious problem in Ethiopian soils (Smaling *et al.*, 1997; FAO, 2001; Sanchez, 2010).

Table 3. Grain yield of wheat (Kgha^{-1}) as affected by different nutrient sources

Treatment	Farm 1	Farm 2	Combined
Control	915.6^{c}	1490.8^{d}	1203.2^{c}
NPSKZnB (all)	3665^{a}	4266.7^{b}	3965.8^{a}
NPSKZn (-B)	3459.3^{a}	4418.9^{b}	3939.1^{a}
NPSKB (-Zn)	3718.9^{a}	4516.7^{b}	4117.8^{a}
NPKZnB (-S)	3442.5^{a}	5444.4^{a}	4443.5^{a}
NPSZnB (-K)	3393.3^{a}	4308.3^{b}	3850.8^{a}
NKSZnB (-P)	1561.1^{b}	3698.3^{c}	2629.7^{b}
PKSZnB (- N)	765.6^{c}	1608.3^{d}	1261.9^{c}
RNP	3436.1^{a}	5149.2^{a}	4292.6^{a}
LSD (0.05)	353.65	349.42	869.25
CV (%)	7.35	5.21	22.62

Effects of Omitted Nutrients of Nitrogen and Phosphorous on Yield of Wheat Over the Applied RNP: The result showed that the omission of Nitrogen (N) and Phosphorus (P), as well as no fertilizer treatment, resulted in the highest reduction in grain yield over the recommended Nitrogen and Phosphorus (NP) treatment (Figure 2). Omitting Nitrogen and Phosphorus resulted in a significant reduction in grain yield, with a 70.60% and 38.74% decrease over the recommended NP. This showed that Nitrogen is the primary yield-limiting nutrient, as omitting it resulted in the highest reduction in grain yield. Phosphorus follows Nitrogen as the second most crucial nutrient affecting yield. The current study aligns with findings from other studies, providing additional support for the importance of Nitrogen and Phosphorus in different crop yields. Buah *et al.,* (2012) and Xu *et al.,* (2016) reported that Nitrogen and Phosphorous omission resulted in a 47% and 27% reduction in sorghum and rice grain yield, respectively. Similarly, Aliyu *et al.,* (2021) reported that about 59 and 56% of maize grain yield reductions were due to the omission of Nitrogen and Phosphorus, respectively. Alemayehu *et al.*, (2022) also reported that about 81.6% and 80.7% of the tef

yield reduction was due to omissions N and P. Similarly, Getahun *et al.*, (2022) reported that the highest yield reductions of 34% and 27% were obtained from Nitrogen and Phosphorous-omitted treatments. A study conducted by Amare *et al.*, (2022) confirms that the maximum yield penalty was recorded from the omission of N, followed by P, and they also reported that the omission of other nutrients did not show a high yield reduction. Similarly, Desta *et al.*, (2022), who did an experiment on sorghum crops, found that the highest yield reduction was due to N omission, followed by P nutrients. Likewise, Teshome *et al.*, (2022) reported that the omission of the N nutrient significantly reduced the yield of sorghum.

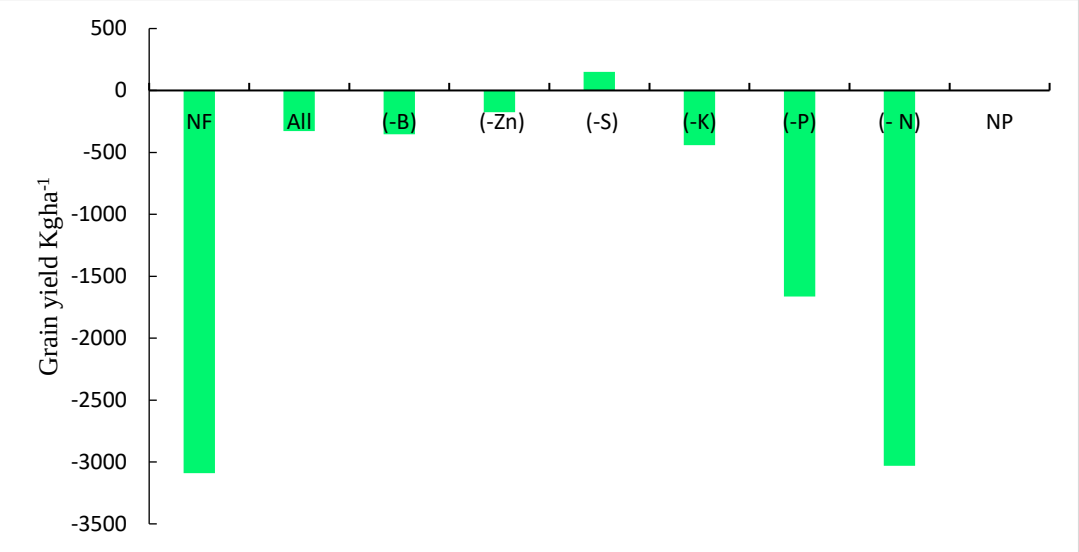

Figure 2 effects of omited nutrient on yield of wheat

Effects of Applied Nutrients on Biomass Yield of Wheat: The applied nutrienthad a significant effect on the biomass yield of wheat (Figure 4). The highest biomass yield was observed in treatments where NPKZnB-S (Nitrogen, Phosphorus, Potassium, Zinc, and Boron) and NP (Nitrogen and Phosphorus) were applied. The lowest biomass yield was recorded in the control and Nitrogen-omitted treatments. Omitting Sulphur, Zinc, Boron, and Potassium did nothave a significant effect on the biomass yield of wheat. However, omitting Nitrogen and Phosphorus had a notable impact, resulting in a lower biomass yield. Among the applied nutrients, Nitrogen and Phosphorus were identified as more critical for biomass yield. There

was no significant difference in biomass yield when Sulphur, Zinc, Boron, and Potassium were omitted, suggesting that these nutrients are not as crucial as Nitrogen and Phosphorus for wheat biomass production. This result was in accordance with the findings of Buah *et al.*, (2012) reported that application of Nitrogen and Phosphorus increased sorghum biomass yield by 58 and 26%, respectively. Similarly Abebe *et al.*, (2020) confirmed that Omission of Nitrogen and Phosphorous reduced total biomass yield of wheat by 66.4 and 20.6%, respectively. Study conducted on maize by Atnafu *et al.*, (2021) showed that the highest biomass yield reduction was obtained from Nitrogen, Phosphorous and Potassium omitted treatmens.

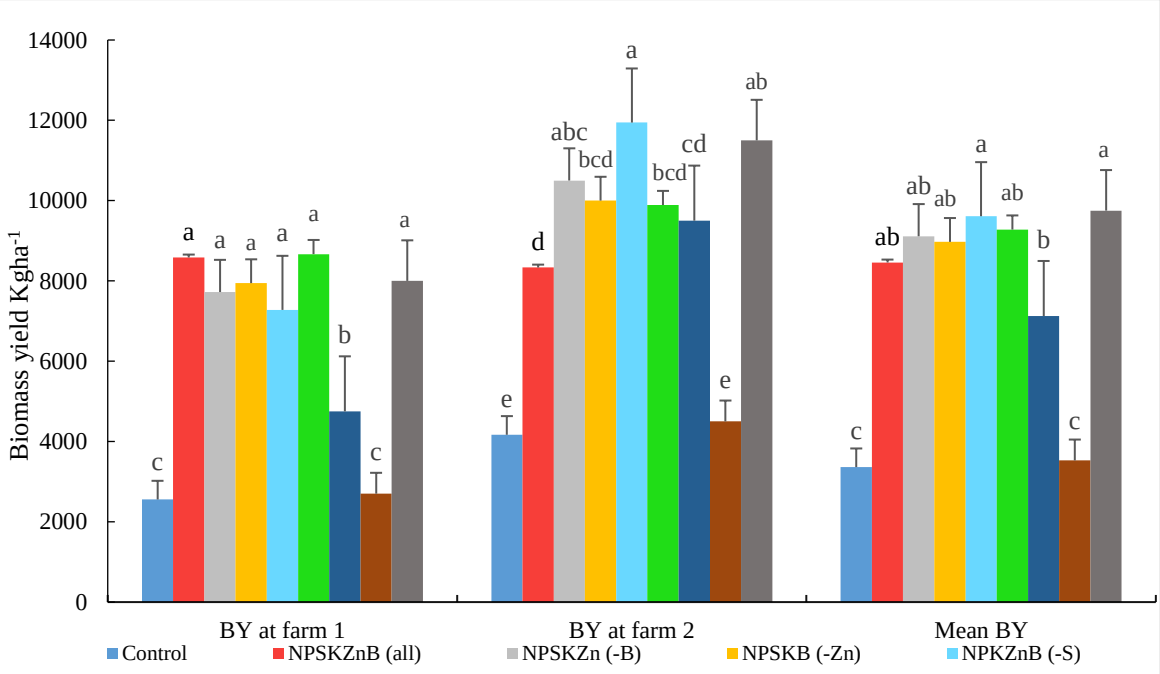

Figure 3 effects of applied nutrient on biomassyield of wheat

Conclusion and Recommendation

Proper nutrient supply through fertilizers enhances both the yield and quality of wheat grains. Omission of Nitrogen and Phosphorous had significant effect on the yield of wheat. The highest yield penality was observed when Nitrogen and Phosphorus were omitted. Hence Nitrogen is identified as the most yield limiting plant nutrient followed by Phosphorous for wheat under irrigation at Woleh irrigation scheme. The highest grain yield

was obtained from NPKZnB (-S) nutrient received treatment but did nothave a significant effect over recommended Nitrogen and Phosphorous applied. This shows that Nitrogen and Phosphorous contained fertilizers are the most important than K, S, Zn, and B contained fertilizers. Hence, it is advisable to emphasize onNitrogen and Phosphorus containing fertilizers to obtain higher wheat yield in the study area and similar agroecologies.

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