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ORIGINAL RESEARCH ARTICLE

Influence of N and P fertilizer rates on yield and yield components of bread wheat (*Triticum aestivum* L.) in Sekota District of Wag-Himira Zone, North Eastern Ethiopia

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ABSTRACT

A field experiment was conducted to study the performance of bread wheat sown under different nitrogen and phosphorous fertilizer rates during 2017 main cropping season on farmer's field at Weleh and Sayda, North eastern Ethiopia. Factorial combinations of four nitrogen (10.25, 20.5, 41 and 60.5 kg ha^{-1}) and four phosphorous (23, 46, 69, and 92 kg ha^{-1}) rates were laid out in randomized complete block design (RCBD) with three replications. The result showed that using a different N and P rate of fertilizer had no significant effect (*P*≥*0. 05*) on the number of total and effective tillers in both locations. Similarly, at Sayda, different rate of nitrogen and phosphorus fertilizers did not show a significant effect on biomass yield, Straw yield, and grain yield. On the other hand, plant height was significantly affected by the interactions of nitrogen and phosphorus fertilizers. While days to 50% heading, days to 90% maturity, number of kernels per spike and thousand kernel weight were significantly affected by different rate of nitrogen fertilizer. Besides that, spike length and number of kernels per spike were significantly affected by phosphorus fertilizer application. Since the homogeneity of error variance was significant, it indicates that both locations were not combined together, rather it was done separately. According to the partial budget analysis, the combination of 20.5N and 23P kg ha^{-1} was economically feasible at both locations. For future conducting of the researches in different seasons and location is important for sound recommendation.

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INTRODUCTION

Wheat (*Triticum spp.*) is one of the major cereal crops grown in the highlands of Ethiopia and this region is regarded as the largest wheat producer in Sub-Saharan Africa (Efrem *et al*., 2000). Bread wheat (*Triticum aestivum* L.) is one of the most staple food crops in the world and it is one of the most important cereals cultivated in Ethiopia. Bread wheat in Ethiopia stands fourth in both area coverage and total annual production, and second in yield per hectare next to maize (CSA, 2017). It is also one of the most important crops in the Amhara Region. Both the country and in the region, its grain is used for making bread, porridge, soup and consumed as roasted and boiled forms. Moreover, the straw of bread wheat is an important feed for livestock, thatching roofs, and bedding (Behera, 1998; Bekele *et al*., 2017). In spite of its tremendous importance, bread wheat production in the country as well as in the region has faced immense production constraints affecting both its yield potential and industrial quality. Among these constraints mainly farmers are using low yielding local varieties, and blanket recommendation of fertilizer inputs rather than location specific once. Bread wheat is produced by many smallholder farmers in the Wag Himra Zone as well as in Amhara region. Bread wheat in Wag Himra Administration Zone stands fourth in area coverage and production next to sorghum, teff and barley. The average productivity of bread wheat in Wag-Himra is 1.47t ha^{-1} and, while the national bread wheat productivity is 2.6 ha^{-1} (CSA, 2017; Gasser and Iordanou, 1967) and the world average is 2.9 t

ha^{-1} (FAO, 2010). According to Amhara National, State Agricultural Bureau Dryland Crop Production Package (2015) the blanket recommendations for bread wheat are 100k.g DAP (18%N&46P) with 50 Urea (46%N) kg/ ha, respectively. Sekota Dryland Agricultural Research Center also adopts the blanket fertilizer recommendation proposed by regional bureau of agriculture. This hence calls an urgent research works to find site specific NP fertilizer recommendations for bread wheat and the likes which are appropriate wag himira dry land areas. Nutrient depletion (mining) is a net loss of plant nutrients from the soil or production system due to a negative balance between inputs and outputs (Doyle and Holford, 1993; Dalcorso *et al*., 2014). Typical channels of nutrient depletion are nutrient removal through harvest, leaching, denitrification, soil erosion, and runoff. As a result of this the average productivity of bread wheat in Wag Himira is very low; about 1.47 tons ha^{-1} CSA (2017) which is much below that of the world's average about 2.9 ton ha^{-1}s (Mengistu *et al*., 2015).

Among several restricting factors responsible for low yielding of bread wheat in the area is due to severe soil fertility depletion mainly nitrogen and phosphorus. Even an inadequate supply of N and P fertilizers can limit not to harness the potential productivity of the crop. On the other hand, too much NP can also cause for the reduction of productivity and reduction of profitability (Dalcorso *et al*., 2014). Determining the appropriate NP fertilizer rate hence necessary for maximizing economic yields. In the study area there is no any visible recommendation of NP for bread wheat as well as for other crops except the blanket recommendation of 23 N and 46 P_2O_5 kg ha^{-1}. Even farmers don't apply NP fertilizers as per the blanket recommendation, rather they use less than the blanket recommendation rates. These all demand research works to study the effect of NP rates on bread wheat growth and yield so as to determine their optimal rates for achieving the potential productivity of bread wheat in the target areas (Litke *et al*., 2017; Kumar *et al*., 2018).

The main objective of the present study was to study the effect of different rates of NP fertilizer on growth and yield of bread wheat in dryland areas of Wag-Himra Zone, northeastern Ethiopia and to suggest the optimum rates of NP fertilizers for maximizing bread wheat productivity in the study area

MATERIALS AND METHODS

Description of the study area

The study was conducted at Sekota district in 2017/2018 main cropping season in Wag Himra Zone North Eastern Ethiopia. Its latitude and longitude range lies 12.65N and 39.03E. This is the place where food insecurity is a chronic problem for the majority of the rural population. The town, Sekota is located 720 km north east of Adis Ababa and 430km from Bahir dar. The two sites of testing are within Sekota district, namely Weleh and Sayda. They are found in the latitude and longitude range of 12.60′N and 39.05′E and12.40′N and 38.20′E respectively. The site is far apart from *Sekota* about 15 and 16 km respectively. Weleh has an altitude range of 2000 m above sea level, whereas sayada has an altitude range of 2200 m above sea level (Figure 1). With respect to rainfall sites have 566mm and 520 mm annual rain for Weleh and Sayda respectively. The minimum temperature for both locations was 14(°C), while the maximum temperature was, 26 (°C) and 24 (°C) for Weleh and Sayda respectively. According to Sekota dry land Agricultural research center laboratory result both of the experimental sites have black (Vertisol) soil type and with respect to pH range the areas have 5.7 to Weleh and 6 to Sayda .

The dominant types of cropping system in the study area are mono -cropping and crop rotation, whereas inter-cropping is rarely practiced in the District. The common type of inter-cropping activities in the study site are: tef +, Saff flower and Sorghum + haricote bean Similarly, the common types of crop rotations practiced in the District are: Teff—barley--pulse crops— teff; Pulse crops-- teff---barley--pulse crops; and wheat/barley (Sekota District Agricultural and Rural Development Office, 2009).

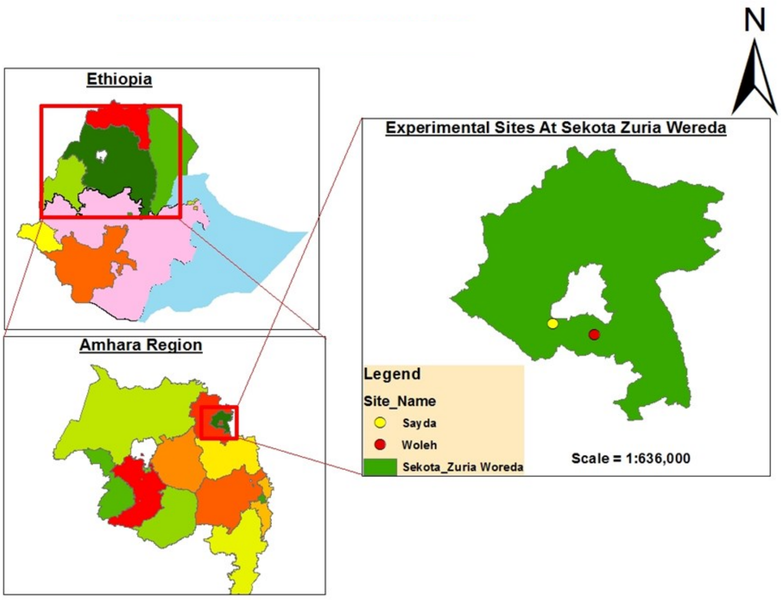

Figure 1. *Location map of the experimental sites in Ethiopia.*

Planting material used for the study

A bread wheat variety "Sekota-1" was the planting material for the present study. The variety was officially released by Sekota Dry Land Agriculture Research Center in 2013 for moisture deficit areas of Eastern Amhara Region and similar agro-ecologies of the country. During its release, the variety had a 30 % yield advantage over the local check and 10% over the standard check. The seed of the variety was drilled by 20cm row spacing on the experimental plots uniformly at 125 kg/ha seeding rate. Sowing was done on set of rain fail at the binging of July and the soil has optimum moisture condition.

Experimental design and treatments

A factorial combination of four N rates (10.25, 20.5, 41 and 60.5 kg/ha) and four rates of P_2O_5 23, 46, 69 and 92 was laid out in a randomized complete block design with three replications. After preparing the experimental plot repeatedly with oxen plow, the land was subdivided into blocks and plots as per the design and the treatments of the study. The gross plot size was 2.5 × 2.4 m (6 m^2) with the net plot size of 2.3 × 2m (4.60 m^2) excluding two outer rows and edge of 10cm length at both ends of each plot. Adjacent blocks and plots with in the blocks were separated by 1.0m and 0.5m, respectively. Using the lottery method, treatment combinations were assigned randomly to the experimental plots each block. DAP (18%N and 46%P_2O_5) and Urea (46%N) were used as sources of nitrogen and phosphorous. Full doses of P-treatments and half doses of N-treatments were applied in a band at planting time, while the remaining half N-treatments were top dressed at a mid-tillering stage after the second wedding.

Data collection and measurements

Data of important study parameters of bread wheat were collected on plant or plot basis. Data of phenological parameters and different kinds of yield including biomass, grain, and straw yields were collected on plot basis in the net plot areas, while, vegetative growth and some yield parameters were collected on a plant basis by taking 5 sample plants randomly in the net plot areas. Detailed methods and procedures used for collecting phenological, vegetative growth and yield related parameters are presented below.

Determination of phenological parameters

Days to 50% heading (DH)

It was measured as a number of days elapsed from sowing to the date on which 50% of the plants on the net plot area produce their first head.

Days to 90% physiological maturity (DM)

Days of maturity were taken as a number of days elapsed from emergence to the stage when 90% of the plants in the net plot area reached physiological maturity.

Vegetative growth parameters

Plant height (cm)

Plant height was determined as a distance in centimeter from the soil surface to the tip of the spike excluding the awns at maturity and expressed as the average of five plants per plot.

Number of total tillers

Number of total tillers was determined by counting numbers of total tillers in 1m row length in the net plot areas during physiological maturity.

Number of effective tillers per plant

Number of effective tillers was also estimated by counting plants that have heads/spikes in 1m row length in the center of the plots during physiological maturity.

Spikes length (cm)

Average length of 5 randomly selected spikes of the main tiller measured during physiological maturity in cm from base to tip excluding the awn.

Estimation of yield related traits

Number kernel per spike

Number of kernel was the average number of kernels of five randomly selected tillers of plants taken in the net plot areas.

Thousand kernel weights (g)

Kernel weight in a gram of randomly taken sample of thousand seeds per plot after threshing and cleaning.

Biomass yield (t/ha)

It was determined by weighing the total air dried aboveground biomass harvested from net plot areas rows and expressed in t/ha.

Grain yield (t/ha)

Weight of grains recovered from harvested wheat plants in the net plot areas after sun-drying threshing and cleaning converted into t/ha.

Straw yield (t/ha)

It was estimated as the difference between biomass yield and grain yield.

Harvest index (%)

It was calculated as a ratio of dry weight of the grain to dry weight of the total aboveground biomass yield (%) multiplied by 100.

Variable costs (Birr/ha)

NP fertilizer costs were considered to analyze the partial budget analysis.

Partial budget analysis

The partial budget was calculated to compare gain and losses between one treatment and another. It was done based on the following methodology prescribed by CIMMYT (1988).

It was considered the analysis of gross benefit (GB), total variable cost (TVC), the net benefit (NB) and finally the analysis of the marginal rate of return (MRR).

GB = (YA×PA) + (YB×PB)

TVC = (The sum of all the costs which vary between treatments

NB = GB-TVC

Where, GB= Gross benefit, TVC=Total variable cost, NB=Net benefit, MRR=Marginal rate of return, YA=Grain yield, PA =Price per unit quintal, YB=Straw yield, PB =Price of straw per unit Shekim.

Data analysis

The collected data were subjected to analyses of variance (ANOVA) using SAS version 9.1. Combined analysis of the two site data was heterogeneous after testing the homogeneity of error variance using F test and gestalt software it was done separately. (Gomez and Gomez, 1984). Mean separation for statistically different treatments was done using least significant difference (LSD) method at 0.05 level of significance depending upon the ANOVA result. Simple correlation analysis was carried out by calculating simple calculation coefficients to see the relationship between yield and yield components as influenced by the application of different rates of NP. Economic analysis was performed following the CIMMYT partial budget analysis methodology (CIMMYT, 1988) to identify economically profitable NP rate.

RESULTS AND DISCUSSION

Phenological parameters of bread wheat as influenced by different rates of nitrogen and phosphorous

Results of analysis of variance showed that both days to 50% heading and 90 % maturity of bread wheat were significantly ($P \leq 0.05$) affected by different rates of nitrogen at Sayda (Table 1). Whereas, at Weleh, days to heading and maturity were responded differently to different rates of nitrogen. Days to heading at Weleh was not significant ($P>0.05$) influenced by different rates of nitrogen, while day to maturity was influenced significantly (Table 1). As the rate of nitrogen increased, there was a prolonged trend of heading at Weleh and of both heading and maturity at Sayda. On the contrary, to nitrogen, different rates of phosphorous didn't significantly affect days to heading and maturity at Sayda and to maturity at Weleh, but days to heading at Weleh was exceptionally affected by different rates of phosphorous significantly. At both Weleh and Sayda, days to heading and maturity of bread wheat were not significant ($P>0.05$) affected by the interaction effect of nitrogen and phosphorus (Table 1). Delay of heading and maturity of bread wheat due to higher levels of nitrogen within its optimum ranges would be associated with vegetative promoting effect of nitrogen. Similar to the present result, Russell (2014) indicated that high levels of nitrogen promoted greater vegetative development before the beginning of reproductive phase and thereby attributed to the delay of and maturity. The present result is line with Tariku (2007) who reported that day to heading of wheat plants was hastened under lower N rates compared to the higher N rates. According to this author the most prolonged duration of heading was recorded on plants grown at the rate of 60.5 kg N ha^{-1}, whereas the shortest duration to heading was recorded on plants grown at the lowest amount of nitrogen rate.

In agreement with the present result, days to maturity were increased with the increase of nitrogen rates (Tariku, 2007). Unlike the results of the present study, Cock and Ellis (1992) reported that optimum level of nitrogen application resulted in rapid growth and heading. According to these authors, too little N application resulted in slow growth rate and delayed heading, and growth, whereas excessive N application kept vegetative growth active and eventually finally resulted in delayed heading and flowering.

Table 1. Treatment combinations used for the fertilization of wheat during the study.

N Fertilizer rate	P Fertilizer rate	Possible treatment combination
N1(10.25)	23(P1)	NIP1(T1)
	46 (P2)	N1P2(T2)
	69 (P3)	N1P3(T3)
	92 (P4)	N1P4(T4)
N2(20.5)	23(P1)	N2P1(T5)
	46 (P2)	N2P2(T6)
	69(P3)	N2P3(T7)
	92(P4)	N2P4(T8)
N3(41)	23(P1)	N3P1(T9)
	46(P2)	N3P2(T10)
	69(P3)	N3P3(T11)
	92(P4)	N3P4(T12)
N4(60.5)	23(P1)	N4P1(T13)
	46(P2)	N4P2(T14)
	69(P3)	N4P3(T15)
	92(P4)	N4P4(T16)

Vegetative growth of bread wheat as affected by different rates of nitrogen and phosphorous

Plant height

The result of analysis of variance showed that the interactions between nitrogen and phosphorous rates were found to be significant ($P \leq 0.05$) to plant height at Sayda while, it was not significant at Weleh. It was significantly increased due to main effect of Nitrogen ($P \leq 0.05$) and phosphorus fertilizer application at Weleh and on the contrary, it was nosignificant at Sayda (Table 2). The average plant height for Sayda and Weleh was in the ranges 76.87 -88.86 cm and 80.93 -86.07 cm, respectively. The highest plant heights (88.86 and 86.07 cm) were recorded on conjointly interactions of 60.5N×23P at Sayda and individually act of 60.5N and 69 P fertilizer rate at Weleh. Whereas the shortest plant heights (76.87 cm and 80.10 cm) were recorded in the interaction of 10.25N × 23P fertilizer rate and main effect of 10.25N and 23P at Sayda and Weleh locations respectively. This finding confirms Plant height increasing tendency with increasing nitrogen application rates from 10.25 to 60.5 kg N ha^{-1}. Consequently, the maximum plant height (85.36 cm) was obtained when 60.5 kg ha^{-1} of N rates was applied to the soil followed by application of 41 kg ha^{-1} N (84.86 cm), which was 6% higher over lowest rate with the mean of 80.93 cm in agreement with the findings of (Kidanu *et al*., 1999; Abdoulaye and Marienville, 1999; Woyema *et al*., 2012; Haile *et al*., 2012; Fana *et al*., 2012; Gerba *et al*., 2013; Kilian *et al*., 2010). Increasing N rate increased plant height mean values for nitrogen rates showed that plant height increased with increase in nitrogen rates from the control to the highest rate. The increased plant height at the highest level of nitrogen was probably due to the availability of more nutrients, which helped, in the maximum vegetative growth of the wheat plant. This result was in line with Khan *et al*. (2000) who reported that increasing nitrogen rates increased the plant height.

Number of total tiller and productive tillers per 1 meter row

The result of analysis of variance showed that both total tiller and productive tiller were not significant ($P>0.05$) affected by different rate of Nitrogen, Phosphorus fertilizer and their interaction at both locations (Table 3). It agrees with other reports which found that with respect to tiller number there is no significant between different N levels of barley (*Hordeum vulgare*). Dalcorso *et al.* (2014) report that NTT was not significantly affected by N and NP interaction. On the contrary, Maqsood *et al.* (1999) reported that the increase in the number of fertile tillers with the increase in nitrogen levels could be attributed to the well-accepted role of nitrogen in accelerating the vegetative growth of plants.

Yield related traits as influenced by nitrogen and phosphors fertilizer

Spike length

The result of Analysis of variance showed that spike length was not significantly ($P>0.05$) affected by the different rate of nitrogen at both locations. On the contrary, to nitrogen application of the different rate of phosphorus fertilizer significantly affect spike length at Weleh, while it was nonsignficantly affect at Sayda (Table 4). As the rate of Phosphorus increased there was a prolonged trend of spike length at Weleh. The interaction effect of these factors on the same parameter was not significant ($P > 0.05$). As indicated in (Table 4), the highest rate (92 P kg/ha) resulted in the highest spike length (8.03cm) and the lowest number of spikes (7.68cm) was obtained at the rate of (46Pkg ha^{-1}) indicating an increment of P shows a 5% advantage over the blanket recommendation. Generally, each increment in the rate of applied P fertilizer resulted in significantly differing spike length.

Number of kernels per spike (NKPS)

The result of analysis of variance showed that number of kernels per spike was significantly ($P \leq 0.05$) affected by nitrogen and Phosphorus fertilizer at both locations. However, the interaction effect of N and P on this parameter was not significant (P > 0.05). This finding confirms that the highest number of kernels per spike (45/ 47**)** was obtained with the application of NP at the rate of 41 kg N / 69P/ha and the lowest kernel per spike (35/42) was recorded from the treatment combination of 10.25 N/ha/ 92P/ha was applied at Weleh and on the other hand at Sayda 60.5N/46P/ha was the highest (37/42) and 20.5N/92P/ha was the lowest (28/32**)** (Table 4). As the rate of nitrogen increased there was an i trend of number of kernel per spike at both location. On the contrary to nitrogen, as the rate of Phosphorus increased there was a decrement trend of number of kernel per spike at both locations. This finding was in line with the data reported by Ali *et al.* (2003) who observed that an increased application of nitrogen increases the number of kernel per spike. Similarly, Kanugo and Rout (1994) indicated that increasing nitrogen rate up to optimum amount increase number kernels per spike.

Thousand kernel weight (g)

The result of analysis of variance showed that thousand kernel weight was significant ($P \leq 0.05$) affected by the different rate of nitrogen at both locations. In contrast to Sayda different rates of phosphorus, fertilizer was significantly affect thousand kernel weight at Weleh (Table 4). At both Sayda and Weleh thousand kernel weight did not significantly affect by an interaction effect of nitrogen and phosphorus fertilizer. This result was in line Darota (2003). Moreover, the main effect of neither P nor its interaction with N brought any significant change in thousand kernel weight. Similar results were reported by Gooding and Davies (1997), who, despite increased in yields found a significant reduction in thousand kernel weight of wheat by N fertilizer application. Harfe (2007) reported no significant effect of the application of different rates of N fertilizer on the thousand seed weight of bread wheat. Gurmessa (2002) also indicated that neither the main effect of N and P nor their interaction brought about significant change in 1000 grain weight. Other similar reports by Gooding and Davies (1997), Asrat (2005), Lemma *et al.* (1992) reported that a non-significant effect on 1000 kernel weight due to different doses of N and P fertilizers.

Table 2. Interaction effect of NP Fertilizer rate on plant height of bread wheat at Sayda.

Fertilizer Treatment		Plant Height (cm)
N	P	
10.25	23	76.87[e]
	46	79.86[de]
	69	80.93[cde]
	92	87.27[ab]
20.50	23	84.53[abcd]
	46	84.86[abcd]
	69	83.20[abcd]
	92	80.93[cde]
41.00	23	81.47[cde]
	46	83.06[bcd]
	69	86.20[abc]
	92	86.66[abc]
60.5	23	88.86[a]
	46	83.87[abcd]
	69	84.86[abcd]
	92	86.46[abc]
Significant difference (N×P)		*
CV		4.13
SE±		1.25

Means followed by the same letter within a column are not significantly different from each other at P< 0.05 according to Fishers LSD; PH = Plant height; LSD = Least significant difference; CV=Coefficient of variation.

Table 3. Main effect of nitrogen and phosphors fertilizer rate on the phenological parameter of bread wheat in 2017 main cropping season at Weleh and Sayda.

Main effect	Treatment	Study site			
		Weleh		Sayda	
		HD	MD	HD	MD
N (Kg)	10.25	57	90.00[c]	60.00[bc]	93.00[c]
	20.5	59	96.00[b]	65.00[ab]	95.00[bc]
	41	57	97.00[ab]	67.00[a]	99.00[a]
	60.5	57	99.00[a]	66.00[ab]	96.00[ab]
	Significant difference	ns	*	*	*
P (Kg)	23	50.00c	96.58	67.67	98.86
	46	55.50b	96.5	64.49	97.2
	69	57.92ab	96.25	65.35	98.98
	92	59.66a	96.66	65.91	96.74
	Significant difference	*	ns	ns	ns
	NXP	ns	ns	ns	ns
	CV	3.88	0.7	4.45	6.78
	SE±	0.92	1.78	1.72	1.82

Means followed by the same letter within a column are not significantly different from each other at P< 0.05 according to Fishers LSD; DH = days to 50% heading; MD; = days to 90% maturity; SE± = standard error =; CV= coefficient of variation.

Table 4. Interaction effect nitrogen and phosphors fertilizer rate on harvest index of bread wheat at Sayda Location.

N Application	Interactive effects	
	P	HI (%)
10.25	23	36.48[ab]
	46	21.12[de]
	69	16.58[e]
	92	26.26[bcde]
20.50	23	21.20[de]
	46	26.85[bcde]
	69	26.52[bcde]
	92	33.62[abc]
41.00	23	22.98[cde]
	46	25.44[bcde]
	69	33.48[abc]
	92	41.55[a]
60.5	23	22.56[bcde]
	46	24.97[bcde]
	69	29.00[bcd]
	92	30.40[abcd]
Significant difference (N×P)		*
CV		4.13
SE±		1.25

Means followed by the same letter within a column are not significantly different from each other at *P< 0.05* according to Fishers LSD; HI = Harvest Index; LSD = Least significant difference; CV=Coefficient of variation.

Increased number of spikelets per spike and vigorous vegetative growth owing to high N application induce competition for carbohydrate available for grain filling and spikelet formation Hasegawa (1994). This reduced the grain weight because of insufficient supply of carbohydrate to the individual grain.

Straw yield (kg ha^{-1})

The result of analysis of variance revealed that straw yield was not significantly affected (*P>0.05*) by the main effect of nitrogen and phosphorus at Sayda and their interaction at both locations (Tables 6). In contrast, the main effect of the nitrogen and phosphorus fertilizer rate was significant ($P \leq 0.05$), influencing the straw yield (Table 6). It increased with the increasing trend of N, the lowest straw yield was recorded at the lowest (6247kg ha^{-1}) rate of nitrogen whereas the highest recorded was at the highest rate (7370 kg ha^{-1}) at Weleh. The maximum straw yield of 7370kg ha^{-1}was obtained with an application rate of 60.5Kg/ha which had 15 % advantage over the lowest rate N similar trend was observed by (Teklu and Hailemariam, 2009; Woyema *et al.*, 2012; Fana *et al.*, 2012; Haile *et al.*, 2012). In terms of phosphorous fertilizer rate, the highest straw yield was recorded at a 46kg ha^{-1} rate of P (7400kg ha^{-1}) as compared to the highest rate of P(5300kg/ha^{-1}) with a statistical significance of (*P>0.05*). This result has been confirmed with the result of (Haileselassie *et al.*, 2014).

Biomass yield (kg ha^{-1})

The result of analysis of variance showed that biological yield of bread wheat was significantly ($P \leq 0.05$) affect by both main effects of nitrogen and phosphorous fertilizer, but the exceptionally interaction effect was not significantly affect at Weleh. On the contrary, to Weleh, both main effect, as well as their interaction, did not significantly affect biological yield at Sayda. Biological yield is the sum total of all dry matter produced through physiological and biochemical processes occurring in the plant system. Biological yield is an important factor because farmers are also interested in straw in addition to grain. Increased biomass production was observed with increasing rates of N; due to this reason application of 60.5 kg N ha^{-1} increased the relative biomass by 1930.62 kg ha^{-1}(19.36%) than the blanket recommendation. The highest (9970.62 kg ha^{-1}) and lowest (8860kg ha^{-1}) total biological yields were obtained with the application of 60.5 kg N/23P /ha and (10.25N/46P), respectively at Weleh (Table 6). Generally, as N rates increased, the total biological yield also increased. Increase and decrease in biomass yield did not show a consistent trend with respect to P level increment.

The current results agree with the extent of yield component's response to nitrogen fertilizer be contingent on the expanse or quantity of the nutrient supplied (Teklu and Hailemariam, 2009; Woyema *et al.*, 2012; Fana *et al.*, 2012; Haile *et al.*, 2012; and Gerba *et al.*, 2013). Similarly, the nitrogen application enhanced the vegetative growth of the wheat crop, which ultimately increased biological yield with an increase in biological yield Allam (2003). The result obtained from this study was similar to the research findings of Haile *et al.* (2012) who reported that as N rate increased the biological yield also increased.

Table 5. Main effect of nitrogen and phosphorus fertilizer rate on grain yield and yield related trait of bread wheat in 2017 main cropping season at Weleh and Sayda.

Main effect	Treatment	Weleh			Sayda			
		SY(kg/ha)	BY(kg/ha)	GY(kg/ha)	SY(kg/ha)	BY(kg/ha)	GY(kg/ha)	HI(%
N	10.25	6400.40bc	8860.60bc	2260.20c	1.80 (7099.80)	9340.30	2240.50	27.26
	20.5	6247.70b	9008.60b	2760.90a	1.80 (5970.10)	8220.10	2430.70	27.91
	41	7650.00a	9650.00ab	2300.00c	1.78 (5859.40)	8260.30	2400.90	29.87
	60.5	7370.62ab	9970.62a	2600.00ab	1.73 (6506.90)	8707.30	2230.10	29.77
	Significant difference	*	*	*	ns	ns	ns	ns
P	23	6550.70ab	9270.80a	2720.10	1.76 (6409.60)	8770.50	2360.90	26.72
	46	7470.60bc	8040.80b	2420.30	1.79 (6916.20)	9306.40	2390.20	26.74
	69	5329.70b	9090.00ab	2710.30	1.77 (6090.60)	8390.60	2300.60	26.88
	92	6149.80a	8560.10c	2410.30	1.75 (5121.90)	7502.30	2380.40	26.98
	Significant difference	*	*	ns	ns	ns	ns	ns
Significant difference (N×P)		ns	ns	ns	ns	ns	ns	ns
CV		24.25	16.15	405	8.10	16.15	12.71	9.94
SE±		517.14	116.45	402.98	115	222.17	311.26	2.27

Means followed by the same letter within a column are not significantly different from each other at P< 0.05 according to Fishers LSD; SY = Straw Yield; BY=Biological Yield; G.Y; =Grain Yield; HI = Harvest Index; SE± =Standard Error =; CV=Coefficient of variation.

Table 6. Correlation coefficient of various parameters of wheat at Weleh.

Parameters	HAD	MD	PH	SL	TKW	SY BY	GY	HI
HAD	1.000							
MD	0.5*	1.000						
PH	-0.085ns	-0.088ns	1.000					
NTT	0.071ns	-0.066ns	-0.021ns					
NET	0.241ns	-0.098ns	-0.098ns					
SL	0.241ns	0.098*	-0.098*	1.000				
TKW	0.024ns	-0.092ns	-0.338ns	0.030ns	1.000			
SY	-0.186ns	0.003ns	0.124ns	-0.091ns	-0.067ns	1.000		
BY	0.14ns	0.54ns	0.11ns	0.01ns	0.35ns	0.8*		
GY	0.20ns	0.18ns	0.23*	0.02ns	0.00ns	-0.077ns	1.000	
HI	0.203ns	0.042ns	-0.209ns	-0.051ns	-0.227ns	0.140ns	0.56*	1.000

HD= Heading date, MD=Maturity date, PH= Plant height, SL=Spike length, NKPS=Number of kernel per spike, BM=Biomass Yield, SY=Straw yield, TKW=Thousand kernel weight, HI =Harvest index and GY=Grain yield.

Table 7. Main effect of nitrogen and phosphorus fertilizer rate on grain related trait of bread wheat at Weleh and Sayda.

Main Effect	Treatment	Weleh			Sayda		
		SL(Cm)	NKPS	TKW(Gr)	SL(Cm)	NKPS	TKW(Gr)
N	10.25	7.58	41^{ab}	32.77^{ab}	7.62	32^{ab}	18.02^{c}
	20.50	7.73	39^{ab}	25.26^{c}	7.52	28^{bc}	22.50^{ab}
	41.00	7.66	45^{a}	29.26^{b}	7.96	30^{ab}	20.66^{b}
	60.50	7.90	35^{c}	37.73^{a}	7.73	37^{a}	23.33^{a}
	Significant difference	ns	*	*	ns	*	*
P	23	7.68^{ab}	46^{ab}	83.75ab	7.78	33bc	21.66
	46	7.42^{c}	43^{c}	93.64a	7.72	42a	21.52
	69	7.69^{b}	47^{a}	83.96ab	7.60	39ab	20.83
	92	8.03^{a}	42^{bc}	75.23b	7.78	32c	22.52
	Significant difference	*	*	*	ns	*	ns
Significant difference (N×P)		ns	ns	ns	ns	ns	ns
CV		7.38	10.32	21.47	0.22	7.15	17.69
SE±		0.22	1.69	2.87	7.15	21.47	1.51

Means followed by the same letter within a column are not significantly different from each other at P< 0.05 according to Fishers LSD; SL = Spike Length; NKPS=Number Kernel per Spike; TKW =Thousand Kernel Weight; SE± =Standard Error =; CV=Coefficient of variation.

Table 8. Correlation coefficient of various parameters of wheat at Sayda.

Parameter	HD	MD	PH	SL	NKPS	BM	SY	TKW	HI	GY
HD	1.000									
MD	0.6*	1.000								
PH	0.058ns	-0.304ns	1.000							
SL	0.034ns	0.031ns	-0.057ns	1.000						
NKPS	0.034ns	0.031ns	-0.057*	0.122ns	1.000					
BM	0.018ns	0.024ns	-0.051ns	0.177*	0.177ns	1.000				
SY	-0.166ns	0.104ns	0.157*	-0.156ns	-0.156ns	0.7**	1.000			
TKW	-0.447ns	0.070ns	-0.174*	-0.141ns	-0.141ns	-0.022ns	-0.188ns	1.000		
HI	0.34ns	0.38ns	0.54ns	0.06ns	0.07ns	-0.7*	-0.6*	0.33ns	1.00	
GY	-0.441ns	0.091ns	-0.174ns	-0.125ns	0.5**	-0.019	-0.63*	0.993***	-0.08ns	1.000

HD= Heading date, MD=Maturity date, PH= Plant height, SL=Spike length, NKPS=Number of kernel per spike, BM=Biomass Yield, SY=Straw yield, TKW=Thousand kernel weight, HI =Harvest index and GY=Grain yield.

Table 9. Comparison of net benefit with respect to the marginal rate of return at Sayda.

Treatment (N×P)	Unit price Qt^{-1}	GY (Qt ha^{-1})	SY (Qt ha^{-1})	Unit price Qt^{-1}	TGB (Eth. birr/ha)	TVC Eth. birr)	NB (Eth. bir)	DA	MRR (%)
10.25/23.00	2500	23.03	58.66	150	66368.12	447.50	62952.50		-
10.25/46.00	2500	21.50	90.43	150	67308.89	561.59	69038.41		724.00
10.25/69.00	2500	25.00	89.22	150	75883.49	780.83	67219.17	D	-
10.25/92.00	2500	23.67	58.99	150	68026.93	789.85	67510.15	D	-
20.50/23.00	2500	24.56	68.22	150	77732.71	894.93	82455.70		3331.46
20.50/46.00	2500	24.32	61.62	150	70032.54	1018.11	79981.89	D	-
20.50/69.00	2500	23.00	65.02	150	68730.48	1114.17	77835.83	D	-
20.50/92.00	2500	24.40	61.77	150	70255.88	1123.19	70626.81	D	-
41.00/23.00	2500	24.24	61.93	150	69877.50	1228.26	81621.74	D	-
41.00/46.00	2500	23.19	55.84	150	66346.93	1447.50	63802.50	D	-
41.00/69.00	2500	23.19	55.78	150	66338.04	1456.52	68043.48	D	-
41.00/92.00	2500	24.88	57.22	150	70780.80	1561.59	53488.41	D	-
60.50/23.00	2500	15.30	35.39	150	43553.34	1684.78	52065.22	D	-
60.50/46.00	2500	19.89	59.53	150	58647.46	1789.85	60960.15	D	-
60.50/69.00	2500	24.56	44.25	150	68030.62	2018.11	64981.89	D	-
60.50/92.00	2500	24.56	45.72	150	68251.01	2180.00	73820.00	D	-

TVC, GB, NB and MRR, Total gross benefit, Total variable cost, Net benefit and marginal rate of return, respectively.

Harvest index (%)

The result of analysis of variance indicated that harvest index of bread wheat was not significant (*P>0.05*) affect by the main effect of different rate of nitrogen and phosphorous fertilizer at both locations. While the interaction effect of nitrogen and phosphorous fertilizer was significantly (*P<0.05*) affect harvest index at Weleh, but it was not significant (*P>0.05*) affect at Sayda. As nitrogen increase from 10.25 to 41 and phosphorous increase from 69 to 92 Harvest index shows an increment trend from 16.58 to 41.55 this result agreed with Harfe (2017) whose result indicate that 34 to 38 an increment trend. Harvest index is an indicator of dry matter partitioning towards the reproductive organs. The highest was a record on 41×92NP (41.55) but the lowest harvest index (16.58%) was obtained with the lowest treatment combination 20.5N×23P.

Grain yield (kg ha^{-1})

The result of analysis of variance showed that grain yield of bread wheat was not significantly (*P>0.05*) affect by different rate of phosphorous fertilizer as well as though their interaction effect at both locations (Table 6). However, application of the different rate of nitrogen fertilizer significantly (*P≤0.05*) affect grain yield at Weleh but it was not significant at Sayada. The mean values for the grain yield were observed at Weleh in the range from 2300 kg ha^{-1} to 2700 kg ha^{-1}. The maximum grain yield of 2700 kg ha^{-1} was obtained in plots that had a nitrogen rate of 20.50 kg ha^{-1} and the lowest was achieved at a rate of 41 kg ha^{-1}.This finding is in line with Haileselassie *et al.* (2014) in which grain yields of wheat were not significantly affected by the main effect of phosphorus. In line with Darota (2003), yields of wheat were not affected significantly due to the interaction effect of nitrogen and phosphorus fertilization in both experimental fields. The amount of nitrogen applied also significantly affected grain yield. Grain yield increased as the amount of nitrogen increased from the low level to 41 kg ha^{-1}. This result agrees with the other finding (Teklu and Hailemariam, 2009; Woyema *et al.*, 2012; Fana *et al.*, 2012; Haile *et al.*, 2012; Gerba *et al.*, 2013). The highest grain yield of any crop is the result of the positive relationships of most yield components due to nitrogen fertilizer application (Teklu and Hailemariam, 2009; Fana *et al.*, 2012; Haile *et al.*, 2012; Gerba *et al.*, 2013). The solicitation of N at the rate of 20.5 kg N/ha resulted in highest grain yield, which was significantly higher than N applied at the rates of 10.25, 41 and 60.5 kg/ha.

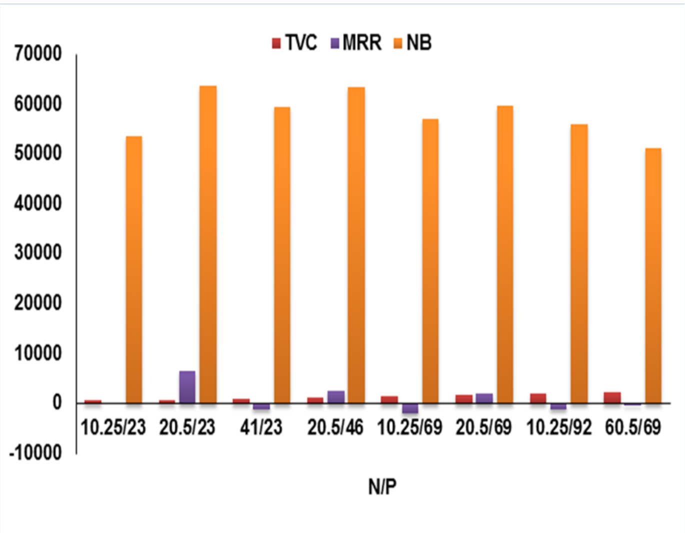

Figure 2. *Graphical presentation of partial budget analysis at Sayda.*

Correlation analysis

Heading date and maturity date, show significant positive correlation and biomass yield and harvest index were significantly negatively correlate at both location. The result revealed that grain yield with harvest index were significantly positively while grain yield with thousand kernel weight correlate non significantly positively at both location. Thousand kernel weight and spike length was correlating no significantly positively correlate and harvest index was strongly and positively correlated with grain yield at both locations. Beside biomass yield was negative non-significantly correlated harvest index at sayada while at Weleh the correlation was significantly negative (Tables 7, 8).

Partial budget analysis

In the present study, the costs for the NP fertilizer rates were considered as variable cost where as other costs were constant for each treatment. In order to recommend the present finding in the study area, it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain. Based on partial budget analysis 20.5/23NP had better than in terms of net benefit (82455.07) and MRR (33.31) than 10.25/46NP which had the net benefit of (69038.41) and MRR (7.24) even though both were situated in the acceptable range at Sayda. At Weleh 10.25/46 NP fertilizer rate had highest MRR (55.34) and lowest net benefit (68404), while 20.5/23NP had the highest net benefit(84355.07) but its MRR was lower as compared to 10.25/46 NP fertilizer rate (Figure 2; Tables 9 and 10).

Conclusion

The result of this study clearly indicates that using a different NP rate of fertilizer had no significant effect on the number of total and effective tillers in both locations. Similarly, at Sayda, different rate of nitrogen and phosphorus fertilizers did not show a significant effect on biomass yield, Straw yield, and grain Yield. While phenological parameters , and yield-related attributes were significantly affected by both main effects of nitrogen and phosphorus fertilizer. At Weleh Harvest, the index was significantly affected by the interaction of nitrogen and phosphorous fertilizers. Moreover numbers of kernels per spike and grain yield were significantly affected by nitrogen fertilizer application. Generally, application of the different rate of nitrogen fertilizer was affected grain yield and yield related traits. Therefore, from this finding, it is possible to conclude that 20.5 N kg ha^{-1} with 23 kg ha^{-1} phosphorous fertilizer rate was better in terms of attainable yield and net benefit as compared to the blanket recommendation and other treatment combinations. Therefore, based on the above data most parameters and grain yield were statically significantly affected by main effect of nitrogen as well as main effect of phosphorous fertilizer and their interaction at Weleh where as at sayada grain yield was not significantly affected by both main effect of nitrogen and phosphorus fertilizer. Therefore, from this finding, it is possible to recommend that 20.5 N kg ha^{-1} with 23 kg ha^{-1} phosphorous fertilizer rate is an appropriate and economically feasible for Sekota -1 variety in the study area and similar agro-ecologies. However, this finding was based on the one-year data or environment so it is better to repeat on wider temporal and spatial scale for a better result.

Conflict of interest

On behalf of all co-authors, the corresponding author declare that there is no conflict of interest in this paper.

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