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Response of bread wheat to different levels of Urea and NPS fertilizer on Andosols, Dugda, Ethiopia

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Abstract

The response of bread wheat to different rates of NPS fertilizer on at Dugda for two years on farmers field was conducted to determine optimum blended fertilizer rate and asses economic feasibility of different blend fertilizers rate for bread wheat. There was no significant difference observed to the different rates of Urea and NPS fertilizers applied when analyzed separately. However, the over location analysis (off all farmers) showed that the grain yield of wheat was significantly affected by the application of different rates of urea and NPS fertilizers. Hence the maximum grain yield of wheat was obtained at the maximum application of 300 kg of urea and 250 kg ha-^{1}of NPS (4341.2kg/ha) over location. The application of 100kg/ha urea+200kg/ha NPS, 100kg/ha urea+250kg/ha NPS, 200kg/ha urea+150kg/ha NPS under balanced fertilization rates were significantly high yield as compared to the agronomic control at P< 0.05 level. Other traits like TKW and above ground biomass was not affected by the application of different rates of Urea and NPS fertilizers. The lowest grain yield of wheat was observed from the plot with no externally applied fertilizer. The application of 138Nkg and 95P_2O_5 kg ha^{-1}fertilizers provided the highest net benefit (69,590.7 ETB ha^{-1}) with a marginal rate of the return (MRR) of 120.51 %. However, the application of 46Nkg and 38P_2O_5kg ha^{-1} fertilizers provided the highest MRR of 563% with (60,538.3 ETB ha^{-1}). These results are greater than the minimum acceptable rate of return (MARR) =100 (CIMMYT, 1988) (Table 4). Hence, for each birr invested in the production of wheat, the farmers could earn birr 1.2 and 5.63 after recovering their cost of production, and these treatments were significantly higher than the agronomic control at P≤ 0.05.

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1. Introduction

Fertilizers application in the right amount, at the time, in right proportion through appropriate methods is important to assure sustainable increase in crop yield. Balanced fertilization is the key to sustainable crop production and maintenance of soil health. It has both economic and environmental consideration. In Ethiopia, considerable numbers of smallholder farmers have good awareness about the contribution of fertilizer for crop production. In line to that percent fertilized cereal cropland have reached about 50% in 2017/18 main production season which was 9 and 18 % in 1997 and 2007, respectively (CSA, 1997/98; 2007/08; 2017/18). However, the yield increase in the past decade was not proportion with the increase in fertilizer consumption of the country.

Only limited types of mineral fertilizers (Urea and DAP) were used in the last decades. Recently acquired soil inventory data revealed widespread deficiencies of different nutrients. Deficiencies of nitrogen was documented on about 86% of the cultivated land, phosphorus on 99%, sulfur on 92%, born on 65% and zinc on 53% (Ethio-SIS, 2016). It is well known that continuous application of nitrogen and phosphorus fertilizers with no application of other nutrients leads to depletion of other important nutrient elements such as to the secondary macro-nutrient and micro-nutrients in soils (Abiye*et al*., 2004 and Bereket*et al.,* 2011). Currently several combinations of blended fertilizers which include vital elements such as N, P, K, S, B, Zn, Fe and Cu are available for different agro-ecologies of the country (EthioSIS, 2013). NPS (19 N - 38 P_2O_5 – 0.0 K_2O + 7S + 0.0 Zn + 0.0 B) is among other important blended fertilizers recommend to the study area, Dugda district. However, information is lacking on the NPS blended fertilizer application rate for yield of wheat production in different AEZ and soil types in Ethiopia.

Wheat is worldwide most important cereal crops for food and nutrition security and its production area coverage is well expanding including to the lowland areas of the country (CSA, xxxx). The demand for wheat is projected to significantly increase with a rapidly increasing population growth in the country. The national average grain yield of wheat showed gap of 61%, 55% and 46% as compared the actual yield at research station, farmers' plot and potential yield at highland part of the country, respectively was documented for wheat as compared the was compared with that of the actual yield at research (Zegeye, F., *et al. 2020*). Fertilizers constitute an integral part of improved crop production technology. Therefore, this experiment was designed to investigate response of bread wheat to NPS and Urea fertilizers to determine economic optimum NPS and urea fertilizer rates for wheat production Dugda areas.

2. Design and treatments

The experiment was set in RCBD by varying levels of urea and NPS fertilizer (0, 100, 150, 200, 250 kg ha-1), and Urea (0, 100, 200, 300 kg ha-1) with three replications. The size of each experimental gross plot was 3.0 m * 3.0 m (9 m2). The bread wheat variety used for the experiment was kingbird. Both fertilizers which varied depending on treatments were applied as side banding at sowing time, urea was applied two times in split half at planting and the remaining at 35 days after planting, the other agronomic practices were kept uniform for all treatments.

2.1 Yield data collection

Plant height, number of spikes per 50cm, spike length, number of seed per spike, grain yield, above ground biomass, and thousand seed grain weight were collected from plants sampled from each plot. Grain and above ground biomass yield were analyzed gravimetrically by using sensitive balance and recorded in units of gram.

2.2 Partial budget Analysis

Partial budget analysis was performed to investigate the economic feasibility of the treatments after checking for the presence of a significant difference in the mean adjusted grain yields of Wheat among the treatments. Dominance and marginal analyses were performed. The average yields were adjusted downwards by 10%, to reflect the difference between the experimental plot yield and the yield farmers expect from the same treatment.

The average open market prices for wheat (20.00 ETB kg^{-1}), for TSP (17.00 ETB kg^{-1}), Urea (14.00 ETB kg^{-1}). Accordingly, fertilizer inputs were considered as variable costs and all others were considered as constant factors for all treatments. The minimum acceptable marginal rate of return (MRR) was set at 100% based on the suggestion by CIMMYT (1988).

3. Materials methods

Descriptions of the study area

The study was conducted in the district of Oromia regional State, Dugda Bora, located in East Shewa zone. East Shewa zone occupies central part of Oromia region and the study areas are located between 8001'to 8025'N Latitude and 38032' to 39004'E Longitude. The study area of Dugda district lie within sub-tropical agro climatic zone locally named as *Badda Dare* or *Woina Dega*, with temperatures ranging between 15 and 20^{O}C and rainfall of 700 to 800 mm. Most parts of the districts are covered by subtropical grassland (OPDEDEZ, 2003).

The East Shewa zone is the most densely populated zone with 128 person/km^2, although the population density of Oromia Regional State is 56 persons/km^2 (OPDEDEZ, 1999). The soils of the zone include Andosols (36.47%), Vertisols (16.12%), Kastenozems and Phaeozomes (22.94%) and Fluvisols (2.05%) (OPDEDEZ, 1999). The major reliefs of the east Shewa Zone are the Rift Valley (the floor and the escarpments), the northwestern and northeastern highlands as well as isolated cinder cones. The rift valley is the most prominent feature of the zone. Concerning climate of the zone, the mean annual temperature ranges from 15 to 27ºC, while the mean annual rainfall is between 410 and 820 mm with marked seasonal variability from year to year (OPDEDEZ, 1999). An average of 763 mm rainfall was recorded at Melkassa (MARC, 1997). Agro-ecologically, seventy per cent of the Zone is *Badda Dare* or *Woina Dega* with altitude ranging from 1500 to

2300 m.a.s.l and average temperatures of 15 to 23°C (OPDEDEZ, 1999). In east Shewa zone, the floor of the rift valley is by large associated with high annual water deficit (750 to1000mm) (OPDEDEZ, 1999).

Land use and land cover patterns of the zone are classified into intensively to moderately cultivated lands (39.09%), forest (1.35%), woodland, bush land and shrub lands (7.78%), grassland (11.49%), water bodies (8%), others (mountain, gorges, swamps, marshes and residential areas (32.29%) (OPDEDEZ, 1999).

4. Result and discussion

There was no significant difference observed to the different rates of Urea and NPS fertilizers applied when yield and yield components of wheat was analyzed separately. However, the pooled mean analysis of variance across locations showed in Table 3 that, above gowned biomass (AGB) and thousand kernel weight (TKW) were not significantly affected by the application of different rates of urea and NPS as compared to the agronomic control at $P \leq 0.05$ level. Adjusted grain yield (AGY) of wheat significantly increased by the application of different rates of urea and NPS at balanced fertilization as compared to the agronomic control (69N kg and $46P_2O_5$ kg ha^{-1}). Statistically significant highest grain yield 4341.2 $kgha^{-1}$ was obtained from the application of 300kg/ha urea+250kg/ha NPS fertilizers and this rate was not significantly different from 100kg Urea and 100 kg NPS at $P \leq 0.05$ level at Dugda. The application of 100kg/ha urea+200kg/ha NPS, 100kg/ha urea+250kg/ha NPS, 200kg/ha urea+150kg/ha NPS under balanced fertilization rates were significantly high yield as compared to the agronomic control at $P < 0.05$ level.

Table 1. Mean Above ground biomass, adjusted grain yield and thousand kernel weight of wheat as influenced by the application of Urea and NPS fertilizers combined across locations

(Farmer 1)

Treatment	Ph	Spkl	SPKLTS	SW	BM	GY
100kg/haurea+100kg/ha NPS	89.067	8.4000	14.60	8.500	10956	3311.3
100kg/haurea+150kg/ha NPS	93.867	8.0667	13.20	8.053	12222	3635.8
100kg/haurea+200kg/ha NPS	95.267	7.8333	13.60	8.333	11911	3694.4
100kg/haurea+250kg/ha NPS	91.733	8.0333	13.80	8.400	10911	3459.9
200 kg/haurea+100kg/ha NPS	93.133	7.2667	14.00	8.733	12000	3774.4
200kg/haurea+150kg/ha NPS	95.067	7.9667	13.47	7.833	13578	4085.8
200kg/haurea+200kg/ha NPS	92.000	7.4000	13.47	7.800	11689	3782.6
200kg/haurea+250kg/ha NPS	92.133	7.1667	13.53	8.266	11400	3515.0
300kg/haurea+100kg/ha NPS	90.867	7.9667	13.13	8.200	12511	3159.8
300kg/haurea+150kg/ha NPS	91.133	7.0667	13.27	8.000	13067	3714.6
300kg/haurea+200kg/ha NPS	89.267	7.2667	13.20	6.930	13478	3672.8
300kg/ha urea+250kg/ha NPS	95.667	7.1667	13.60	8.600	14067	4528.0
Rec. N&P rates (150 kg N+100kg P)	85.000	7.9667	13.067	8.166	9844	2974.9
Control (No fertilizer)	82.800	8.3333	12.48	7.400	8556	2527.1
CV	7.04	10.64	7.37	9.17	21.21	23.65
LSD	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2. Mean Above ground biomass, adjusted grain yield and thousand kernel weight of wheat as influenced by the application of Urea and NPS fertilizers combined across locations

(Farmer 2)

Treatment	Ph	Spkl	SPKLTS/ spk	SW	BM	GY
100kg/haurea+100kg/ha NPS	96.66	8.800	15.533	7.266	13667	3740.0
100kg/haurea+150kg/ha NPS	91.00	8.866	14.267	8.000	10733	2743.3
100kg/haurea+200kg/ha NPS	96.00	9.333	14.933	8.166	15156	4095.6
100kg/haurea+250kg/ha NPS	97.66	9.333	15.333	7.500	15067	4173.3
200 kg/haurea+100kg/ha NPS	92.00	8.866	14.333	6.800	10200	3094.4
200kg/haurea+150kg/ha NPS	92.33	8.800	14.800	7.300	11933	3806.7
200kg/haurea+200kg/ha NPS	95.00	9.333	14.333	6.933	13178	3010.0
200kg/haurea+250kg/ha NPS	99.66	8.733	14.800	7.766	11244	3282.2
300kg/haurea+100kg/ha NPS	97.33	9.266	14.533	7.166	12844	3082.2
300kg/haurea+150kg/ha NPS	97.00	9.066	14.933	6.766	12044	3461.1
300kg/haurea+200kg/ha NPS	97.00	9.200	14.800	7.833	13089	3298.9
300kg/ha urea+250kg/ha NPS	94.66	9.200	14.000	7.833	14444	4154.4
Rec. N&P rates (150kg N+100kgP)	94.00	8.400	13.600	7.966	11178	2962.2
No inputs	82.66	8.400	13.267	7.933	7689	2255.6
CV	6.45	6.38	7.52	12.10	22.57	27.92
LSD	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3. Mean Above ground biomass, adjusted grain yield and thousand kernel weight of wheat as influenced by the application of Urea and NPS fertilizers combined across locations

Treat	AGB	AGY	TKW
100kg/ha urea+100kg/ha NPS	12311	3525.7abc	39.42
100kg/ha urea+150kg/ha NPS	11478	3189.6bcd	40.13
100kg/ha urea+200kg/ha NPS	13533	3895.0ab	41.25
100kg/ha urea+250kg/ha NPS	12989	3816.6ab	39.75
200 kg/ha urea+100kg/ha NPS	11100	3434.4a-d	38.83
200kg/ha urea+150kg/ha NPS	12756	3946.2ab	37.83
200kg/ha urea+200kg/ha NPS	12433	3396.3a-d	36.83
200kg/ha urea+250kg/ha NPS	11322	3398.6a-d	40.08
300kg/ha urea+100kg/ha NPS	12678	3121.0bcd	38.42
300kg/haurea+150kg/ha NPS	12556	3587.8abc	36.92
300kg/haurea+200kg/ha NPS	13283	3485.8a-d	36.91
300kg/ha urea+250kg/ha NPS	14256	4341.2a	41.08
Control (150kg N+100kgP)	9867	2744.7cd	38.42
Control (No Input)	8767	2448.6d	40.25
CV(%)	23.51	26.18	10.49
$LSD_{<0.05}$	ns	1046.3	ns

Partial budget analysis

A partial budget analysis was performed to reveal the superior treatment. The result is given in (Table 4). The application of 138Nkg and 95P_2O_5 kg ha^{-1}fertilizers provided the highest net benefit (69,590.7 ETB ha^{-1}) with a marginal rate of the return (MRR) of 120.51 %. However, the application of 46Nkg and 38P_2O_5kg ha^{-1} fertilizers provided the highest MRR of 563% with (60,538.3 ETB ha^{-1}). These results are greater than the minimum acceptable rate of return (MARR) =100 (CIMMYT, 1988) (Table 4). Hence, for each birr invested in the production of wheat, the farmers could earn birr 1.2 and 5.63 after recovering their cost of production, and these treatments were significantly higher than the agronomic control at P≤ 0.05.

Table 4. Partial budget analysis of the effect of Urea and NPS on Wheat at Dugda

	Treat	AGY	GFB	TC V	N Benefit	MRR%
14	0Nkg 0P_2O_5kg ha^{-1}	2203.74	44074.8	0	44074.8	
1	46Nkg 38P_2O_5kg ha^{-1}	3173.13	63462.6	2924.35	60538.3	562.98
2	46Nkg 57P_2O_5kg ha^{-1}	2870.64	57412.8	3686.52	53726.3D	
13	69Nkg 46P_2O_5kg ha^{-1}	2470.23	49404.6	4040	45364.6D	
5	92Nkg 38P_2O_5kg ha^{-1}	3090.96	61819.2	4504.35	57314.9D	
3	46Nkg 76P_2O_5kg ha^{-1}	3505.5	70110	4568.7	65541.3	304.26
6	92Nkg 57P_2O_5kg ha^{-1}	3551.58	71031.6	5326.52	65705.1	21.61
4	46Nkg 95P_2O_5kg ha^{-1}	3434.94	68698.8	5390.87	63307.9D	
9	138Nkg 38P_2O_5kg ha^{-1}	2808.9	56178	6144.35	50033.7D	
7	92Nkg 76P_2O_5kg ha^{-1}	3056.67	61133.4	6208.7	54924.7D	
10	138Nkg 57P_2O_5kg ha^{-1}	3229.02	64580.4	6966.52	57613.9D	
8	92Nkg 95P_2O_5kg ha^{-1}	3058.74	61174.8	7030.87	54143.9D	
11	138Nkg 76P_2O_5kg ha^{-1}	3137.22	62744.4	7788.7	54955.7D	
12	138Nkg 95P_2O_5kg ha^{-1}	3907.08	78141.6	8550.87	69590.7	120.51

NB: AGY=Adjusted grain yield, GFB= Growth field benefit, MRR= Marginal rate of return, N. Benefit= Net benefit, TCV=Total variable cost

MMRR=Minimum marginal rate of return should be = 100%

Conclusion

To enhance wheat production and productivity, further investigation on the rate of Urea and NPS fertilizers on the representative soil and agro ecology by far required.

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