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Response of Malt Barley to NPSB and Urea Fertilizers Across Soil Types and Agro-Ecologies, Arsi Zone of Oromia, South-Eastern Ethiopia

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ABSTRACT

The Experiments were conducted in 2017 - 2019 cropping seasons on farmers' fields to determine optimum NPSB and urea fertilizers rate for Malt barley crop, and to assess economic feasibility of NPSB and urea fertilizers rate by using four levels of NPSB (0, 100, 150, 200, 250 kg ha^{-1}),with three level urea (0, 100, 150, 200 kg ha^{-1}) and recommended NP in combined RCBD with three replications on yield and yield components of malt barley. The soil analysis result of experimental sites at post-harvest showed, the application of treatments significantly ($p < 0.05$ and $p < 0.001$) affected pH, total N, and organic matter for samples taken from experimental sites of malt barley crop. Due to the application of different fertilizer levelsa significant improvement was observed in soil chemical contents compared to the contents of the soil before treatment application Lemu-Bilbilo district. Combined levels of NPSB and urea fertilizers rates was significantly affected grain and biomass yields at Lemu-Bilbilo and Kofele districts. The maximum grain and biomass yield (5881 and 9813 kg ha^{-1}) in 2017 and minimum (3092 and 6482 kg ha^{-1}) of malt barley in 2018 cropping season were obtained, respectively, at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (5159 and 9976 kg ha^{-1}) were obtained from the application of 250, 150 kg ha^{-1} NPSB, urea respectively. The highest grain and above ground biomass yield (5349 and 10887 kg ha^{-1}) in 2019 and 2017, and lowest (4042 and 6103 kg ha^{-1}) in 2017 and 2018 cropping season were obtained, respectively at Kofele district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (4806 and 10119 kg ha^{-1}) were obtained from the application of 250, 150 and 250, 200 kg ha^{-1} NPSB,urea, respectively.

Keywords: Experiment; NPSB and UREA Fertilizers; Malt Barley

Introduction

Barley (Hordeum vulgare) is a very important grain which ranks fourth in both quantity produced and in area of cultivation of cereal crops in the world. The annual world harvest of barley in the late century was approximately 140 million tons from about 55 million ha. It is very versatile in every way and has well adapted through its evolution. The second largest use of barley is for malt. Barley is the primary cereal used in production of malt. Historically this may have resulted from its availability compared to that of other cereals, but there are several sound reasons for its use (Zhou MX [1]). It is a cool-season crop that is adapted to high altitudes, and grown in a wide range of agro-climatic regions under several production systems (Bekele B, et al. [2]). In Ethiopia barley is the major cereal crop grown by subsistence farmers in the highlands above 1800 m mainly under rainfed conditions with minimum or no external inputs (Ejigu [3]). Barley is produced mainly for human consumption and is one of the most important staple food crops. Barley straw is a good source of animal feed, especially during the dry season. It is also a useful material for thatching roofs of houses and for use as beddings (Grando, Macpherson [4]).

Efforts have been made so far to generate improved production technologies however, productivity of barley in production fields has remained very low in Ethiopia, which is 1.96 t ha^{-1} compared with the world average of 2.95 t ha^{-1} (CSA and USAD [5,6]). This is primarily due to the low yielding ability of farmers' cultivars, which are the dominant varieties in use; the influence of several biotic and abiotic stresses; and the minimal promotion of improved barley production technologies. Several abiotic and biotic factors have contributed to this low productivity, such as poor crop management practices; the use of low yielding cultivars; the limited availability of the very few improved cultivars released; weeds, insects and diseases; and the inherently low yield potential of the prevalent local varieties (Bayeh, et al. [7]). Several researches have been conducted on high land areas of Ethiopia, like Bale, Arsi, Gojam, and central part of the country, there are as yet much barley producing highland areas starving of new technology, including improved varieties and appropriate rate of fertilizer (Wakene et al. [8]). Barley farmers in Ethiopia have not fully adopted modern inputs like fertilizer and modern seeds that help boost production (CSA, [9]). Sustaining soil and soil fertility in intensive cropping systems for higher yields and better quality can be achieved through optimum levels of fertilizer application. Thus, information on soil fertility status and crop response to different soil fertility management is very crucial to come up with profitable and sustainable crop production (Shahnaj et al., [10]).

In most regions of Ethiopia, soils are deficient in nitrogen and phosphorus, this aggravated by the long history of cultivation without any NP replenishment, which led to low soil fertility and low crop yields (Taye G, et al. [11]). Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen, phosphorus, sulfur, born and zinc are widespread in Ethiopian soils and similarly in the study area (EthioSIS, [12]). However, information on the application rate of blended fertilizer and urea was not determined for the study areas. As a result, this experiment was designed to investigate the response of malt barley to NPSB and Urea fertilizers with the specific objective of determine optimum NPSB and urea fertilizer rates for malt barley crop, soil, and climatic conditions.

Materials and Methods

Area Descriptions

The experiment was carried out on farmers' fields and research stations for three cropping seasons during 2017-2019 at Lemu-Bilbilo and Kofele districts in Arsi zone of Oromia, South-eastern Ethiopia. Geographically, the study area is located between 07^0 36' 870" to 07^0 27' 530" N, and 039^0 14' 270" to 039^0 15' 133" E with an elevation ranging from 2526-2873 meters above sea level at Lemu-Bilbilo; and 07^0 56' 648"N latitude, 38^0 47' 584"E longitude at altitude of 2662 meters above sea level at Kofele district. The average weather data recorded on the weather station located near the study areas from the years 2017 - 2019 indicate that the total annual rainfall for Lemu-Bilbilo district were 956.6, 803.5 and 990.6 mm respectively, and the annual mean minimum and maximum daily air temperature for the consecutive years were (4.7, 2.9, 3.3 ^{0}C) and (18.5, 20.3, 20.5 ^{0}C) respectively.

Design and Treatments

The experiment was set in combined RCBD by varying levels of NPSB fertilizer (0, 100, 150, 200, 250 kg ha^{-1}), and Urea (0, 100, 150, 200 kg ha^{-1}) with three replications. The size of each experimental gross plot was 2.6 m * 4 m (10.4 m^2). The malt barley variety used for the experiment at both locations was Ibon. 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.

Soil Sampling and Analysis

Before and after harvesting, surface soil (0 - 20 cm depth) was collected from the entire experimental field. The soil was air dried every day and finely ground with a mortar and pestle. The fined soil was sieved through a 2mm sieve, and the pH, Available P, Total N, and Organic matter of the soil were determined at the Kulumsa Agricultural soil Laboratory. A pH meter was used to measure soil pH (H_2O) in a 1:2.5 soil:water ratio. The Walkley-Black wet oxidation method was used to determine soil organic carbon. The micro-Kjeldahl digestion, distillation, and titration method was used to estimate total nitrogen, and the standard Olsen extraction method was used to determine available P. Accordingly, The soil analysis result before planting at Lemu-Bilbilo and Kofele districts indicated that the pH value were 5.64 (moderate) and 5.89 (moderate) (Foth and Ellis, 1997), available phosphorus were 11.35 ppm (high) and 8.19 ppm (medium), (Olsen et al., 1954), total N were 0.26 % (high) and 0.20 % (medium),and Organic matter 5.55 % (high) and 4.92 % (high), (Berhanu, 1982), respectively (Table 1).

Table 1: Mean value of some selected soil chemical properties selected from the experimental sites before planting at Lemu-Bilbilo and Kofele districts.

Location	pH (1:2.5)	Av.P (ppm)	Total N (%)	OC (%)	OM (%)
Lemu-Bilbilo	5.64	11.35	0.26	3.22	5.55
Kofele	5.89	8.19	0.2	2.85	4.92

Yield and Yield Component Data Collection

Data of grain yield, above ground biomass, and thousand seed grain weight and hectoliter weight were collected from each plot. Grain and biomass yield and were analyzed gravimetrically by using sensitive balance and recorded in units of gram.

Statistical Analysis

The ANOVA procedure of statistical analysis system (SAS Institute, [13]) was used for performing the significance of differences in grain and above ground biomass yield parameters. A post hoc separation of means was done by least significant difference (LSD) test after main effects was found significant at $P<0.05$ [14-17].

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Results and Discussions

Soil Chemical Properties of the Study Area Before and After Planting

The soil analysis results of experimental sites at harvest revealed that the application of treatments significantly ($p < 0.05$ and $p < 0.001$) affected pH, total N, and organic matter for samples taken from experimental sites of malt barley crop. Different fertilizer levels had significant effects on post-harvest pH and organic carbon content. There were no significant variations in P values among fertilizer-treated malt barley fields. At the Lemu-Bilbilo district, soil chemical contents improved significantly when compared to those before treatment application (Tables 1 & 2).

Table 2: Selected Soil chemical properties after harvesting of malt barley at Lemu-Bilbilo district.

Treatments		pH (1:2.5)	AvP (ppm)	Total N (%)	OC (%)	OM (%)
NPSB (kg ha^{-1})	Urea (kg ha^{-1})					
0	0	5.68	18.36	0.27	3.46	5.96
100	100	5.66	20.39	0.3	3.31	5.71
100	150	5.61	20.44	0.26	3.18	5.48
100	200	5.72	21.9	0.24	3.63	6.26
150	100	5.71	18.8	0.28	3.47	5.98
150	150	5.8	21.16	0.27	3.43	5.91
150	200	5.62	20.52	0.26	3.69	6.36
200	100	5.61	18.33	0.29	3.4	5.98
200	150	5.66	18.93	0.29	3.42	5.9
200	200	5.68	20.43	0.28	3.5	6.04
250	100	5.75	18.95	0.3	3.76	6.48
250	150	5.51	20.78	0.29	3.4	5.86
250	200	5.5	22.21	0.29	3.46	5.96
Mean		5.65	20.09	0.28	3.47	5.99
F-prob.		***	ns	***	*	*
$LSD_{0.05}$		0.12	2.77	0.02	0.31	0.53
CV (%)		1.79	11.96	7.36	7.72	7.62

Note: *, *** = significant at $p < 0.05$, and $p < 0.001$; ns = not significant.

Effect of NPSB and Urea Fertilizers on Grain and Biomass Yield of Malt Barley

The maximum grain and biomass yield (5881 and 9813 kg ha^{-1}) in 2017 and minimum (3092 and 6482 kg ha^{-1}) of malt barley in 2018 cropping season were obtained, respectively at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (5159 and 9976 kg ha^{-1}) were obtained from the application of 250 + 150 kg ha^{-1} NPSB + urea respectively (Table 3). The highest grain and biomass yield (5349 and 10887 kg ha^{-1}) in 2019 and 2017, and lowest (4042 and 6103 kg ha^{-1}) in 2017 and 2018 cropping season were obtained, respectively at Kofele district up on the application of NPSB and urea fertilizers. Similarly, significant grain and biomass yield (4806 and 10119 kg ha^{-1}) were obtained from the application of (250, 150) and (250, 200) kg ha^{-1} NPSB and urea, respectively (Table 3). The mean Maximum value of harvest index (49.4 %) in 2018, HLW and thousand seed weight (69.7ghL^{-1}, 50.5 g) in 2017, and mean minimum (47.6 %, 60.7 ghL-1) in 2019, and (41.3 g) in 2018 cropping season of malt barley were obtained, respectively at Lemu-Bilbilo district with application of NPSB and urea fertilizers. Similarly, significantly different result of harvest index (51.1 %), at the control, HLW (65.4 ghL^{-1}), with the application of (100, 100), (250, 150), (250, 150), and thousand seed weight (47.5 g) with the application of (250, 200) kg ha^{-1} NPSB and urea were obtained, respectively (Table 4). The greatest value of harvest index (59.8 %) in 2018, HLW and thousand seed weight (64.8 ghL^{-1}, 46.8 g) 2017, and lowest (38.1 %) in 2017, (57.3 ghL^{-1}) in 2019 and (43.0 g) in 2018 cropping season were obtained, respectively at Kofele district with the application of NPSB and urea fertilizers. Similarly, significantly different value of harvest index (51.4 %), at the control, HLW (61.1 ghL^{-1}) with the application of (200, 150) kg ha^{-1} NPSB and urea, respectively.

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Table 3: Effect of NPSB and urea fertilizers on Grain) and biomass yield of malt barley at Lemu-Bilbilo and Kofele districts.

		Lemu-Bilbilo		Kofele	
Factors		GY (kg ha^{-1})	BY (kg ha^{-1})	GY (kg ha^{-1})	BY (kg ha^{-1})
Year					
2017		5881a	9813a	4042c	10887a
2018		3092c	6482c	3559b	6103c
2019		4816b	9393b	5349a	10080b
LSD (≤0.05)		165.4	345.9	245.8	658.9
Fertilizers rate, kg ha^{-1}					
NPSB	Urea				
0	0	2925g	4802e	3445d	6653d
100	100	4206ef	7431d	4426ab	8837abc
100	150	4789bcd	8745c	4299ab	8711abc
100	200	4940abc	8861bc	3766cd	7985bc
150	100	4138f	7458d	4062bc	8660cd
150	150	4720cd	8716c	4480ab	10098bc
150	200	4688cd	9032bc	4471ab	8922a
200	100	4533de	8631c	4340ab	9625abc
200	150	4748cd	8910bc	4633a	9418ab
200	200	5099ab	9879a	4441ab	9323abc
250	100	4876abcd	9306abc	4296ab	9206abc
250	150	5159a	9976a	4806a	9747ab
250	200	4929abc	9569ab	4650a	10119a
CV(%)		11.4	12.8	12.7	16.3
$LSD_{0.05}$		344.3	720.1	511.7	1371.6

Further, the value of thousand seed weight was not significantly different among the treatments (Table 4). A one year (2019) malt barley study showed that the 100 and 200 kg ha^{-1} NPSB and urea fertilizer rates produced the highest grain and biomass yields (5714 and 10618 kg ha^{-1}, respectively), while the controls and previous recommendations produced the lowest yields (2845 and 4623 kg ha^{-1} and 4319 and 8153 kg ha^{-1}, respectively). Thus, the blanket recommendation has a grain yield advantage (34.1%) over the control and a yield loss of 6.9 to 24.4% over the other remaining treatments in the Lemu-Bilbilo district. Similarly, the application of (100, 100) and (250, 150) kg ha^{-1} NPSB and urea fertilizers showed the highest grain and above ground biomass yields (6087 and 10902 kg ha^{-1}) and the lowest (4591 and 8567 kg ha^{-1}) yields (4591 and 8567 kg ha^{-1}). Thus, the blanket recommendations resulted in a grain yield loss (1.9 to 4.5%) compared to the other remaining treatments in the Kofele district (Table 5).

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Table 4: Effect of NPSB and urea fertilizers on Harvest index hectoliter weight and thousand seed weight of malt barley at Lemu-Bilbilo and Kofele districts.

		Lemu-Bilbilo			Kofele		
Factors		HI (%)	HLW (gm hL^{-1})	TKW (gm)	HI (%)	HLW (gm hL^{-1})	TKW (gm)
Year							
2017		48.7ab	69.7a	50.5a	38.1c	64.8a	46.8a
2018		49.4a	63.7b	41.3c	59.8a	58b	43c
2019		47.6b	60.7c	47.4b	49.8b	57.3b	44.8b
$LSD_{0.05}$		1.3	6.0	1.0	1.8	0.7	0.9
Fertilizers rate, kg ha^{-1}							
NPSB	Urea						
0	0	51.1a	64.7ab	46.2ab	51.4a	60.3abc	44.3
100	100	50.5ab	65.4a	45.3b	50.7ab	60.3abc	45.9
100	150	48.8abc	64.7ab	47.1ab	49.5abc	60.7ab	45.5
100	200	48.6abc	64.5ab	45.9ab	48.8abc	60.4abc	45.6
150	100	48.3bc	63.7b	45.5ab	49.7abc	59.5bc	44.1
150	150	48.8abc	64.3ab	45.5ab	46.9cabc	60.3abc	44.9
150	200	47.1c	64.7ab	46ab	49.9abc	60.1abc	44.4
200	100	48.1bc	64.3ab	46.4ab	48.6abc	60abc	45.1
200	150	48.5abc	65.4a	46.9ab	50abc	61.1a	45.6
200	200	47.2c	64.6ab	46.7ab	49.4abc	60.1abc	44.2
250	100	48.1bc	64.5ab	47ab	47.1bc	59c	44.1
250	150	47.7c	65.4a	47.2ab	49.8abc	59.1c	44.5
250	200	48.5abc	65.1a	47.5a	48.1abc	59.7abc	44.9
CV(%)		8.5	3.0	6.62	8.1	2.6	4.6
$LSD_{0.05}$		2.7	1.3	2.0	3.7	1.5	Ns

Table 5: Effect of NPSB and urea fertilizers on yield and yield related/component of malt barley at Lemu Bilbilo and Kofele districts (2019 cropping season).

Fertilizer rate, kg ha^{-1}		Lemu-Bilbilo			Kofele		
NPSB	Urea	GY (kg ha^{-1})	BY (kg ha^{-1})	HI (%)	GY (kg ha^{-1})	BY (kg ha^{-1})	HI (%)
0	0	2845f	4623e	52.5a	5110cdefg	9718abcd	49.6abc
100	100	4856bcde	8387bcd	50.9ab	6087a	10723a	51.3ab
100	150	5346ab	10067a	47.5bcd	4591g	8567d	51ab
100	200	5714a	10514a	47.5bcd	4847fg	9031cd	50.1abc
150	100	4247e	7815d	48.9abc	5573abcde	10674a	49.5abc
150	150	5041abc	9741a	49abc	5439abcdef	10431ab	48.7abc
150	200	5019bc	10326a	45.6cde	5749abc	10530a	51.1ab
200	100	4637cde	9236abcd	47.8bcd	4966defg	9123bcd	50.6abc
200	150	5028abc	9633abc	47.7bcd	5925a	10072abc	52.3a
200	200	4918bcde	10532a	43.7e	5557abcde	11036a	47.1c
250	100	5022abc	10451a	46cde	5175bcdef	10469ab	49.2abc
250	150	5104abc	10618a	45.1de	5602abcd	10902a	48.1bc

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250	200	4952bcd	10320a	46.3cde	4912efg	9760abcd	48.8abc
RNP		4319de	8153a	49.2abc	5812ab	10050abc	51.4ab
Mean		4789	9315	47.7	5382	10077	49.9
CV(%)		12.6	14.3	6.7	7.4	8.3	4.5
$LSD_{0.05}$		693.2	1535.5	3.7	667	1393.1	3.7

Note: RNP = Recommended Nitrogen and Phosphorus

Conclusions and Recommendations

The soil analysis result of experimental sites at post-harvest showed that, the application of treatments significantly ($p < 0.05$ and $p < 0.001$) affected pH, total N, and organic matter for samples taken from experimental sites of malt barley crop. Application of different fertilizer levels had significant effects on post-harvest pH and organic carbon contents. Significant differences in P values were not observed among fertilizer level treated plots of malt barley. A significant improvement was observed in soil chemical contents compared to the contents of the soil before treatment application at Lemu-Bilbilo district. Maximum grain and biomass yield (5881 and 9813 kg ha^{-1}) in 2017 and minimum (3092 and 6482 kg ha^{-1}) of malt barley in 2018 cropping season were obtained, respectively at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant grain and biomass yield (5159 and 9976 kg ha^{-1}) were obtained from the application of 250 + 150 kg ha^{-1} NPSB + urea respectively. The highest grain and biomass yield (5349 and 10887 kg ha^{-1}) in 2019 and 2017, and lowest (4042 and 6103 kg ha^{-1}) in 2017 and 2018 cropping season were obtained, respectively at Kofele district up on the application of NPSB and urea fertilizers. Similarly, significant grain and biomass yield (4806 and 10119 kg ha^{-1}) were obtained from the application of 250 + 150 and 250 + 200 kg ha^{-1} NPSB + urea, respectively.

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