Advances in Crop Science and Technology
ISSN: 2329-8863
Workineh, Adv Crop Sci Tech 2024, 12:9
Research Article Open Access

Evaluating Blended Fertilizers Response of Malt Barley Grown In the Vertisols Areas of South Tigray, Ethiopia

Assefa Workineh*

Tigray Agricultural Research Institute, Alamata Agricultural Research Center, Ethiopia

Abstract

Study on the effect of different bended fertilizers level on malt barley was conducted in 2018 and 2019 cropping season on vertisols of Ofla, Enda-Mehoni and Emba-Alaje districts of Tigray, Ethiopia with the objective of determining the optimum blended fertilization for malt barley production. The experiment contained randomized complete block design with seven level of blended fertilizer (0, 50, 100, 150, 200, 250 and 300 kg NPSZnB ha-1) and replicated three times. The analysis of variance for grain yield indicate that effects of NPSZnB blended fertilizer were significance (P<0.05) for grain yield. Significantly more grain yields (3.67 and 4.17 t ha-1) with higher economic return were obtained from application of 150 kg NPSZnB ha-1 in Adigolo and Mekan areas respectively. More over higher grain yield of 3.51 t ha-1 with economic return was obtained at Atsela districts from the application of 100 kg of NPSZnB ha-1 blended fertilizer. Hence application of 150 kg NPSZnBha-1 blended fertilizer are agronomical and economical optimum level for Adigolo and Mekan districts and 100 kg NPSZnBha-1 of blended fertilizer for Atsela and other similar agro ecologies. Even if there is significance effect of blended fertilizer on grain yield of malt barley, the maximum grain yield obtained is not the potential of the variety, hence integration of blended and nitrogen fertilizer is further research directions to boost the grain yield with brewing quality attributes in malt barley.

Keywords: Malt barley; Blended fertilizer; Grain yield

Introduction

Barley *(Hordeum vulgare L.)* is an important cereal crop grown worldwide for not only food and feed but it is also used as a raw material for the malting process to produce beer or other alcoholic beverages (Henry, 1989; Celus et al., 2006). It is a cool-season crop with a wide range of adaptation grow but well at an altitude of about 3,000 m above sea level or above. It provides food, homemade drinks, animal feed, cash and other necessities to many millions of people (Berhanu et al., 2005; Mulatu and Lakew, 2011). In Ethiopia, there is significant opportunity for the production of malting barley and can be one of the major sources of income for smallholder farmers due to the booming demand for malt following the expansion of breweries (Mohammed and Legesse, 2003) [1].

The profitability of malting barley is influenced largely by the grain yield, which in turn depends on a number of factors including differences in cultivar, farming conditions, soil and climate (Fathiet et al., 1997). Though, grain yield of malt barley are increasing, during the past decades, barley yields in Ethiopia have averaged 2.5 t ha^{-1}(CSA, 2020), which is quite low compared to the world average (2.95 t ha^{-1}, which is still less than half of barley yields in the two best performing African countries of Kenya (3.26 t ha^{-1}) and South Africa (2.93 t ha^{-1}), and well below yields in the highest-performing countries, such as France, Germany and the Netherlands, with average barley yields over 6.0 t ha-1 (FAOSTAT, 2018).

Agriculture in Ethiopia is characterized by low productivity, mainly caused by low soil fertility and absence of efficient, sustainable and site specific soil fertility management practices (Abushet al., 2011). Fertilizer use on food and malting barley is the lowest than among all cereal crops, which is only 48.3% of the total area of land covered by barley compared to Teff, Wheat, and Maize receiving fertilizer on 59.7%, 69.1%, and 56.3% of their total land area, respectively (CSA 2010). In addition in the past decades, Ethiopian agriculture depended solely on imported fertilizer products namely urea and di-ammonium phosphate which are source of N and P although most Ethiopian soils lack other macro- and micro-nutrients (EthioSIS, 2014) [2]. This may lead to low nutrient uptake efficiency of crops due to low availability or lack of synchrony of maximum growth of crops with adequate availability of the nutrients in the soil. Based on the national soil data base, in addition to the macronutrients, due to long year cultivation, some of the micronutrients like zinc, boron, and copper are depleted from the soil in the major crop producing area of the country (EthioSIS, 2014).

One major impediment to increase fertilizer use efficiency in the country has been lack of information about the fertility status of the agricultural land. Currently, the government and a national land resource have recognized the problem and soil fertility mapping work is undertaken by the EthioSIS project of the Agricultural Transformation Agency (ATA). This initiative has been conducted throughout the country to assess the soil fertility status so that fertilizer recommendations can be based on soil test results [3].

Many research findings have indicated that nutrients like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (ATA, 2013). Most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014). Macronutrients as well as micronutrients are of primary importance in our agriculture system but due to unawareness of the farmers about importance of applying micronutrients and unavailability, the soils are becoming deficient in micronutrients.

***Corresponding author:** Assefa Workineh, Tigray Agricultural Research Institute, Alamata Agricultural Research Center, Ethiopia, E-mail: assefaw.02@gmail.com

Received: 01-Sep-2024, Manuscript No: acst-24-147163, **Editor Assigned:** 04-Sep-2024, pre QC No: acst-24-147163 (PQ), **Reviewed:** 18-Sep-2024, QC No: acst-24-147163, **Revised:** 22-Sep-2024, Manuscript No: acst-24-147163 (R), **Published:** 29-Sep-2024, DOI: 10.4172/2329-8863.1000738

Citation: Workineh A (2024) Evaluating Blended Fertilizers Response of Malt Barley Grown In the Vertisols Areas of South Tigray, Ethiopia. Adv Crop Sci Tech 12: 738.

Citation: Workineh A (2024) Evaluating Blended Fertilizers Response of Malt Barley Grown In the Vertisols Areas of South Tigray, Ethiopia. Adv Crop Sci Tech 12: 738.

However, relatively little information is known and limited recommendations exist about effects of NPSZnB blended fertilizer on malting barley productivity in Ethiopia in general and the Tigray highlands of Ethiopia in particular. Therefore, the aim of this study was to investigate the effects of NPSZnB blended fertilizer rates on the productivity of malting barley in the vertisol areas of southern high lands of Tigray, Ethiopian [4].

Material and Methods

Description of the study area

This study was conducted for two years (2018 & 2019 main cropping season) at Ofla (Adigolo) Enda-Mehoni (Mekan) and Emba-Alaje (Atsela) districts of south Tigray, northern Ethiopia. The study districts receives a bimodal rainfall pattern with the main wet season ('Kiremt') extending from July to September and the small wet season ('Belg') which extends from March to May. The areas are characterized by heavy and erratic rainfall distribution. Adigolo kebelle is located in southern zone of Tigray in Ofla woreda. It located on the geographic coordinates of 12o32'15" N, 39o30'4" E and lies at an altitude of 2450 m.a.s.l. The long mean annual rainfall was 720 mm, while the mean annual rainfall for the study period of 2018 and 2019 was 1070 mm and 820 mm respectively. Similarly, the mean maximum and minimum temperatures were 22.3°C and 7.8°C, respectively [5]. Mekan kebelle is located in southern zone of Tigray in Enda-Mehoni woreda. it is located on the geographic coordinates of 12o44'31" N, 39o31'17"E N and lies at an altitude of 2470 m.a.s.l. The long-term mean annual rainfall was 685 mm, rainfall for the study period of 2018 and 2019 was 838.7 mm and 823.7 mm respectively with the mean maximum and minimum temperatures were 22.4°C and 10.2°C, respectively. Atsela kebelle is located in southern zone of Tigray in Emba-Alaje woreda. It located on the on the geographic coordinates of 39o31'37"E,12o55'21"N, and lies at an altitude of 2490 m.a.s.l. The long term mean annual rainfall was 602 mm, with the mean maximum and minimum temperatures were 22.1 °C and 10.1°C (Figure 1).

The study areas have mixed farming system (crop and livestock) with crop dominating The main crops growing around the experimental areas are Wheat *(Triticum aestivum L.)*, Faba bean *(Vicia faba L.)* Maize *(Zea mays L.)*, barley *(Hordeum vulgare)*, Tef *(Eragrostis tef)* and some oil and vegetable crops.

Experimental design, treatment and procedure

The field experiment consists seven different rate of NPSZnB fertilizer (0, 50, 100, 150, 200, 250, and 300 kg ha^{-1}). The field experiment was laid down in a randomized complete block design with three replications. All experimental unites were treated with a uniform rate of nitrogen fertilizers. Nitrogen fertilizer was applied in two splits, 1/3rd at sowing and 2/3rd after 40 days of sowing. The plot size was 2 m x 3 m (6 m^2) gross size and 1.6 m x 3 m (4.8 m^2) net size and there were 10 rows in each plot. The middle eight rows were used for agronomic data collection and the two rows served as border. The spacing between plants, rows, plots, and blocks were 5, 20, 50, and 150 cm, respectively. An improved malt barley variety known EH1847 was sown by drilling in rows using manual row maker at recommended seed rate of 150 kg ha^{-1} and row spacing of 20 cm and was used as test crop. Plots were kept free of weeds by hand weeding. No insecticide or fungicide was applied since there was no outbreak of insects or diseases. Harvesting was done manually using hand sickle [6].

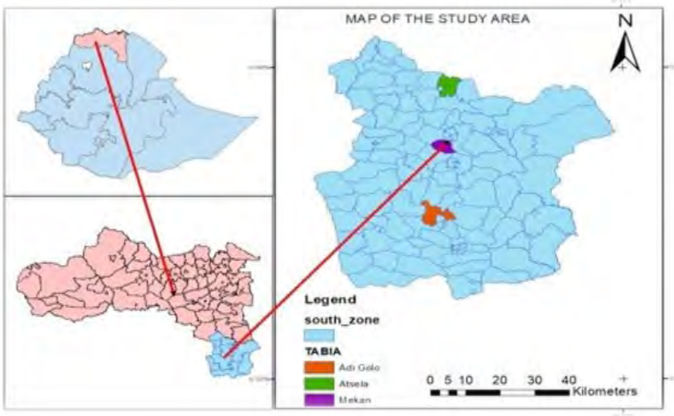

Figure 1: Map of study locations.

Data Collection

Grain yield: Grain yield (kg $plot^{-1}$) was taken from each plots by excluding the border rows and adjusting to 12.5% moisture level and then converted to hectare basis.

Soil sampling, sample preparation and analysis: Five composite disturbed soil samples were collected randomly at the 0–20 cm soil depth from the entire experimental site before imposing any treatment at the beginning of the research period in 2018. The disturbed soil samples were pooled and mixed thoroughly in a basket and a subsample of 500 g was taken for analysis following a standard procedure for soil sampling and sample preparation (Andreas & Berndt-Micheal 2005) [7]. The samples were air-dried, passed through 2 mm sieve and analyzed for texture, organic matter, cation exchange capacity, pH, total nitrogen and available phosphorus using standard methods of physico-chemical analysis. Soil texture was analyzed using the hydrometer method (Bouyoucos,1951). Soil organic matter content was determined by oxidation of organic carbon with acidic potassium di-chromate by the Walkley and Black method (Jacson, 1967). Total nitrogen was analyzed by Micro-Kjeldhal method (Bremner, et al., 1982). Soil pH was determined in 1:2.5 (weight/volume) soils to water dilution ratio using pH meter (Jackson, 1967). CEC was measured after saturating the soil with 1N ammonium acetate (NH4OAC) and displacing it with 1N NaOAC (Chapman, 1965) whereas Av.p was determined using Olsen method (Olsen et al., 1982). The results of soil parameters are described in section 3.1 [8].

Data analysis

The analysis of variance (ANOVA) for the studied variables was computed using the GLM procedure of R software version following the standard procedures of ANOVA for RCB desig). The data were analyzed using R programming software (version 4.0.0) with the updated statistical package R Core Team (2020). Tukey's HSD test (α = 0.05) was used for mean separation when the treatments were significantly different at the 5% level.

Partial budget analysis

A partial budget analysis was used to evaluate the economic benefits of the different blende fertilizer levels based on the grain and straw yields of the crop. In this experiment, we determined the most economically acceptable NPSZnB treatments by estimating the respective costs and benefits based on market prices for 2019. It is common that experimental yields are higher than the yields that farmers can expect using the same treatments (CIMMYT, 1988). Therefore, in the economic calculations, the aboveground straw biomass and grain yield were adjusted to 90% of the actual yield obtained from the experimental plots to represent a more realistic yield in farmers' fields (CIMMYT, 1988). The gross and net benefits were calculated as;

Gross benefit (GB) =yield×Price

Net benefit (NB) =Gross benefit (GB)-total varying cost (VC)

The marginal rate of return (MRR) was calculated by dividing the change in net benefit by the change in variable cost, which is the increase in return by increasing the input. The marginal rate of return was calculated after conducting a simplified dominance analysis (CIMMYT, 1988) to select the treatments that are relevant to farmers in terms of return. A treatment is said to be dominated when increase in costs does not lead to an increase in net benefits. It is dominated because there is at least one other treatment of less or equal cost that gave greater benefits. To perform the economic analysis, the treatments were arranged according to an increasing order of variable costs (VC) and compared with respect to whether increasing costs are followed by a larger increase in net benefits (NB). Blended rertilizer and labor costs were determined based on the current rates of fertilizer in the specific locations.

The cost for the NPSZnB blended and urea fertilizer was 15.81 and 16.5Birr kg^{-1}. The grain and straw yields harvested from the plot were converted to a hectare basis, and the market values of both components were computed based on the 2019 cropping season market prices, with prices of 30 and 1.5 Birr kg^{-1} for grain and straw of barley, respectively.

Result and Discussion

Soil physic chemical properties of the study districts

The mean pH values of the composite surface soil samples of the experimental sites were falls under the slightly neutral soil reaction class (Tekalign, 1991). The soil organic matter (SOM) contents were in the ranges of 1.24-1.99 % on the surface soils thus, these values fall under low to moderate range based on the ratings of soil test values established by Tekalign (1991). Total nitrogen (TN) levels of the study sites ranged between 0.101 and 0.17 % and taken as low for tropical soils (Beyene, 1988) [9]. Moreover, according to Phosphorus rating developed by Olsen et al. (1954), the available phosphorus (Av. P) contents of the soil of the experimental sites fall under the medium phosphorus status. This indicate the low level of fertility status of the soil aggravated by long term cereal based cultivation, lack of incorporation of organic materials in to the soils through mulching or crop residues retention after harvest and frequent tillage. Mono-cropping and inadequate replacement of nutrients removed in harvested materials or loses through erosion and leaching has been the major causes of soil fertility decline (Matson et al., 1998). The electrical conductivity (EC) ranged from 0.019 to 0.16 ds/m indicating that these soils have a low content of soluble salts and that there is no danger of salinity in the study areas (Table 1).

Grain yield of malt barley showed significantly ($P < 0.05$) to the application of different rates of NPSZnB blended fertilizer rate at Adigolo, Mekan and Atsela districts respectively. At Adigolo district of Ofla Woreda, significantly highest mean malt barley grain yield (3.668 t ha^{-1}) was obtained from application of 150kg NPSZnB ha^{-1} blended fertilizer. However, there were not statistically significant difference ($P > 0.05$) compared to the grain yields 3.406, 3.338 & 3.233 t ha^{-1}respectively obtained from the application of 200,250 and 300 kg NPSZnB ha^{-1} blended fertilizer levels respectively. While the least malt barley grain yield (1.75 t ha^{-1}) was obtained from the control plot.

At Mekan testing site, the over year combined grain yield shows that the higher malt barley grain yield (4.301 t ha^{-1}) was obtained with application of 150kg NPSZnB ha^{-1} blended fertilizer, however statistically, there is no also significance different ($P > 0.05$) on grain yield of malt barley with the application of 200 and 250 kg NPSZnB ha-1 blended fertilizer application (Table 2) [10].

Similarly, at Atsela site the combined grain yield of malt barley shows that the higher grain yield of 3.795 t ha^{-1} was obtained from the application of 100kg NPSZnB ha^{-1} blended fertilizer. However statistically, there is no also significance different ($P > 0.05$) on grain yield of malt barley with the treatments of 150,200 and 250 kg NPSZnB ha^{-1}, blended fertilizer applications. While the least malt barley grain yield (1.75 t ha^{-1}) was obtained from the control plot.

Generally in Adigolo and Atsela districts grain yield of malt showed that a linear increase with increasing rate of application of NPSZnB fertilizer (0-150 kg ha^{-1}) to certain level and grain yield show decreasing trend in maximum application of NPSZnB fertilizer (200-300kg ha^{-1}).

Partial budget analysis

In economic analysis, it is assumed that farmers require a minimal rate of return of 100% (CIMMYT, 1988), representing an increase in net return of at least 1 Birr for every 1Birr invested, to be sufficiently motivated to adopt a new agricultural technology. Every shift in

Table 1: Soil Physic-Chemical Properties of the Study Sites.

Soil properties	Ofla (Adigolo)	Emba-Alaje (Atsela)	Enda-Mehoni (Mekan)
pH(1:2.5 H2O)	6.74	7.55	6.87
Available phosphorus(mg P_2O_5/kg soil)	11.00	47.40	35.10
Total nitrogen (%)	0.101	0.17	0.15
OC (%)	1.99	1.36	1.24
Electrical conductivity (ds/m)	0.09	0.16	0.09
Cation exchange capacity (meq/100g of soil)	41.67	40.28	48.85
Exchangeable k (meq k^+/100g of soil)	0.20	1.34	0.55
Exchangeable Na (meq Na^+/100g of soil)	0.66	1.28	0.96
Exchangeable Ca (meq Ca^{+2}/100g of soil)	25.56	27.03	24.17
Exchangeable Mg (meq Mg^{+2}/100g of soil)	8.52	9,59	8.9
Silt (%)	15	24.16	14.84
Sand (%)	25	25.31	30.05
Clay (%)	40	50.53	55.11
Textural class	clay	clay	clay

Table 2: Combined mean grain yield of malt barley.

NPSZnB rate (kg ha^{-1})	Mean grain yield (t ha^{-1}) in 2018 & 2019 cropping season		
	Adi-Golo	Mekan	Atsela
0	1.754d	2.542e	1.924d
50	2.521c	3.281d	3.022c
100	2.812bc	4.179b	3.516ab
150	3.668a	4.301ab	3.795a
200	3.406a	4.53a	3.691a
250	3.338a	4.214ab	3.581ab
300	3.233a	3.634c	3.337bc
LSD (5%)	0.314	0.18	0.304
CV %	9	4.7	5.5

Table 3: Partial budget analysis.

Location	NPSZnB rate (kg ha^{-1})	GY (t ha^{-1})	Adj.GY (t ha^{-1})	TVC (birr ha^{-1})	TR (birr ha^{-1})	NB (birr ha^{-1})	MRR (%)
	0	1.92	1.73	0	38,979.18	38,979.18	
Atsela	50	3.02	2.72	1900	61,224.06	59,324.06	1,070.78
	100	3.52	3.16	3200	71,232.23	68,032.23	669.86
	150	3.8	3.42	4500	76,884.61	72,384.61	334.8
	200	3.17	2.86	5800	64,303.49	58,503.49	D
	250	3.41	3.07	7100	69,165.76	62,065.76	274.02
	300	3.71	3.33	8400	75,061.26	66,661.26	353.5
Adigolo	0	1.754	1.58	0	35535.08	35535.08	
	50	2.521	2.27	1900	51074.07	49174.07	717.84
	100	2.812	2.53	3200	56969.57	53769.57	353.3
	150	3.668	3.3	4500	74311.66	69811.66	1234.01
	200	3.406	3.07	5800	69003.69	63203.69	D
	250	3.338	3	7100	67626.04	60526.04	D
	300	3.233	2.91	8400	65498.8	57098.8	D
Mekan	0	2.542	2.29	0	51499.52	51499.52	
	50	3.281	2.95	1900	66471.26	64571.26	687.99
	100	4.179	3.76	3200	84664.24	81464.24	1299.46
	150	4.301	3.87	4500	87135.89	82635.89	90.13
	200	4.53	4.08	5800	91775.31	85975.31	256.88
	250	4.214	3.79	7100	85373.32	78273.32	D
	300	3.634	3.27	8400	73622.84	65222.84	D

Where: GY=Grain yield, AdJ= Adjusted Grain yield, GY=TVC = Total variable cost, NB = Net benefit, TR = Total Revenue, MRR = Marginal rate of return, D=Dominance

investment of blended fertilizer from the lower selected treatments to higher resulted to more than 100% return..

The partial budget analysis showed the highest net benefits (72,384.61, 69811.66 and 85975.31 birr ha^{-1} from Atsela, Adigolo and Mekan areas respectively) were obtained from the application of 150,150 and 200 kg NPSZnB ha^{-1} blended fertilizer levels. Next to the control, the application of 50 kg NPSZnB ha^{-1} blended fertilizer level gave the lowest net benefits at all locations. Economically viable options depend on a combination of the marginal rate of return and the net benefits [11].

The marginal rates of return for the non-dominated treatments with blended fertilizer application 100 &150 kg NPSZnB ha^{-1} were 669.86 and 334.8%, respectively for Atsela 669.86 and 334.8, 1299 and 90.13 % for Mekan districts respectively. In Adigolo, the marginal rates of return for the non-dominated treatment with blended fertilizer application 100 & 150 kg NPSZnB ha^{-1} was 353.3, 92.5 and 1234.01% respectively. The farmers would thus earn an additional birr 10.7, 6.69 or 3.34 per birr invested from 50,100 and 150 kg NPSZnB ha^{-1} blended fertilizer, respectively in Atsela. Birr 7.17, 3.53 & 12.34 in Adigolo and birr 6.89, 12.99 & 9.01 in Mekan from application of 50, 100 and 150 kg NPSZnB ha^{-1} blended fertilizer respectively. Economically viable options depend on a combination of the marginal rate of return and the net benefits. Based on that, Application of 100 kg NPSZnB ha^{-1} blended fertilizer for Adigolo and 150 kg NPSZnB ha^{-1} for Atsela and Mekan areas are economically viable and could therefore be recommended for use by smallholder farmers (Table 3).

Sensitivity analysis was also done with the assumption of the likely rise in increase of input costs that can vary over time. The results revealed that the MRR values were still in excess of 100% demanding the same recommendations of 150 and 100 kg NPSZnB ha-1 may still work in the future should blended fertilizer price increase. In case If the market value of the variable cost increase by at least 30% with in the coming three years, farmers who make the decision to produce malting barley with application of NPSZnB blended fertilizer at a rate of 150 kg ha^{-1} for Mekan and Adigolo and 100 kg ha^{-1} for Atsela areas respectively, potentially could earn an additional return for every Birr 1.0 investment [12].

Conclusion and Recommendation

Many factors limiting crop yields have been reported by many researchers and the current study showed that application of different NPSZnB blended fertilizer levels were significantly ($P \leq 0.05$) influenced grain yield of malt Barley at Adigolo, Atsela and Mekan districts of Ofla, Enda-Mehoni, and Emba-Alaje Woredas Tigray region respectively.

Application of 150 kg NPSZnB ha^{-1} have sound and promising impact yield of malt barley production and the determined blended fertilizer level reaches argonomically and economically optimum for malt barley production in the at Adigolo and Mekan districts respectively and 100 kg NPSZnB ha^{-1} at Atsela disricts. Even if there is significance effect of blended fertilizer on grain yield of malt barley, the maximum grain yield obtained is not the potential of the variety, hence integration of blended and nitrogen fertilizer is further research directions to boost the grain yield with brewing quality attributes in malt barley.

References

1. Beyene D (1988) Soil fertility research on some Ethiopian Vertisols. In Proceedings of a Conference Held at ILCA on the management of vertisols in Sub-Saharan Africa. 223-231.
2. Bouyoucos GJ (1995) A Recalibration of the Hydrometer Method for Making Mechanical Analysis of Soils 1. Agronomy journal 43: 434-438.
3. Celus I, Brijs K, Delcour JA (2006) The effects of malting and mashing on barley protein extractability. J Cereal Sci 442: 203-211.
4. Chapman HD (1965) Cation-exchange capacity 1. Methods of soil analysis. Part 2. Chemical and microbiological properties. 891-901.
5. CIMMYT International Maize and Wheat Improvement Centre (1988) From Agronomic Data to Farmer Recommendation: an Economics Training Manual Completely Revised Edition. CIMMYT Mexico.
6. CSA Central Statistical Agency (2020) Report on Area and Production of Major Crops for 2019/2020 (Private Peasant Holdings, Meher Season). Addis Ababa, Ethiopia 1: 587.
7. Fathi G, McDonald GK, Lance RCM (1997) Effects of post-anthesis water stress on the yield and grain protein concentration of barley grown at two levels of nitrogen. Aust J Agric Res 48: 67-80.
8. Henry RJ, McLean BT (1984) Effect of sample size on the micro malting of barley. J Sci Food Agri 35: 767-772.
9. Mohammed H, Legesse G (2003) An Overview of malt barley production and marketing in Arsi. In: Proceedings of the Workshop on Constraints and Prospects of Malt Barley, Production, Supply and 16. Marketing 1-25.
10. Mulatu B, Lakew B (2011) Barley research and development in Ethiopia-an overview. In: Mulatu, B., Grando, S. (Eds.), Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop. ICARDA, Holeta, Ethiopia 1-18.
11. Olsen SR, Cole CW, Watanabe FS, LA Dean (1954) Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate Circular 939, US. Department of Agriculture.
12. Tekalign T, Haque I, Aduayi EA (1991) Soil, plant, water, fertilizer, animal manure and compost analysis. Working document.