

Yield and Quality of Malt Barley (*Hordeum vulgare* L.) in Response to Special Liquid Fertilizer (Trafos Synergy) Application in the Central Highlands of Ethiopia

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Abstract

Fertilizer application requirement to crops varies from location to location due to several factors. Thus, there is a need to evaluate response of yield and quality of malt barley to liquid fertilizer applications. Accordingly, an experiment was conducted to evaluate different dose of liquid fertilizer applications on yield and yield components of malt barley at Welmera (Holeta and Telecho) and Ejere (Cheri) districts during 2016 and 2017 main cropping season. The experiment was laid out in randomized complete block design with four replications. The treatments were different doses of Trafos synergy with the recommended NP, that is, 0, 100% NP, 100% NP + Trafos synergy 4 L/ha, 100% NP + Trafos synergy 2 L/ha and 100% NP + Trafos synergy 6 L/ha. Applications of recommended NP and Trafos synergy liquid nutrient sources in combination had a significant ($p < 0.05$) effect on grain and biomass yield of malt barley. The highest grain yield (3251.1 kg/ha) was obtained from the application of 100% NP + Trafos synergy 6 L/ha at Cheri. Based on economic analysis, application of 100% recommended NP with Trafos synergy 4 L/ha fertilizer at HARC and Cheri site indicates promising for barley production on yield and grain quality.

Keywords: Grain quality, Trafos synergy, protein content

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the most important, economically valuable and widely used cereal crops. One source of income could be growing malting barley, which has dependable local buyers in the country (Agegnehu *et al.* 2011). This crop is used for preparing traditional food and beverage consumptions (Araya *et al.*, 2011; Kemelew and Alemayehu, 2011). In the highlands of Ethiopia, farmers practice malt barley production systems were poor as dual purpose crops. In Ethiopia, barley production is highly concentrated in Oromia National Regional State with total area coverage of 454,662.78 hectares and total annual production of about 1.09 million tonnes, whereas the mean barley productivity was around 2.4 tonnes ha⁻¹ in main cropping season (CSA, 2017). The most important factors that reduce yield of barley in Ethiopia are poor soil fertility status, lack of special liquid fertilizer, poor crop management practices, and limited availability of improved varieties is among the most important constraints that threaten barley production in Ethiopia (Shiferaw and Anteneh, 2014). Trade corp's range of differentiated formulas is highly concentrated in micro, macronutrients and bio stimulants. This range is developed to meet specific needs of crops which influence quality, such as the protein content, sugar level, photosynthetic activity, etc according to the supplier blogger. It also provides a complete improvement of soil fertility. Moreover, it is easy to use and believed that it is safe to people and the environment. Liquid Chemical fertilizer usage by malt barley producers in Ethiopia is not practiced yet. Hence, it is a significant to evaluate Trade corp products as new fertilizer for malt barley production under rain fed condition. On behalf of these motivations, special liquid fertilizer (Trafos synergy) is applied to improve grain yield and grain quality of malt barley. Therefore, the objective of this study was to evaluate the response of yield and quality of malt barley to liquid fertilizer (Trafos synergy) applications.

MATERIALS AND METHODS

Description of the Experimental Site

The experiment was conducted during the 2016 and 2017 main cropping season at Welmera (Holeta and Telecho sites) and Ejere (Cheri sites) Districts in West Showa Zone, Oromia National Regional State. The study sites were located in the highlands of West Shewa zone between 09°00'3"N latitude and 38°0'20" E longitude and at an altitude of about 2400 meter above sea level (masl). The rainfall is bimodal with average annual rainfall of 1041.4 mm, about 85% of which is received from June to September and the rest from January to May. The average minimum and maximum air temperature is 6.7 and 21.7 °c respectively and with relative humidity of 58.7% (HARC, 2016 and 2017). The environments are seasonally humid and the major soil type of the trial sites is Eutric Nitisols (FAO classification).

Experimental Treatments, Design and Procedure

Grain yield and quality response of malt barley to special liquid fertilizer (Trafos synergy) experiment was

conducted in major malt barley growing areas in West Showa Zone for two years (2016 and 2017). The experiment was designed in RCBD with four replications and consisting of different doses of Trafos synergy with recommended NP (0, 100% NP, 100% NP + Trafos synergy 4 L/ha, 100% NP + Trafos synergy 2 L/ha and 100% NP + Trafos synergy 6 L/ha). The test crop was sown with row to row spacing of 20 cm comprising a total of 20 rows per plot in which a seed rate of 125 kg kg/ha was maintained. Phosphorus was applied to all plots uniformly at the rate of 46 kg P₂O₅ kg/ha as triple super phosphate (TSP) at planting. Urea as N source was applied at the rate of 46 kg N kg/ha. Split application of nitrogen was used. Similarly, Trafos synergy fertilizer were applied on 35 days after planting, and then the recommended doses for liquid fertilizers (2, 4 and 6 L/ha) were applied more than six times with 20 days intervals.

Soil Sample and Analysis

Composite surface soil samples were collected from experimental fields (0-20 cm depth) before and after harvesting from each plot and then composited by replication to obtain one representative sample per treatment. Samples collected during both times were then analyzed for the determinations of soil pH, total organic carbon (OC), total N, available P. Soil particle size distribution/ texture/ was determined using the Bouyoucos hydrometer method (Bouyoucos, 1962). The pH of the soil was measured from suspension of 1:2.5 (weight/ volume) soil to water ratio using a glass electrode attached to digital pH meter (Page, 1982). Soil organic matter was determined by wet oxidation method (Walkely and Black, 1934). Total nitrogen was determined using Kjeldahl method (Jackson, 1967) and available phosphorus was determined using the Bray II method (Bray and Kurtz, 1945). Cation exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH₄OAC) (Chapman, 1965).

Data collection and analysis

Biomass yield and grain yield were collected as yield parameters of malt barley. Grain yield (kg ha⁻¹) was recorded in six central rows in each plot by considering net plot area and converting into kg ha⁻¹ after the grams are adjusted to 12.5% moisture. Biomass yield (kg ha⁻¹) was obtained by weighing above ground dry matter of plant (straw and grain) in central rows in each plot and converting into kg ha⁻¹.

Grain quality parameters

Thousand grain weight (TGW) was counted by grain counter machine and the thousand counted grain was weighed and taken as thousand grain weight. Hectoliter weight (HLW) was determined on dockage free samples using a standard laboratory hectoliter weight apparatus and moisture grain content (%) was measured by grain analysis computer (GAC) (AACC, 2000) method. Grain protein content (GPC %) was determined by multiplying grain N percent by 5.83, i.e. Grain protein (%) = N % x 5.83 (AACC, 2000). Germination energy was determined by taking one hundred barley grains were spread on wetted (4ml distilled water) filter paper lined on Petri dishes (90mm) and allowed to germinate at nearly 100% relative humidity set at a temperature of 16°C germination cabinet for 3 days (Bam *et al.*, 2006) method 3.6.

Statistical analysis

The collected data was subjected to statistical analysis using SAS software, version 9.0 (SAS, 2004). Significant differences between and/or among treatments was separated by Least Significant Differences (LSD) test. Interpretations were done following the procedures described by Gomez and Gomez (1984)

Economic feasibility analysis

The mean grain yield data were reduced by 10% to adjust the yield to the farmers' management conditions and subjected to partial budget analysis (CIMMYT, 1988). The cost of fertilizer was considered as a variable cost for the economic analysis. The cost varied for each treatment and treatments were ranked in order of ascending variable cost. Dominance analysis was used to eliminate those treatments which cost more, but which produced a lower net benefit, than the next lowest-cost treatment. The marginal rate of return (MRR) was calculated for each non dominated treatment and a minimum acceptable MRR of 100% was assumed (CIMMYT, 1988). Two years average market grain price of malt barley (12 ETB /kg), farm-gate price of N and P fertilizers (12 and 15 ETB /kg) respectively, price of Trafos synergy liquid fertilizer 65ETB/L were used.

RESULTS AND DISCUSSION

Effects of special liquid (Trafos synergy) fertilization on soil chemical properties

The results of the selected physio-chemical properties of the soils of the experimental sites, taken after harvesting are presented in Table 3. The soil textural class was dominated by clay (72%), silt (18.25%) and sand (9.75%) for HARC, while for Cheri clay (73.4%), silt (19.65%) and sand (6.55%), categorized under clay soil for both sites.

Table: 3. The Trafos synergy liquid fertilizer application on soil chemical properties analyzed samples after harvest of the crops

Location	Treatment	Soil physico-Chemical Properties								
		Clay (%)	Silt (%)	Sand (%)	Textural class	pH (H ₂ O)	TN (%)	CEC Cmol _c kg ⁻¹	OC (%)	Av.P (ppm)
HARC	0	72.5	21.25	6.25	Clay	5.70	0.12	27.1	1.82	13.24
	100% RNP	72.5	16.25	11.25	Clay	5.75	0.13	24.64	1.82	12.32
	100% RNP + 4 L/ha	70	18.75	11.25	Clay	5.68	0.14	29.3	1.78	11.79
	100% RNP + 2 L/ha	72.5	16.25	11.25	Clay	5.60	0.14	30.32	1.74	12.11
	100% RNP + 6 L/ha	72.5	18.75	8.75	Clay	5.62	0.24	30.92	1.70	12.52
Cheri	0	73.0	21.25	3.75	Clay	4.65	0.1	26.72	1.74	11.29
	100% RNP	73.5	18.75	7.75	Clay	4.63	0.14	26.92	1.90	10.79
	100% RNP + 4 L/ha	72.5	21.25	6.25	Clay	4.66	0.15	28.96	1.78	11.78
	100% RNP + 2 L/ha	73.5	18.25	8.25	Clay	4.75	0.16	28.7	1.74	12.13
	100% RNP + 6 L/ha	74.5	18.75	6.75	Clay	4.62	0.24	30.92	1.70	12.52

CL=Clay, CEC=Cation exchange capacity, OC=Organic carbon, TN=Total nitrogen, Av.P=Available phosphorus. RNP= recommended NP

At HARC the soil pH (H₂O) was 5.67 which is moderately acidic in its reaction; for Cheri the soil pH (H₂O) was 4.66 it falls in strongly acidic which is similarly with Getachew and Sommer, 2000. The total N contents of soils after harvest were 0.15% (HARC) and 0.16% (Cheri), respectively. The soil organic carbon content was 1.76% for HARC and 1.77% for Cheri which means they are ranged in medium level for both sites and the result is agreement with Zelleke *et al.*, (2010). The cation exchange capacity of the experimental study area was 28.46 cmol_ckg⁻¹, 28.44 cmol_ckg⁻¹, respectively for HARC and Cheri. The available phosphorus content of the experimental area for HARC and Cheri was 12.39 ppm, and 11.7 ppm, respectively. Thus, soil fertility status is sub-optimal for the production of barley.

Response of malt barley to Trafos Synergy liquid fertilizer.

The effect of trafos synergy liquid fertilizer on grain yield, pooled over the two cropping years, is presented in Table 4. This study clearly indicated that, productivity of malt barley was significantly affected by different dose of Trafos synergy and NP applied.

Table: 4. over years (2016 and 2017) combined analysis to response of Trafos synergy liquid fertilizer on malt barley grain and biomass yield

Treatments	Grain yield (kg/ha)			Biomass yield(kg/ha)		
	Site1 (HARC)	Site2 (Cheri)	Site3 (Telecho)	Site1 (HARC)	Site2 (Cheri)	Site3 (Telecho)
Negative control	2330.6	1738.65 ^b	1347.7 ^b	7743.1 ^b	7925.2 ^b	4268.9
100% RNP	2695.0	3082.9 ^a	1976.9 ^a	8949.7 ^a	10171.9 ^a	5771.0
100% RNP + Trafos synergy 4L/ha	3010.4	2713.1 ^{ab}	1773.2 ^{ab}	9567.8 ^a	10243 ^a	5673.5
100% RNP + Trafos synergy 2L/ha	2731.0	2649.1 ^{ab}	2211.6 ^a	9078.2 ^a	10067.9 ^a	7206.4
100% RNP + Trafos synergy 6L/ha	3067.5	3251.1 ^a	2218.4 ^a	9081.6 ^a	11007 ^a	6856.2
LSD (5%)	NS	988.2	406.2	427.5	782.6	NS
CV (%)	14.95	18.2	21.5	8.6	17.2	16.4

Thus, applications of recommended NP and Trafos synergy liquid nutrient sources in combination had a significant ($p < 0.05$) effect on grain and biomass yield of malt barley. The application of recommended rates of NP with 6 L/ha Trafos-synergy increased malt barley grain yield by 13.8% at HARC, 5.5% at Cheri and 12.2% at Telecho when compared with standard check control (100% RNP). The biomass yield of malt barley was significantly influenced by the application of Trafos synergy. The application of recommended rates of NP with 4 L/ha Trafos-synergy increased biomass yield by 6.9% at HARC, and application of recommended rates of NP with 6 L/ha Trafos-synergy resulted in biomass yield advantage of 8.2% at Cheri when compared with standard check control.

Grain Quality as affected by liquid fertilizer application

Hectoliter weight had a linear and positive response to Trafos synergy liquid fertilizer. The highest Hectoliter weight (68.42 kg hl⁻¹) was recorded at application of 100% RNP + Trafo synergy 4 L/ha and the lowest (64.18 kg

hl⁻¹) hectoliter weight was recorded from negative control treatment (Table 5). The acceptable test weights (hectoliter weight) for barley are in the range **66.1–72.8kg** hl⁻¹ (Rick *et al.*, 2014). While, the highest (13.23%) grain protein content was recorded on 100% RNP + Trafo synergy 6 L/ha and the lowest(10.46%) grain protein from negative control treatment and the highest germination energy (96.86%) value was obtained from negative control treatments, while the lowest (94.11%) was obtained from the application of 100% RNP + Trafo synergy 6 L/ha .

Table: 5. Effect of Trafo Synergy liquid fertilizer on malt barley quality parameter

Applied N rate (kg/ha)	Hectoliter weight (kg/hl)	Grain protein content (%)	Germination energy (%)	Moisture Contents (%)
Negative control	64.18	10.46	96.86	12.64
100% RNP	67.14	11.48	95.42	12.79
100% RNP + Trafos synergy 4 L/ha	68.42	13.04	94.88	12.83
100% RNP + Trafos synergy 2 L/ha	68.02	11.27	95.14	12.42
100% RNP + Trafos synergy 6 L/ha	68.19	13.23	94.11	12.88

On the other hand, as protein content of malt barley increases, as Trafos synergy fertilizer was increased. Similar research findings with many authors (Bremer, 2004; McKenzie *et al.*, 2005; Shiferaw and Anteneh, 2014) reported that with low available nutrient soil, malt barley responds well to applied fertilizer, showing increases in both yield and protein content. However, too much fertilizer especially nitrogen can increase protein beyond levels set by the maltsters. This increase in protein may increase steep times, cause uneven water uptake during steeping, make germination more erratic/not uniform, create undesirable qualities in the malt, increased malt loss due to abnormal growth, excessive enzymatic activity, low extract yield, excessive nitrogenous compounds in the wort during brewing and chill haze formation in beer (Johnston *et al.*, 2007). Regards to grain moisture levels need to be low enough to inactivate the enzymes involved in seed germination as well as to prevent heat damage and the growth of disease microorganisms. Fox *et al.* (2003) reported that the maximum reasonable industrial specification of malt barley moisture content for safe storage is 12.5%, whereas, the EBC standard, a moisture content of 12-13.5 % is accepted.

Economic feasibility of Trafos synergy fertilizer application

Application of Trafos synergy liquid fertilizer 4L/ha with 100% Recommended NP fertilizer indicated that the highest marginal rate return of 2414.2% at HARC site (Table 6) and at Cheri and Telecho study site 100% Recommended NP plus Trafos synergy 6L/ha fertilizer provided the highest marginal rate of the return (MRR) of 4742% (Table 7) and 3907.3%(Table 8) were recorded, respectively. Whereas, based on the economical recommendation of CIMMYT (1988) which stated that farmers should be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return.

Table 6: Partial budget and dominance analyses of Trafos synergy fertilizer on malt barley HARC on station

Treatment	GY kg/ha	AD GY kg/ha	TVC (ETB)	Gross Benefit (ETB)	Net Benefit (ETB)	MRR (%)
Negative control	2330.6	2097.5	12	25170.5	25158.5	0.0
100% RNP	2695	2425.5	3162	29106	25944.0	24.9
100% RNP + Trafos synergy 2 L/ha	2731	2457.9	3582	29494.8	25912.8	D
100% RNP + Trafos synergy 4 L/ha	3010.4	2709.3	3702	32511.8	28809.8	2414.2
100% RNP + Trafos synergy 6 L/ha	3067.5	2760.8	3822	33129	29307.0	414.4

Table 7: Partial budget and dominance analyses of Trafos synergy fertilizer on malt barley at Cheri

Treatment	GY kg/ha	AD GY kg/ha	TVC (ETB)	Gross Benefit (ETB)	Net Benefit (ETB)	MRR (%)
Neg control	1738.7	1564.8	12	18777.4	18765.4	0.0
100% RNP	3083.0	2774.7	3150	33295.9	30145.9	362.7
100% RNP + Trafos synergy 2 L/ha	2649.1	2384.2	3570	28610.3	25040.3	D
100% RNP + Trafos synergy 4 L/ha	2713.1	2441.8	3690	29301.5	25611.5	476.0
100% RNP + Trafos synergy 6 L/ha	3251.1	2926.0	3810	35111.9	31301.9	4742.0

Where, price of Trafos synergy liquid fertilizer =65ETB/L, price of N (12 ETB /kg) and P (15 ETB /kg) fertilizers, respectively, ETB =Ethiopian Birr, TVC =total variable cost, GY=grain yield, AD GY= Adjusted grain yield Therefore, it would be desirable for producer in the study area application of 100% Recommended NP plus 4L/ha Trafos synergy at HARC station (Table 6) for better barley production but at Cheri (Table 7) and Telecho(Table 8) study sites application of 100% recommended NP out-of-the-way is economical.

Table 8: Partial budget and dominance analyses of Trafos synergy fertilizer on malt barley at Telecho

Treatment	GY kg/ha	AD GY kg/ha	TVC (ETB)	Gross Benefit (ETB)	Net Benefit (ETB)	MRR (%)
Negative control	1347.7	1212.9	12	14555.2	14543.2	0.0
100% RNP	1976.9	1779.3	3162	21351.1	18189.1	115.7
100% RNP + Trafos synergy 2 L/ha	2211.6	1990.5	3582	23885.8	20303.8	503.5
100% RNP + Trafos synergy 4 L/ha	1773.2	1595.9	3702	19150.0	15448.0	D
100% RNP + Trafos synergy 6 L/ha	2218.4	1996.6	3822	23958.7	20136.7	3907.3

CONCLUSION AND RECOMMENDATION

Chemical fertilizer put forward nutrients which are readily soluble in soil solution and thereby immediately available to plants. The aim of this study was to increase yield and yield components of malt barley production using appropriate nutrient form and, rates. Application of different dose of Trafos synergy liquid fertilizers was not significantly affect grain and biomass yield when compared to 100% recommended NP treatment, but there was significance difference observed on grain and biomass yield, when compared to with negative control (without fertilizer) treatment. With regard to the protein content, all the Trafos synergy liquid fertilizer doses slightly increases the protein content of the malt barely. However, the protein content of the malt barely is considered to be superior when it is lower than 12%, recommended nitrogen and phosphorus fertilizers being the best. The result of the current study showed that grain protein content within the acceptable range, except (100% RNP + Trafo synergy 4 and 6L/ha) (Table 11). Accordingly, application of 100% Recommended NP plus 4L/ha Trafos synergy fertilizer at HARC station (Table 6) was encouraged for improvement of yield and quality.

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