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# Response of Malt Barley to Special Liquid Fertilizer (Rutter AA) in the Central Highlands of Ethiopia

*Girma Chala[1] Zeleke Obsa[1] Emenu Jembere[2]
1.Holetta Agricultural Research Center, EIAR, P.O. Box. 31
2.Chemtex Trade Corp Company Country Coordinator

**Abstract**
The experiment was conducted at Welmera (Holeta &Telecho) and Ejere (Cheri) districts during 2016 and 2017 main cropping season to evaluate response of yield and yield components of malt barley to special liquid fertilizer (Rutter AA) applications. The experiment was laid out in randomized complete block design with three replications. The treatments were different doses of Ruter AA with recommended NP, that is,0, 100% NP, 100% NP + Ruter AA 4 L/ha, 100% NP + Ruter AA 2 L/ha and 100% NP + Ruter AA 6 L/ha). The results of this study indicated that the productivity of malt barley was significantly affected by different dose of Ruter AA applied. Applications of 100% NP fertilizer with Ruter AA liquid nutrient sources combination had a significant ($p<0.05$) effect on grain yield and biomass yield of malt barley. In general application of liquid fertilizer (Rutter AA) indicates positive response on grain quality of malt barley. In conclusion, based on the findings of the experiment without application of liquid fertilizer but 100% recommended NP fertilizer are economically optimum for malt barley production with acceptable grain quality in the Holeta, Cheri and Telecho study sites.
**Keywords:** Grain yield, Liquid fertilizer, Protein content
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## INTRODUCTION

Barley (*Hordeum vulgare L.*) is grown in diverse grain crop that could be used as forage as well as cover environments with the altitude range of 1500 and 3500 crop to improve soil fertility (Muluken Bantayehu, 2013). In Ethiopia, barely is the fourth most important crop after *tef*, maize and sorghum. 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). Barely is used in different forms such as bread, porridge, soup and roasted grain and straw is used for animal feed, thatching roofs and bedding. It is a fast growing, cool season, annual grain crop that could be used as forage as well as cover crop to improve soil fertility (Ghanbari *et al*,.2012). However, barely production in Ethiopia in general and in Oromia Region in particular is usually practiced with little or no external input mainly in the higher altitude or steep slopes, eroded lands or in moisture stress areas (Getachew, 2001). Malt barley is a high-opportunity crop, with great room for profitable expansion, particularly when connected with the country's commercial brewing and value-added industries (Berhane*,* 2011). Despite the importance of malt barley and its many useful characteristics, there are several factors affecting its production. 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 (Paul *et al*., 2011). Liquid Chemical fertilizer usage by malt barley producers in Ethiopia is too little yet. However, special liquid fertilizer (Rutter AA) is applied to improve yield and grain quality of malt barley. Therefore, the objective of this research was to evaluate response of malt barley to liquid fertilizer application which effects on yield components and grain quality.

## MATERIALS AND METHODS

### Description of the Experimental Site

The experiment was conducted during the 2016 and 2017 main cropping season at Welmera (Holeta &Telecho) and Ejere (Cheri) districts .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 $^{o}$c respectively 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 quality and yield response of malt barley to special liquid fertilizer (Rutter AA) experiment was conducted in major malt barley growing areas in west shoa zone for two years (2016-2017). The experiment was designed in RCBD with four replications and consisting of different doses of Ruter AA with recommended NP (0, 100% NP, 100% NP + Ruter AA 4 L/ha, 100% NP + Ruter AA 2 L/ha and 100% NP + Ruter AA 6 L/ha). At least one weeding was done at tillering stage of barley even though farmers have no experience of weeding. 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. Urea as N source was applied at the rate of 46 kg N kg/ha. Split application of nitrogen was used. Similarly, Rutter AA fertilizer (Table 2) 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. Phosphorus was applied to all plots uniformly at the rate of 46 kg $P_2O_5$ kg/ha as triple super phosphate (TSP) at planting.

Table 1: The five treatments used to examine the response of malt barley to liquid fertilizers.

| Treatments | Ruter AA- liquid product to spray |
|---|---|
| T1 | Negative control |
| T2 | 100% NP |
| T3 | 100% NP + Ruter AA 4 L/ha |
| T4 | 100% NP + Ruter AA 2 L/ha |
| T5 | 100% NP + Ruter AA 6 L/ha |

Table: 2. Nutrient compositions of the product (Ruter AA)

| Name | N (%) | $P_2O_5$ (%w/w) | $K_2O$ (% w/w) | CaO (%w/w) | MgO (%w/w) | Fe (%w/w) | Zn (% w/w) | Mn (% w/w) | $SiO_2$ (% /w) | Mo (/% w/w) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ruter AA | 5.5 | 5 | 3.5 | 0 | 0 | 0.04 | 0.07 | 0.07 | 0 | 0.1 |

**Soil sampling and analysis**

Composite surface soil samples were collected from experimental fields (0-20 cm depth) before treatment application. Similarly, samples were collected after harvest from each plot and then composited by replication to obtain one representative sample per treatment. Then, soil samples were analyzed to determine the soil pH, OC, total N, available P. Soil particle size distribution/ texture/ was determined by Bouyoucos hydrometer method (Bouyoucos, 1962). The pH of the soil was measured from suspension of 1:2.5 (weight/ volume) soil to water ratio (Page, 1982). Soil OC was determined by wet oxidation method as described by Walkely and Black (1934). Total nitrogen was determined using Kjeldahl method as described by Jackson (1967) and available phosphorus was determined by the Bray II method (Bray and Kurtz, 1945). Cation exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH4OAC) and displacing the ammonium ion with 1N NaOAC (Chapman, 1965)

**Data collection and analysis**

All agronomic data were taken from the net harvested plot areas. Spacing between replications and between plots was 1 and 0.5 m, respectively. Plant height at maturity (cm), spike length (cm), biomass yield and grain yield were collected as growth and yield parameters of malt barley. Hectoliter weight, grain protein content, Moisture Contents and germination energy were collected as malt quality parameters of the study. Grain yield was adjusted to a moisture content of 12.5% before proceeding to statistical analysis.

The analysis of variance (ANOVA) was carried out for growth and yield parameters of the study following statistical procedures appropriate for the experimental design using SAS statistical Analysis System (SAS, 2004). Whenever treatment effects were significant at 0.01 or 0.05 probability level and the means were separated by using the least significant difference (LSD) procedures at 0.05 probability level of significance. A grain sample was taken at all sites of each location for determination of grain protein content. The grain N content was analyzed by the Kjeldahl method (Minale *et al*., 2011) and the result was multiplied by 5.85 to obtain the grain protein content.

**Economic analysis**

Partial budgeting analysis was widely used to better understand the economic implication of adopting new technologies by smallholders (Assefa, 2015). 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) as showed in (Table 6, 7 and 8). Two years average market grain price of malt barley (12 birr/kg), farm-gate price of N and P fertilizers (12 and 15 birr/kg) respectively and price of Rutter AA liquid fertilizer 40 birr/Letter were used.

## RESULTS AND DISCUSSION

**Soil chemical properties of the study sites**

The soil analytical results of selected physio-chemical properties of the soils before planting and after harvesting were presented in Table 3. The soil particle size distribution of the study sites were clay (72%), silt (18.25%) and sand (9.75%) for Holeta, while for Cheri clay (73.4%), silt (19.65%) and sand (6.55%), and textually dominated by clay soil for all sites. For Holeta the average soil pH ($H_2O$) after harvesting was 5.67 which is moderately acidic in its reaction; for Cheri the average pH ($H_2O$) of the experimental field soil after harvesting was 4.66 showing strong acidity in its reaction.

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

| Location | N kg/ha | Particle size Distribution | | | | Chemical Properties | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Clay (%) | Silt (%) | Sand (%) | Textural class | pH ($H_20$) | TN (%) | CEC $Cmol_ckg^{-1}$ | OC (%) | Av.P (ppm) |
| Holeta | 0 | 72.50 | 21.25 | 6.25 | Clay | 5.70 | 0.12 | 27.1 | 1.82 | 13.24 |
| | RNP 100% | 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

The total N contents of soils after harvest were 0.154% (Holeta) and 0.158% (Cheri), respectively. Organic carbon content of the soil after harvesting was 1.76% for Holeta and 1.77% for Cheri which means they are classified under medium level for both sites. The CEC of the study area after harvesting was 28.46 cmolc $kg^{-1}$, 28.44 cmolc $kg^{-1}$, respectively for Holeta and Cheri. The available phosphorus content of the study area for Holeta and Cheri after harvesting was 12.39 ppm, 11.7 ppm, respectively.

**Response of malt barley to Ruter AA liquid fertilizer**

The effect of Ruter AA liquid fertilizer on grain and biomass yield, pooled over two cropping seasons, are presented below in table 4. The study indicated that productivity of malt barley was significantly affected by different treatments applied. Thus, applications of RNP and Ruter AA liquid nutrient sources in combination had a significant ($p<0.05$) effect on grain and biomass yield of malt barley. When compared with standard check, application of 100% RNP with 6 L/ha Ruter AA increased malt barley grain yield by 8.6, 8.9 and 17.6% at Holeta, Cheri and Telecho, respectively. The biomass yield of malt barley was also significantly influenced by supplemental application of Ruter AA fertilizer, particularly at Cheri and Telecho sites. The application of 100% RNP with 4 L/ha Ruter AA increased biomass yield by 21.2% at Holeta. Similarly application of 100% RNP with 6 L/ha Ruter AA increased biomass yield by 7.4% but at Telecho application of recommended rates of NP with 6L/ha Ruter AA increased biomass yield by 16.9% yield advantage when compared with standard check control.

Table: 4. over years (2016 and 2017) mean response of malt barley grain and biomass yield to Ruter AA liquid fertilizer

| Treatments | Grain yield (kg/ha) | | | Biomass yield (kg/ha) | | |
|---|---|---|---|---|---|---|
| | Site1 (Holeta) | Site2 (Cheri) | Site3 (Telecho) | Site1 (Holeta) | Site2 (Cheri) | Site3 (Telecho) |
| Negative control | 1779.0[b] | 1432.1[b] | 1243.9[b] | 7227.5 | 7197.8[b] | 3873.3[b] |
| 100% RNP | 2679.4[a] | 2511.7[a] | 2228.6[a] | 8361.1 | 9440.8[a] | 6789.7[a] |
| 100% RNP +Ruter AA 4 L/ha | 2878.6[a] | 2613.6[a] | 2060.75[a] | 8861.1 | 9944.5[a] | 6102.5[a] |
| 100% RNP +Ruter AA 2 L/ha | 2647.2[a] | 2548.6[a] | 2017.6[a] | 7312.5 | 9444.5[a] | 5524.6[a] |
| 100% RNP +Ruter AA 6 L/ha | 2768.5[a] | 2533.9[a] | 2318.3[a] | 9216.9 | 9852.4[a] | 6644.1[a] |
| LSD (5%) | 417.7 | 704.9 | 613.7 | Ns | 864.6 | 2417.3 |
| CV (%) | 11.2 | 19.7 | 20.2 | 7.9 | 19.3 | 19.5 |

**Quality Parameters of malt barley**

Hectoliter weight had a linear and positive response to Ruter AA liquid fertilizer. The highest (68.52 kg $hl^{-1}$) hectoliter weight was recorded from the highest applied 100% RNP + Ruter AA 6 L/ha and the lowest (66.79 kg $hl^{-1}$) hectoliter weight was recorded from negative control treatment (Table 5). Low values of HLW indicate poor grain filling. The acceptable test weights (hectoliter weight) for barley are in the range **66.1–72.8kg** $hl^{-1}$ (Rick *et al*., 2014). Similarly, the highest grain protein content (13.86%) was recorded on 100% RNP + Ruter AA 6 L/ha and the lowest grain protein (10.58%) from negative control treatment and the highest germination energy (96.14%) value was obtained from negative control treatments, while the lowest (94.24%) was observed at 100% RNP + Ruter AA 6 L/ha .On the other hand, as protein content of malt barley increases, as Rutter AA fertilizer was increased. Similar research findings with many authors (McKenzie *et al*., 2008; Daniel ,2010) reported that with low available nutrients in the soil, malt barley responds well to applied fertilizer, showing increases in both yield and protein content(Johnston *et al*., 2007). Regards to 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 (EQSA, 2006). Fox *et al*. (2003) reported that the maximum reasonable industrial specification of malt barley moisture content for safe storage is12.5%, whereas, the EBC standard, a moisture content of 12-13.5 % is accepted.

Table: 5. Effect of Ruter AA 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 | 63.79 | 10.58 | 96.14 | 12.56 |
| 100% RNP | 66.74 | 11.23 | 95.66 | 12.62 |
| 100% RNP + Ruter AA 4 L/ha | 68.22 | 12.28 | 94.72 | 12.48 |
| 100% RNP + Ruter AA 2 L/ha | 67.46 | 11.46 | 95.06 | 12.65 |
| 100% RNP + Ruter AA 6 L/ha | 68.52 | 13.84 | 94.24 | 12.58 |

**Economic analysis**

The results of the partial budget analysis (Tables 6, 7 and 8) revealed that the economically optimum yield and acceptable grain quality was varies with application dose of liquid fertilizer (Rutter AA). The economic analysis further indicates that, the highest marginal rate of the return (MRR) were recorded from the application of 100% Recommended NP plus 4L/ha Rutter AA at Holeta(Table 6 )and Cheri site (Table 7), but 6 L/ha Rutter AA liquid fertilizer at Telecho study sites. From this findings, application of different dose of liquid fertilizer (Rutter AA ) were not economically feasible with combination of 100% recommended NP for malt barley production with acceptable grain quality in the Holeta, Cheri and Telecho study sites.

Table 6: Partial budget and dominance analyses of Rutter AA fertilizer on malt barley at Holeta

| Treatments | Average yield (kg/ha) | Adjusted yield-10% (kg/ha) | Net benefit (birr/ha) | Total variable cost | MRR (%) |
|---|---|---|---|---|---|
| Negative | 2293.1 | 2063.79 | 24765.48 | 0 | |
| 100% RNP | 3262.5 | 2936.3 | 32085 | 3150 | 232.37 |
| 100% RNP + Rutter AA 2 L/ha | 3268.5 | 2941.7 | 31729.8 | 3610 | D |
| 100% RNP + Rutter AA 4 L/ha | 3510.3 | 3159.3 | 34301.2 | 3570 | 6428.6 |
| 100% RNP + Rutter AA 6 L/ha | 3456 | 3110.4 | 33634.8 | 3690 | D |

Table 7: Partial budget and dominance analyses of Rutter AA fertilizers trial on malt barley at Cheri-sites

| Treatments | Average yield (kg/ha) | Adjusted yield-10% (kg/ha) | Gross benefits (birr/ha) | Total variable cost | Net benefit (birr/ha) | MRR (%) |
|---|---|---|---|---|---|---|
| Negative | 1729.4 | 1556.46 | 18677.5 | 0 | 18677.5 | |
| 100% RNP | 2881.7 | 2593.53 | 31122.4 | 3150 | 27972.4 | 295.1 |
| 100% RNP + Ruter AA 2 L/ha | 2941.8 | 2647.62 | 31771.4 | 3610 | 28161.4 | 41.1 |
| 100% RNP + Ruter AA 4 L/ha | 2577.4 | 2319.66 | 27835.9 | 3570 | 24265.9 | 9738.8 |
| 100% RNP + Ruter AA 6 L/ha | 2789.7 | 2510.73 | 30128.8 | 3690 | 26438.8 | 1810.7 |

Table 8: Partial budget and dominance analyses of Rutter AA fertilizers trial on malt barley at Telecho

| Treatments | Average yield (kg/ha) | Adjusted yield-10% (kg/ha) | Gross benefits (birr/ha) | Total variable cost | Net benefit (birr/ha) | MRR (%) |
|---|---|---|---|---|---|---|
| Negative | 1480.7 | 1332.63 | 15991.56 | | 15991.56 | |
| 100% RNP | 2473.6 | 2226.24 | 26715 | 3150 | 23564.9 | 240.4 |
| 100% RNP + Ruter AA 2 L/ha | 2196.3 | 1982.37 | 23788 | 3570 | 20218.4 | D |
| 100% RNP + Ruter AA 4 L/ha | 2012.6 | 1811.34 | 21736 | 3610 | 18126.1 | D |
| 100% RNP + Ruter AA 6 L/ha | 2639.3 | 2375.37 | 28504 | 3690 | 24814.4 | 8360.5 |

## CONCLUSION AND RECOMMENDATION

Ethiopia has a high potential for barley production and field experiment was conducted at Welmera (Holeta &Telecho) and Ejere (Cheri) districts during 2016-2017 main cropping seasons. Barley production is heavily dependent on available nutrient in the soil and other condition for plant growth. Information on crops response to nutrients and improved variety is crucial to come up with profitable and sustainable crop production. The aim of this study was to increase yield and yield components of malt barley production using appropriate nutrients and agronomic practices at Welmera (Holeta &Telecho) and Ejere (Cheri) districts. Application of different rates of Rutter AA liquid fertilizers was not significantly affected 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 treatment. With regard to the protein content of the treatments, all the Ruter AA doses slightly increased 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.

According to the Ethiopian standard authority and Asella malt factory (AMF), the protein level of the raw barley quality standard for malt should be between 9–12% (EQSA, 2006). The results of the current study showed that grain protein content within the acceptable range, except (100% RNP + Rutter AA 6L/ha) (Table 10). So, applying Rutter AA liquid fertilizer product in addition to the recommended fertilizers doesn't improve both the yield and protein quality of malt at all locations. Economic analysis showed that the highest marginal rate of return was obtained from application of 100% Recommended NP plus Rutter AA 4L/ha fertilizer at Holeta and Cheri but at Telecho the highest marginal rate of return was obtained from application of 100% recommended NP plus Rutter AA 6L/ha fertilizer.

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