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Yield Related Traits and Yield of Quality Protein Maize (*Zea mays L.)* affected by Nitrogen Levels to achieve maximum yield in the Central Rift Valley of Ethiopia

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Abstract

Maize is one of highly valued crop in the national diet of Ethiopians especially in southern and south eastern regions of the country; it is produced across various agro-ecologies of the country. However, its productivity is constrained by blanket application of mineral nutrients, in particular nitrogen (N). In this study, we aimed to test site-specific nutrient management particularly nitrogen to maximize yield, increase net benefit and reduce environmental pollution. Drastic increase in N fertilizer cost, environmental pollution and increased public scrutiny have encouraged development and implementation of improved N management practices. In this context, on-farm and on-station experiments were carried out during 2014 main cropping season in the central rift valley of Ethiopia. The experiment were layout using randomized complete block design (RCBD) with three replication having six treatments of nitrogen fertilizer, phosphorous fertilizer were applied uniformly to all treatments. Plant height, number of grains per ear, leaf area, leaf area index, grain yield, above ground biomass stover yield,1000 kernels weight harvest index, were significantly ($P<0.05$) affected by N fertilizer rate. However, seed nitrogen content was not affected by rate of N-fertilizer. Generally, 75kg ha^{-1} N fertilizer have improved most of the yield related traits and yield of maize while 100kg ha^{-1} treatment have improved only some of yield traits at both location . Hence, this is one cropping season experiment has to be conducted through a different seasons and locations of uniform agro-ecology, soil type and crop in order to made concrete conclusions and seat out site specific recommendations.

Keywords: maximum yield, nitrogen, quality protein maize, yield related trait.

Introduction

Maize (*Zea mays L.*) is one of the most important cereal crops used in the human diet in large parts of the world and it is an important feed source for livestock. In addition to food and feed consumption, maize has wide range of industrial applications as well; from food processing to manufacturing of ethanol. In terms of total world production, maize out ranked over the last five years paddy rice (*Oryza sativa*) and wheat (*Triticum aestivum*).

Global maize production exceeds 600 metric tons (McDonald and Nicol, 2005). About 60% produced in the developed countries, particularly the United States of America, and China produces 27% of the world's maize. A large proportion is produced in the tropics and subtropics. Maize grain has greater nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3.0% sugar and 1.7% ash (Chaudhary, 1983;, Fageria and Baligar, 2005).

Maize is one of the most important cereal crop cultivated in Ethiopia (CIMMYT, 2012). It ranks second after teff in area coverage and first in total production. According to a 2013/14 survey, Meher season post-harvest crop production covered a total land areas of about 12,407,473 hectares were covered by grain crops. Out of the total grain crop areas, 79% (9,848,746 hectares) was under cereals. Of this maize covered 16 % (about 1,994,814 ha), and 18% (44,186,225) quintals of grain yields (CSA, 2014).

Despite the large area under maize cultivation, the national average yield of maize is about 3.2 t/ha (CSA, 2014). This is by far below the world's average yield which is about 5.21t/ha (FAO, 2011). This yield gap of maize is attributed to a number of factors like frequent occurrence of drought, declining of soil fertility, poor agronomic practice, limited use of input, insufficient technology generation, lack of credit facilities, poor seed quality, disease, insect, pests and weeds infestation (CIMMYT, 2004).

One of the major problems constraining the development of an economically successful agriculture is nutrient deficiency (Fageria and Baligar, 2005). It is estimated that some 30 to 50% of the increase in world food production since 1950s is attributable to fertilizer use (Higgs *et al*., 2002) Nevertheless, many farmers refrain from using fertilizer due to escalating costs, uncertainty about the economic returns to fertilizing food crops and, more often, lack of knowledge as to which kinds and rates of fertilizers are suitable (Hopkins *et al*., 2008).

The supply of food for human being and feed for animals more limited by N than any other element, since large amount of N is lost through denitrification, leaching, volatilization and removal by crops (Acquaah, 2002). The maximum N uptake by maize occurs during the month prior to tasseling and silking (Hammons, 2009). Since yield is likely to be low under N stress during silking, coincidence of N availability in soil solution and plant uptake demands are crucial to unlocking the potential of modern hybrids. Indeed, poor kernel formation, increased abortion and ultimately low grain yield under N stress has been reported widely (Andrade *et al*., 2000).

Compared to other cereals, maize requires higher inputs of N fertilizer. However, high N applications are costly and can pose serious threat of nitrate accumulation in surface and groundwater (Hopkins *et al*., 2008). N is a highly mobile nutrient both in the soil and plant system. As a result, placement of N fertilizer at the wrong time and/or at the wrong place results in losses through e.g. leaching, with negative economic and environmental consequences. This is compelled by the fact that the synthesis of N fertilizers is energy-dependent, and their costs are thus projected to increase in parallel with the cost of oil (Ramírez and Worrell, 2005).

In addition to releasing QPM varieties it would be very important to have site specific nutrient management packages to increase production and productivity of QPM for the benefit of producer in Ethiopia in terms of nutrition, economic and reduce environmental protection. Site-specific nutrient management aims at 'doing the right thing, at the right place, at the right time', Therefore, this study was conducted to investigate site specific N fertilizer recommendation based on yield related traits and yield of MH138Q quality protein maize under agro-climatic conditions of central rift valley of Ethiopia.

2. MATERIAL AND METHODS

2.1. Description of study area

The experiment was conducted on two locations of central rift valley of Ethiopia, on station (Melkassa Agricultural Research Center) and on farm in Oromia Administrative Region, Adami Tulu Jido kombolcha wereda Gerbi Wedina Boremo kebele, South Eastern part of Ethiopia during 2014 main cropping season. The difference locations were aimed to provide site specific recommendation for N application. The farmer site is located about 5 km away to Southern part from Ziway town. The geographical coordinate of the study site were at about 7° 72' N Latitude and 38°37'E longitude, and an elevation of 1600 meter above sea level (m.a.s.l). The area receives a mean annual maximum rainfall of 750 mm and minimum rainfall of 546 mm, mean annual maximum temperature of 28.5° C and mean annual minimum temperature of 12.6° C (Getachew*et al*., 2012). The area is characterized by sub moist semi-arid and arid agro ecology and the major soil type of the area is loam with an alkaline pH. Whereas Melkassa Agricultural Research Center (MARC) was established in 1969.The Center is geographically located at latitude of 8° 24' Longitude of 39° 21' East and an altitude of 1,550 meters. It is situated at about 107 km from Addis Ababa and 17 km from Adama on the way to Asella. Loam and clay loam soil textures are the dominant soils of the area (MARC, 2012).

2.2. Experimental Materials

2.2.1 Plant Material

MH138Q, which is a three-way cross QPM hybrid released by Melkasa Agricultural Research Center in 2012 (EIAR, 2014), was used for the study; it is well adapted to drought stressed mid-altitude areas of Ethiopia (1000 -1800 m.a.s.l), such as Welenchiti, Meki, Ziway, Adami Tulu and rain fall of 500-1000 mm. It needs 140 days to maturity, having white kernel, light yellow pollen color, semi dent grain texture with straight kernel row arrangement and resistance to rust and blight. It performs better if planted during late May to mid-June. It has yield potential ranges from 7-8 t ha^{-1} yields at research field and 5.5-6.5t ha^{-1} at farmers field (MARC, 2013).

2.2.2. Fertilizers

N fertilizer in the form of urea (46% N) and DAP was used for the study. N- Fertilizer applied at different rates in split application, while phosphorus-fertilizer was applied uniformly to all plots of each treatment at the time of planting.

2.3 Experimental Design and Treatments

Treatments consisted of seven rates of N (0, 25, 50, 75,100 and 125 kg N ha^{-1}) in split application, half during planting and the remaining half after emergence at vegetative stage. The size of each plot was 4.5 m x 5.1 m (22.95 m^2), consisting of six rows and the distance between adjacent plots and blocks kept at 1.0 m and 1.5 m apart, respectively. Seeds were sown with inter rows spacing of 75 cm apart and intra row spacing of 25 cm, three to two seeds per hill were sown to ensure emergence and good stand of the crop. However, to obtain the required plant density the seedlings were thinned to one plant per hill two weeks after emergence. The net plot area was 2.25 m x 5.1 m (11.47 m^2). Consequently, the experiment was laid out as a randomized complete block design (RCBD) replicated three times.

2.4. Experimental procedures.

2.4.1. Fertilizer application and field activities

Planting was done on June 2014 by placing two seeds per hill in hand made furrows and tined to one seedling to inter and intra-row spacing of 75 cm and 25 cm, respectively. Phosphate fertilizers in the form of triple super phosphate (TSP) were equally applied to all plots manually at the time of planting. For the N fertilizer application, urea was applied in two split at the specified rates by banding at planting approximately 2-3 cm distance from the seed (plant) and immediately covered with soil and by top dressing during the growth of the plants. All field activities were carried out following standard production practices.

Weeds were controlled manually either pulling with hand or using a hoe during cultivation. Stand count at emergence to see the uniformity of the plant stand, number of fully expanded leaf, plant Height, leaf length, and width continuously with in fifteen days interval were recorded finally, maize plants in the central four rows that had net plot area (11.47m^2) were harvested on November 2014.

3. RESULTS AND DISCUSSION

4.1. Crop Phenology, Growth, Yield Related Traits and Yield of Maize

4.1.1. Days to Physiological Maturity (DPM)

The analysis of variance revealed that N fertilizer rate had a significant difference ($P<0.01$) on days to maturity (DPM). The highest day had been recorded on the treatment 125kg Nha^{-1} at both locations. This might indicate that application above certain level encourage vegetative growth and delay maturity date. As the rate of fertilizer change from 0-125kg N ha^{-1} the maturity date delayed by 8.96 % at Adami Tulu whereas it was delayed by 14% at MARC (Table.2). The results are similar to those reported by Hammad (2011), days to maturity of the crop increased linearly by increasing N dose up to 300kg ha^{-1}. Akbar *et al.* (2002) found that maize crop took 102 days to maturity when the crop was subjected to 200kg N ha^{-1}. The changes in the N application timing and increase in N fertilizer rate and might have enhanced the rate of photosynthesis which resulted in the leaf longevity and delay tasseling and maturity stage of the crop in maize (Gungula *et al.,* 2003).

4.1.2. Number of ears per plant (NEP)

Number of ears per Plant was significantly ($P<0.05$) affected by N fertilizer rate, the higher number of ears (1.33) were recorded from treatments that received higher N, (100kg N ha^{-1} and 125kg N ha^{-1}) rates (appendix table.1). However results of analysis of variance shows no significant difference among thus two treatments in Adami Tulu. In similar trend number of ear per plant increased along control plants to those plants received 100kg N ha^{-1}at MARC. On the other hand the lower number of ear per plants (1.06) and (1.0) were recorded from those treatments received lower N rate at Adami Tulu and MARC respectively, Comparing the number of ear per plant showed that 100 kg N ha^{-1} and 125kg N ha^{-1} applications resulted in 25% more ear as compared to the control treatment at Adami Tulu, whereas 27% more ear were recorded from plants received 100kg N ha^{-1} over the control treatment at MARC. Generally, the trend showed that increase in ear number per plant was noted with increase in N rate.

Table 7. Days to Physiological Maturity (DPM), Ear Length (EL) and Number of Ear per plant (NEP) of Maize as influenced by N rate at Adami Tulu and MARC 2014, Main Cropping Season.

	Adami Tulu (On Farm)			MARC (On Station)		
Treatments N (Kg/ha)	**DPM**	**EL**	**NEP**	**DTM**	**EL**	**NEP**
0	135.67^{d}	17.83^{d}	1.07^{c}	128.12^{d}	16.40^{c}	1.0^{c}
25	136.67^{dc}	21.24^{b}	1.17^{bac}	129.47^{cd}	22.80^{cb}	1.0^{c}
50	137.67^{d}	21.39^{b}	1.17^{bac}	135.87^{bc}	24.30^{b}	1.20^{ab}
75	138.00^{c}	21.39^{b}	1.30^{ba}	139.68^{bc}	24.50^{ab}	1.20^{ab}
100	140.33^{b}	23.07^{a}	1.33^{a}	142.45^{ab}	24.53^{ab}	1.27^{a}
125	147.83^{a}	23.61^{a}	1.33^{a}	146.32^{a}	26.03^{a}	1.07^{cb}
Mean	**138.9**	**21.4**	**1.21**	**139.25**	**23.03**	**1.1**
LSD (5%)	**0.85**	**0.84**	**0.205**	**0.72**	**2.41**	**0.185**
CV (%)	**1.39**	**7.72**	**33.23**	**2.14**	**9.86**	**9.4**

Production of higher number of ears per plant in response to the split application of N at sowing and mid-vegetative growth stage might have been attributed to synchrony of application of N when it is demanded by the plant to maximize ear production. Singh *et al.* (2003) reported that application of N at 50 per cent higher (180 kg N ha^{-1}) over recommended level (120 kg N ha^{-1}) significantly enhanced the length of cob, girth of cob, number of ears per plant and grains cob^{-1}, grain weight cob^{-1}, test weight, grain and Stover yields of maize than lower doses. The authors obtained similar results when N was applied 0.75 fold (210kg N ha^{-1}) than the recommended dose (120kg N ha^{-1}) on clay loam soil. However our result was not in agreement with Karasu, (2012) reporting that seed number per ear of maize plants was not affected by N fertilizer levels.

4.1.3. Ear Length (EL)

Ear length increased significantly ($p<0.05$) when the rate of N was increased from 0 to 100 kg N ha^{-1}. Increasing the rate of N application beyond this level of N supply did not affect this parameter. Maximum ear length (23.61 cm) was recorded at application of 125 kg N ha^{-1} and minimum ear length (17.83cm) was recorded at the control treatment at Adami Tulu (Table 2). Similarly at MARC larger ear length was attained from application of 125kg N ha^{-1}. This indicates that N-fertilizer is the main factor for the increase in length that accommodates large number of kernel on the cob, to contributing grain yield in general. Comparing the ear length showed that 125 kg N ha^{-1} application resulted in 32 % bigger compared to the control treatment. Sharifi and Taghizadeh (2009) reported that the length of ears per plant was significantly affected by N application rate in which the maximum length of ear was produced in response to applying 240 kg N ha^{-1}, where the longest ear (167.4 mm) and the shortest was produced at control treatment (152.2 mm) .Similar findings by Amanulla (2009) reported that Increase in N rate increased plant and ear length with the highest rate of 180 kg N ha^{-1} produced the taller plants and higher ears lengths; while the shorter plants and ears lengths were recorded in the plots which received the lowest rate of 60 kg N ha^{-1}.

4.1.4. Plant Height (PH)

The result of analysis of variance showed that a significant ($P<0.05$) effect of N fertilizer rate on maize plant height, Plant height increased linearly and significantly with the increase in the rate of N application. When the rate of N was increased from 0 to 125kg N ha^{-1} plant height increased by 100% in Adami Tulu (Table.3). The increment in plant height with respect to increased N application rate indicates maximum vegetative growth of the plants under higher N availability. At MARC also plant height showed a significant ($p<0.01$) difference among the N fertilizer rate applied to the maize plant. Higher plant height was recorded from application of 125kg N ha^{-1} N-fertilizer which resulted in 39% increment in plant height as compared to the control treatment (Table.3). Sah and Dawadi (2012) reported increasing N level from 120 kg ha^{-1} to 200 kg ha^{-1} resulted in increased plant height of hybrid maize varieties. The authors reported that higher N applications increased cell division, cell elongation, nucleus formation as well as green foliage. Higher doses of N increased the chlorophyll content which improved the rate of photosynthesis and extension of stem resulting in increased plant height (Thakur *et al*., 1997; Diallo *et al*., 1996).

4.1.5. Leaf Area Index (LAI)

The effects of rate of N fertilizer application had significant ($P\leq0.01$) influence on leaf area index (LAI). The highest LAI (4.14) was recorded from 100 kg N ha^{-1} while the lowest (3.32) was recorded from the control plot (Table 3). Thus, 100kg N ha^{-1} application resulted in 24.69% more LAI than the control plot at Adami Tulu. But the higher LAI was recorded from application of 125kg N ha^{-1} at MARC, thus contributing more for the photosynthesis efficiency of the plant within a given area coverage. Increase in LAI stay-green and maintain photosynthesis of green leaves during Reproductive (R1) stage (Tollenaar *et al*., 2004). Generally, an increasing trend in LAI was observed with increased N application rates. The increase in LAI was possibly due to the improved leaf expansion in plants by giving optimum Nous fertilizers and thus helps plants to intercept more light for photosynthesis activities.

The result is in agreement, with the findings of, Haghighi *et al*. (2010) on maize who reported an increasing trend in LAI on maize due to an increase in N fertilizer application rates. Similarly, our results were also in corroboration with those of Turgut, (2000) and Akbar *et al*., (1999) who found that N rates and time of application have significant effects on maize phenology.

Table 8: Plant height (PH), Leaf Area Index (LAI) of Maize as influenced by N rate both at Adami Tulu and MARC 2014, Main Cropping Season.

	Adami Tulu (On Farm)		MARC (On Station)	
Treatments N (Kg/ha)	PH (cm)	LAI	PH (cm)	LAI
0	126.17^{d}	3.32^{c}	193.63^{d}	3.09^{d}
25	195.89^{cc}	3.84^{b}	236.83^{cb}	3.85^{c}
50	223.39^{b}	3.87^{b}	249.67^{b}	4.55^{cb}
75	224.94^{b}	3.99^{a}	260.00^{ab}	4.58^{cb}
100	232.00^{b}	4.14^{a}	266.50^{a}	5.07^{ab}
125	257.61^{a}	4.10^{a}	270.07^{a}	5.33^{a}
Mean	**207.11**	**3.84**	**241.76**	**4.54**
LSD (0.05)	**13.196**	**0.45**	**23.49**	**0.89**
CV	**9.65**	**6.59**	**5.46**	**4.98**

4.1.7. Above Ground Biomass Yield (AGB)

Maize above ground biomass was significantly (P<0.01) affected by the rate of N fertilizer. Consistent increment of above ground biomass as the rate of N fertilizer increased from 0 to 125 kg N ha^{-1} both on farm and on station (Table.4). The highest value was recorded at 125kg N ha^{-1}; with an increment was 11% while the lowest values observed from Neil treatment. The correlation analysis (Tables 9 &10) also shows that there were strong relationship between above ground biomass and that of N fertilizer rate. There was a general reduction in biological yield at lower N fertilizer rate. The result was in agreement with Fazal (2012); Increase in N levels significantly enhanced the biological yield.

Similar findings were reported by Wakene (2014). Number of fertile tillers and total biomass yield were significantly increased by N fertilization. Thus increases in these parameters directly or indirectly contributed to the increase in grain yield. Corresponding result were reported by Amanullah *et al.* (2009) in which biological yields of 14.70 t ha^{-1} were attained in maize in response to the N application at the rate of 180 kg N ha^{-1}.

4.1.8. Stover yield (Syld)

Maize Stover yield was significantly (P<0.01) affected by the rate of N fertilizer applied (appendix table.2); we observed regular increment in Stover yield in line with increasing N fertilizer rate. Highest Stover yield was attained with application of maximum N (125kg N ha^{-1}) level in both locations, the increment was 68% in Adami Tulu whereas 45% increment in MARC from the control treatment (Table. 4). Similar result was reported by Merkebu (2013), Maize Stover yield showed consistent increment due to the application of N. Its serve as a constituent of may plant cell component, including amino acids and nucleic acids. Therefore N deficiency rapidly inhibits plant growth, thus also inhibit sink source nutrient supplementation, finally reduction in dry matter production.

This result also in agreement with Tank *et al.* (2006) from Anand reported that maize recorded more grain and stover yield with the application of 140 kg N ha^{-1} and 180 kg N ha^{-1}, respectively on sandy loam soils. Similar kind of improvement of maize yield attributes and yield also reported by some other researchers elsewhere (Duraisami V. P., 2001; and Ramulu V., 2006) even up to 240 kg N ha^{-1}. Bharathi *et al.* (2010) reported that on clay soils of Guntur, Andhra Pradesh increase in yield attributes, kernel and Stover yield of maize under no-till condition was up to 240 kg N ha^{-1} application.

4.1.9. Grain Yield (Gyld)

The analysis of variance showed a significant (P<0.01) differences in maize grain yield due to the effect of N fertilizer rate applied (Table.4). Application of 75kg N ha^{-1} results 82% yield advantage over the control treatment at MARC. Additions of 100kg N ha^{-1} N fertilizer provide yield advantage of 114.9% over the control treatment at Adami Tulu. However it was dropped suddenly towards 125kg N ha^{-1}. This might be due the effect of extraneous factors also management activities for on station and on farm trials in addition to this rain fall (moisture) variability in the growing season of the crop, for the field were got excess it encourages luxuries (luxurious consumption) growth to the crop this extend the vegetative period and reduces the efficiency of source to convert the dry matter to sink rather the plant grow luxuriously and extends days to physiological maturity.

Table 9. Above Ground Biomass Yield (Byld), Stover Yield (SYld), and Grain Yield (Gyld) of Maize as influenced by N rate at Adami Tulu and Melkasa Agricultural Research Center 2014, Main Cropping Season.

	Adami Tulu (On Farm)			MARC (On Station)		
Treatments N (Kg/ha)	**Byld (ton/ha)**	**Syld (ton/ha)**	**Gyld (ton/ha)**	**Byld (ton/ha)**	**Syld (ton/ha)**	**Gyld (ton/ha)**
0	16.61^{d}	3.08^{d}	3.05^{d}	15.23^{d}	4.12^{f}	4.03^{e}
25	18.36^{cd}	5.02^{cd}	4.96^{c}	20.05^{cb}	5.07^{e}	5.11^{cd}
50	19.23^{c}	6.13^{c}	5.28^{cb}	20.93^{ab}	6.08^{d}	5.54^{c}
75	23.96^{b}	8.56^{b}	6.12^{ab}	21.27^{ab}	6.70^{c}	8.07^{a}
100	23.68^{b}	9.33^{a}	6.55^{a}	21.18^{ab}	7.10^{b}	7.34^{b}
125	27.22^{a}	9.68^{a}	5.35^{cb}	23.12^{a}	7.48^{a}	6.82^{b}
Mean	**20.93**	**15.09**	**5.02**	**19.95**	**5.83**	**5.97**
LSD (0.05)	**2.34**	**2.2**	**0.85**	**2.7**	**0.31**	**0.64**
CV	**9.5**	**12.42**	**14.53**	**7.61**	**2.98**	**6.08**

This could be attributed to the fact that yield and yield components depend on better growth and development of the crop which was observed with the plants applied N fertilizer, hence, better photosynthetic processes for higher assimilate production leading to higher grain yield.

The lowest grain yield was obtained from untreated plots. Consistent with these results, Neil et al (2004) also reported that a greater yield response was obtained for maize with increasing N application under adequate soil water condition. Similarly report by Merkebu (2013) higher application rates of N and Green manure (GM) increased grain yields of maize and lower grain yields were obtained particularly at low levels of N and GM. According to the result of this experiment application of 100kg N ha^{-1} rather than blanket recommendation (64kgN ha^{-1}) in split, first at sowing and second at mid vegetative stage resulted highest grain yield of hybrid maize. Our result also in agreement with Alam and Haider (2006) who indicated that increased N level increased total dry matter irrespective of cultivars. In addition with this Torbert *et al.* (2001) reported that yield and yield component of maize were increased by increasing the rate of applied N.

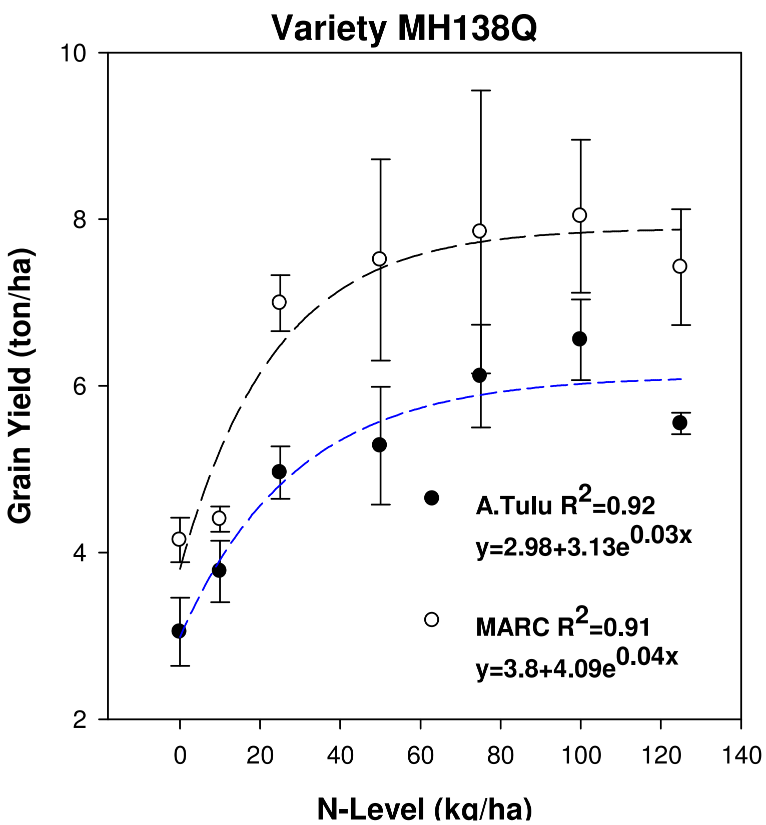

Figure.1: Exponential Growth Curve Model (non-linear regression) between Grain Yield and applied N-fertilizer on both locations, at Adami Tulu and MARC, 2014 Main Cropping Season.

4.1.10. Thousand Kernel Weight (TKW)

The result of analysis of variance shows that thousand kernels weight (TKW) was significantly (P<0.01) affected by the rate of N fertilizer (Table 5). Result of statistical analysis shows that increasing N rates from the control treatment up to 100kg N ha^{-1}increase thousand kernels weight at both Adami Tulu and MARC. Thus might be the result of N which has a direct contribution to chlorophyll content and enhancing metabolic activities finally to protein synthesis in the grain. The grain is a storage organ for starch.

Table 10: Harvest index (HI), Thousand Kernel weight (TKW) and Grain N Content (SN) of QPM Maize influenced by N Rate in Adami Tulu and MARC, 2014 Main Cropping Season

	Adami Tulu (On Farm)			MARC (On station)		
Treatment N (kg/ha)	**HI%**	**TKW**	**SN**	**HI%**	**TKW**	**SN**
0	33.83[c]	219.17[d]	1.51[c]	49.493[cd]	139.75[d]	1.39[c]
25	37.50[cab]	242.83[bc]	1.56[ab]	50.187[cd]	208.83[cb]	1.44[cb]
50	38.00[cab]	257.30[b]	1.59[ab]	47.647[d]	248.96[ab]	1.48[cab]
75	42.50[a]	299.50[a]	1.67[ab]	54.620[a]	250.33[ab]	1.49[cab]
100	41.17ab	315.26[a]	1.67[ab]	50.817[cb]	261.03[a]	1.57[ab]
125	40.00[cab]	307.03[a]	1.69[a]	47.663[d]	218.50[cab]	1.61[a]
Mean	**38.31**	**267.72**	**1.6**	**50.53**	**214.59**	**1.49**
LSD(0.05)	**0.069**	**28.74**	**0.176**	**3.03**	**46**	**0.156**
CV	**15.37**	**9.14**	**9.32**	**3.37**	**12.05**	**5.87**

The highest thousand kernel weight was recorded from 100kgNha^{-1} treatment followed by 125kg N ha^{-1}at Adami Tulu. Similarly 100kg N ha^{-1} provide higher TKW followed by 75kg N ha^{-1} at MARC, while the lowest TKW was recorded from the control treatment at both locations, the increment in 1000kernels weight due to N also revealed relatively higher grain yields. But for economical return use of those treatments should be based on the economic analysis of both treatments.

Maize 1000 kernels weight was reduced as a result of N shortage, as N levels decreased confirming that N is the principal nutrient controlling the growth and development of crops in general. That is why the control treatment had the lowest 1000 kernels weight as compaired to the rest of the treatments. This result is in agreement with increased amount of N-application in the experiment conducted at various places reported increased thousand seeds weight (Aulakh and Pasrich, 2007). Akbar *et al*. (2002) and Rasheed *et al*. (2004) also concluded that increasing level of N enhanced 1000-grain weight in maize. Since Increased kernel weight with increasing N levels might be due to the formation of more leaf area which might have intercepted more light and produced more carbohydrates in the source which was probably translocated into the sink (the grain) and resulted in more increased kernel weight than the control. Also, increasing N rates increases the enzyme activity in maize which may result in production in dry mater and result higher kernel weight.

4.1.11. Harvest Index (HI)

The physiological efficiency and ability of a crop for converting the total dry matter into economic yield is known as harvest index. Harvest index (HI) was significantly (P<0.01) affected by the rate of N fertilizer, the result shows that increasing N from 0 to 75kg N ha^{-1} increase harvest index but after wards there is no a significant difference among harvest index by increasing N above 75kgNha^{-1} at both location (Table.3).

This result indicates that grain formation was highly affected by N rate. Since HI is the balance between the productive parts of the plant and the reserves which forms the economic yield, greater improvement in grain yield compared to the corresponding increases in Stover yield might have contribute to the increase in harvest index across the increasing levels of N. But harvest index was decreased at higher dose of the treatment (125kg ha^{-1}), this might be the result of lower biomass partitioning to grain production when N was increased rather encouraging the vegetative growth.

The lower mean HI values in this experiment for the higher N application might indicate the need for the enhancement of biomass partitioning through genetic improvement of crop plant. On the same trend lowest harvest index was recorded from the control treatment, is the result of low grain and Stover yield ratio, comparatively with the treatments received more N-fertilizer (Urea and DAP). This result is in agreement with results were reported by Gupta (2004) in which application of N showed linear and consistent HI increment ranging from 30% to 25% over the control. Likewise, Mosavi *et al*. (2008) reported that 28% HI increment was recorded due to N-fertilizer application as compared to the control treatment. However, the current finding disagrees with the findings of Tenaw (2000) who reported that harvest index did not differ significantly among the different levels of N

4.2. Grain Nitrogen Content

Analysis of variance indicate that shows significant ($p<0.05$) between the control and added fertilizer rates, but there exist none significant difference of Seed N content with addition of N fertilizer above 10kg N ha^{-1} at both locations (table .4). Correlation analysis shows a strong positive relationship was existed between N-application rates and grain N-content thus reveal that increasing the N fertilizer rate enhances the source to make drier mater in the sink. Generally, the result indicated that as N-Fertilizer increases grain N content increase consistently but in this study statistically not significantly increasing seed N as rate of N fertilizer increase. Our result in agreement with Jaliya, (2012) there was no significant difference in maize grain N content between varieties tested. But Weiser and Seilmeier (1998) reported that protein content was strongly influenced by N. Sip*et al*. (2000) reported that application of N in split doses increased grain protein content by 1.55%, the content of protein increased significantly with increasing dose of N application which disagreed to this result. Asif *et al*. (2013) also reported that Protein contents continued to increase with increasing N levels.

Conclusion

Nutrient management for crop production requires that quantitative information on all nutrient sources be made available. Inadequate uses of nitrogen fertilizer result in lower yield. On the other hand over application of the fertilizer have detrimental effect to the environment. Hence, nitrogen fertilizer management is among the most important concerns to maximize yields and yield component of maize crop. In view of this, a field experiment was conducted to study the effects of different rates of inorganic nitrogen fertilizer at the rates (0, 25, 50, 75,100 & 125kg/ha) on yield related traits and yield of maize on farm and station condition using RCBD with 3 replications. The results of the soil sample test showed that the soil of the experimental site was contained sand 35%, silt 40%, and clay 25% and sand 23%, silt 48%, and Clay 28%, at Adami Tulu and MARC Respectively. Clay content might indicate better water and nutrient holding capacity of the soil in the experimental site. Soil PH of 7.88 & 7.43 belongs to alkaline, whereas organic carbon content of the soil was 1.55% and 1.23% at Adami Tulu and MARC respectively. This indicates suitability of the soil reaction in the experimental site for optimum crop growth and yield.

Plant height, number of grains per ear, leaf area, leaf area index, grain yield, above ground biomass stover yield,1000 kernels weight harvest index, were significantly ($P<0.05$) affected by N fertilizer rate. However, seed nitrogen content was not affected by rate of N-fertilizer. Increased application of N fertilizer rate up to 75kg/ha increasing grain yield in both location. Also the economic analysis shows economic benefit using 75kgN/ha. Hence based on the result we recommend this for both locations. Levels of N fertilizers applied, agro-ecological suitability of the experimental area for this specific maize variety might have contributed to this difference. Our study in agreement with the result of the present study and as various other studies has shown. Since nutrient availability is a function of a number of factors and their interactions, fertilizer recommendations for crops in most cases should be based on soil tests for plant available nutrients. However, a major limitation is that, for the same sites plant species and management systems may differ from year to year due to different seasonal conditions. As a general conclusive remark, the result of the current study provided base line information for further research and development efforts in soil fertility management for sustainable utilization of the soil resources in the area. This experiment was conducted only in two locations for one cropping season on one crop variety. Hence, studies involving different hybrid varieties and different N levels replicated in seasons over several locations should be conducted in order to recommend agronomically optimum and economically feasible rates of N under the agroclimatic conditions of the areas.

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