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ARTICLE

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Full length Research Paper

Effect of rootstock type and scion cultivar on apple leaf total nitrogen in Chencha, GamoGofa zone, Southern Ethiopia

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This study was conducted to evaluate the interaction between rootstock type and scion cultivar on total nitrogen (N) concentration in the leaf of grafted apple scion at Chencha district of GamoGofa zone, Toloa site. For this purpose rootstocks MM.104, MM.111, MM.106, and M.26 were planted in a completely randomized design with three replications under naturally acidic soil (pH 4.8) condition. After two months of growth the rootstocks were grafted with scion of apple cultivars Crispin, BR, Granny Smith, Jonica and Royal Gala. After six months of growth, total N concentration in the leaf of scions was analyzed. Results showed that rootstock type had significant influence on total N concentration in leaf of apple scion. Highest (2.48 mg kg^{-1}) and the lowest (1.71 mg kg^{-1}) total N concentration were recorded on MM.106 and M.26 rootstocks, respectively. There was also significant difference in leaf total N between scions. Arrangement of scions from highest to lowest of total N concentration in leaf was Crispin (2.35 mg kg^{-1}), Granny Smith (2.13 mg kg^{-1}), Jonica (1.96 mg kg^{-1}), Royal Gala (1.86 mg kg^{-1}), and BR (1.74 mg kg^{-1}). The result showed that the concentration of N in leaves of Crispin and Granny Smith were within the adequate range ($2.00\text{-}2.25 \text{ mg kg}^{-1}$), while Jonica, Royal Gala, and BR was below the range. In evaluate of rootstock and scion interaction distinguished rootstock type and scion cultivar have influence on leaf total N concentration.

Key words: Apple, rootstocks, scion cultivar, total N concentration.

INTRODUCTION

The coverage of acid soil in Ethiopia is close to 40% of the landmass and from this 15.6% is strongly acidic (Mesfin, 2007). The availability of N decreases with the decrease in soil pH < 5 (Pam and Brain, 2007). Apple production is practiced for many years under naturally occurring acidic soil of Chencha, Southern Ethiopia. Apple rootstocks have differences in absorption and utility

of total nitrogen. Rootstocks directly have influence on ability of grafted plant to absorption of water and nutrients from soil. Between plant nutrient elements, total nitrogen caused direct role in photosynthesis, carbohydrates and protein synthesis has very importance to plant growth and development control (Taiz and Zeiger, 2015). Rootstocks greatly affect the vigor, productivity of plants

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and quality of the fruit by their differences in absorption and translocation of mineral elements from soil which ultimately affect the overall performance of the plants.

The availability of plant nutrients is considerably affected by soil pH. It has been reported that in the area with very low soil pH (< 5.0), cations of Al^{3+} , Fe^{2+} , and Mn^{2+} , normally bound to negatively charged soil colloids, become solubilised and are available for plant uptake (Tromp et al., 2005; Alan et al., 2009). Nitrogen and other macronutrients are less available below pH 5.5, such that they can become deficient in the plant (Alan et al., 2009). Other study reported that, in the soil with low pH value, nitrogen were tied up in the soil and not available for uptake of the plants (Tromp et al., 2005). A number of studies have reported that, different rootstocks induce clear differences in absorption and transport of nutrients to the scion cultivars. However, the performance of rootstocks differs from site to site and/or region to region, types of scion cultivars and thus, there is no universal rootstock for all climatic and soil conditions (Tromp et al., 2005; Przemyslaw and Maciej, 2006). Thus, apple cultivars obtain adequate amount of nitrogen based on the types of rootstocks used (Taiz and Zeiger, 2015). Although vigour's rootstock, a key source for high apple fruit yield in Chenchu highland where the soil pH(4.8) is mostly acidic at experimental site, study on rootstocks and scion interaction on absorption of nitrogen under low soil pH stress remained far from scientific investigation. Therefore, the aim of this investigation has been to evaluate the effects of rootstock type and scion cultivar on leaf total N concentration of apple scions in stage of grafted plant production.

MATERIALS AND METHODS

In order to evaluate the influence of rootstock type and scion cultivar on leaf total N concentration in grafted plants of apple cultivars an experiment was conducted in the field. Vegetatively propagated apple rootstocks MM.104, MM.111, MM.106, and M. 26 were planted with three replications in completely randomized design. Necessary cares were done until grafting stage. After two months of growth the rootstocks were grafted with Crispin, Royal Gala, Granny Smith, Jonica and BR (local name) cultivars. Under each block, there were four plots, each with 15 trees in three replications. A total of 180 apple trees (3 blocks x 4 plots x 15 cultivars) were planted with 1.5 m space between trees and 2 m between rows. The blocks and plots were 2 m by 1.8 m apart, respectively. Organic and inorganic fertilizer was not used during study period.

The pH of the soils was measured in water and potassium chloride (1M KCl) suspension in a 1:2.5 (soil:liquid ratio) potentiometrically using a glass-calomel combination electrode following Van Reeuwijk (1992) method. For soil N analysis the soil was sampled from surface layer (0 to 30 cm) from six random spots across the field using an auger before the rootstocks were planted. Soil sample was air dried and ground to pass a 2 mm size sieve. The total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by Schuman et al. (1973) in Arba Minch University chemistry laboratory. After six months of growth the apple cultivars leaf was analyzed. Samples of ten young leaves that were near base of current season growth were collected from

three replications. Leaves were air dried under the shade and then dried in an oven at 70°C to constant weight. Completely dried leaves were ground to pass 1 mm sieve and stored in airtight plastic bottles for nitrogen analysis.

Nitrogen concentration in leaf samples was determined according to modified Kjeldahl method in which 0.5 g sample digested in concentrated H_2SO_4 and distilled with NaOH (40%). The ammonium N was fixed in H_3BO_3 (2%) and titrated with 0.1 N H_2SO_4 following the procedure described by Kucukyumuk and Erdal (2011). The obtained data was analyzed by MSTAT-C software and means compared by Duncan's multiple range test. Sigma plot 10 was used to present the analyzed data in different graphs.

RESULTS AND DISCUSSION

The soil pH and total N tested at experimental site was 4.8 and 0.35 % respectively. Landon (1991) indicated the total soil N of >1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and <0.1% as very low. Under low soil pH (4.8) of study site, total N (0.35%) qualified for the medium range indicating that the availability of N decreased by decreasing soil pH < 5 (Pam and Brain, 2007). According to the result of two way analysis of variance significant differences ($P \leq 0.05$) were recorded between rootstocks, scions and their interaction (Table 1). The effect of low soil pH (4.8) on rootstocks total nitrogen absorption was significant ($P < 0.000$). In agreement with this, previous study indicated that, apple rootstocks nutrient absorption thrive best in soils with pH of 5.5 to 6.5 (Webster, 2005). In this study, significant differences between MM.111 MM.106, MM.104, and M.26 rootstocks in uptake and transport of N to the scion were recorded.

Among the four types of rootstocks used, the result revealed that, MM.106 rootstock had significantly highest level of N followed by MM.104 while M.26 was the lowest (Figure 1). As shown in Figure 1, the highest concentration of total N (2.09 mg kg^{-1}) was recorded in scion leaf grown on MM.106 rootstock and lowest (1.93 mg kg^{-1}) in scion leaf on M.26 rootstock. The results agree with Kucukyumuk and Erdal (2011) who reported that rootstocks had a significant effect on scion leaf mineral concentration in apples.

There was significant difference in ($P \leq 0.05$) level of Duncan's Multiple Range test between all scions with regard to total N concentration (Figure 2). The amount of total N in scions leaf was variable from 1.72 to 2.34 mg kg^{-1} . Highest total N concentration (2.34 mg kg^{-1}) was recorded in leaf of Crispin and lowest (1.72 mg kg^{-1}) in leaf of BR (local name). Arrangement of scions from highest to lowest of total N concentration in leaf was Crispin, Granny Smith, Jonica, Royal Gala, and BR.

The standard values of nitrogen level in apple tree leaves established by Heckman (2004) indicates the ranges for N, 2.00 to 2.25 mg kg^{-1} is rated as adequate. The result showed that the amounts of N in leaves of Crispin and Granny Smith were within the acceptable limits, while Jonica, Royal Gala, and BR registered below

Table 1. Analysis of variance of total nitrogen concentration in scion leaf.

| Source of variation | d.f | M.S | F | P-value |
|---------------------|-----|---------|---------|---------|
| Rootstocks | 3 | 0.0686 | 33.316 | 0.000 |
| Scion cultivars | 4 | 0.670 | 325.418 | 0.000 |
| Rootstock x scion | 12 | 0.00556 | 2.700 | 0.009 |
| Error | 40 | 0.00206 | - | - |

Significance is at $P \leq 0.05$.

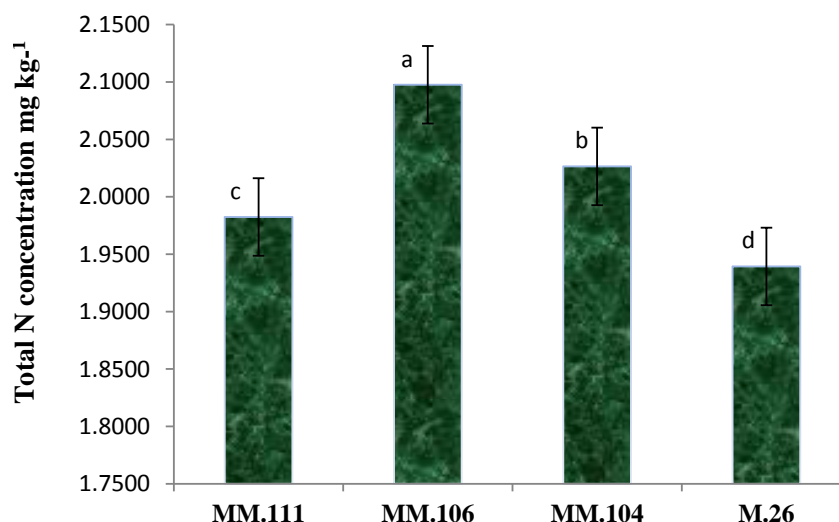


Figure 1. Mean comparison of the effect of rootstock type on total N concentration. Means with same letter in each column have not significant difference in 1% level of DMRT. Values are the means of 3 repetitions \pm SE.

the range except Jonica on MM.106.

There was significant interaction between rootstock type and scion cultivar in viewpoint of total N concentration (Table 2). Leaf of Crispin on MM.106 rootstock had highest total N concentration (2.48 mg kg^{-1}) followed on MM.104, MM.111 and M.26 in descending order. Among the grafted scion the lowest total N concentration (1.71 mg kg^{-1}) was observed in BR leaf on M.26 rootstock. Total N concentration in leaf of Royal Gala on MM.106, and MM.104 rootstocks approximately was equal but it was significantly at the lowest level on M.26 rootstock. Total N concentration in leaf of Granny smith and Jonica on all rootstocks had significant difference at 1% level of Duncan's test whereas in leaf of BR on all rootstocks except MM.106 had not significant difference (Table 2).

Comparison of the obtained amounts with optimum total N established by Heckman (2004) showed that, total N concentration in leaf of Crispin and Granny Smith on all rootstocks was in optimum range. Between rootstocks, only MM.106 had optimum range of total N concentration in Jonica scion in contrast to the rest three rootstocks (Table 2). This indicate that, under naturally occurring low

soil pH of 4.8, Jonica on MM.106 was more compatible in uptake of total N compared to other three rootstocks. In contrast, total N concentration in the leaf of both Royal Gala and BR grafted on all rootstocks was less than optimum range, relatively more in Royal Gala than BR. This indicated that, the uptake and transport of nutrients to the scion was mainly determined by the type of rootstocks on which the cultivars were grown. These findings agree with the earlier report by Abdolhossein et al. (2012) who reported that, rootstocks directly influence the ability of grafted cultivars for absorption of nutrients from the soil.

On the basis of this study it can be said that, among the four types of rootstocks, MM.106 could operate better than other rootstocks in uptake of total N under the soil condition of study site. Thus, apple rootstocks used showed significant differences in absorption and transport of total N which could possibly be due to their differences in uptake of total N. These results are according to findings of Iqbal et al. (1999) who reported that, under similar soil conditions, some apple rootstocks absorb more nitrogen from soil and transfer to shoots, which reason of this subject can be due to rootstocks genetics.

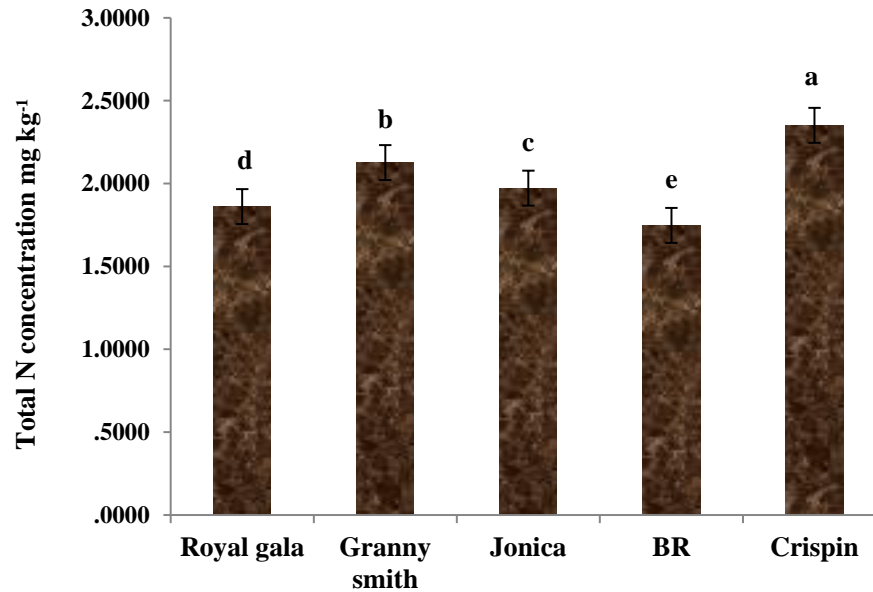


Figure 2. Mean comparison of the effect of scion cultivars on leaf total N concentration of apple cultivars. Means with the same letter in each column have not significant differences in 1% level of DMRT. Values are the means of 3 repetitions \pm SE.

Table 2. Effect of rootstock and scion interaction on total N concentration.

| Scion | Rootstock | | | |
|--------------|-------------------|-------------------|-------------------|-------------------|
| | MM.111 | MM.106 | MM.104 | M.26 |
| Royal Gala | 1.84 ⁿ | 1.89 ^m | 1.88 ^m | 1.82 ^o |
| Granny Smith | 2.09 ^g | 2.21 ^d | 2.14 ^f | 2.06 ⁱ |
| Jonica | 1.91 ^k | 2.08 ^h | 1.97 ^j | 1.90 ^j |
| BR | 1.72 ^q | 1.81 ^o | 1.73 ^q | 1.71 ^q |
| Crispin | 2.34 ^c | 2.48 ^a | 2.40 ^b | 2.18 ^e |

Values are the means of 3 repetitions Means with same letters have no significant difference in 1% level of DMRT.

On the other hand, the result of rootstock and scion interaction showed that rootstock type and scion cultivar affect total N concentration in leaf of apple cultivars. Generally, from our results, under soil condition of this experiment in stage of grafted plant production, Crispin and Granny Smith cultivars on MM.111, MM.06, MM.104 and M.26 and Jonica on MM.106 rootstocks utilize soil total nitrogen effectively and between these Crispin on MM.106, MM.104, MM.111 and Granny Smith on MM.106 scions have higher efficiency (Table 2).

Conclusion

The study confirmed that the uptake and transport of N to the apple scion was determined by the type of rootstocks as well as scion cultivars. Although total N is in medium

range status in the soil, its absorption and translocation to the leaf of apple cultivars is affected due to limited availability under low soil pH. Under this soil condition, MM.106 rootstock is vigorous in absorbing and translocation of adequate N to the leaves of Crispin, Grany Smith and Jonica cultivars indicating an evidence for compatibility of the combination while M.26 was inferior to all the rest. On the other hand, all the rootstocks were found efficient to absorb and transport adequate N to the leaves of Crispin and Grany Smith. However, cultivar BR is inferior in translocation of N from all the rootstocks to its leaves.

Conflict of Interests

The authors have not declared any conflict of interests.

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