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INFLUENCE OF SOME APPLE ROOTSTOCKS GRAFTED BY GOLDEN DELICIOUS ON N, P, AND K MINERAL UPTAKE UNDER RAINFED CONDITIONS

SUMMARY

The study was carried out at the agricultural scientific research center in Sweida- GCSAR, to evaluate the influence of apple rootstocks on N, P and K minerals uptake in the vegetative parts during growth season. Two apple rootstocks; vegetative rootstock MM106 and seedling rootstock Malus domestica Borkh. Which grafted by Golden delicious cultivar were studied. The results showed that MM106 rootstock revealed highest significant accumulation of Nitrogen in shoots in May (1.69%), while the seedling rootstock revealed the highest accumulation of nitrogen in leaves in May (2.81%).The highest fruit concentration of N was in June for the two rootstocks. Likewise, phosphorous content in shoots was the highest in June for the two rootstock (0.214% and 0.213% for MM106 and seedling rootstock, respectively), and the Phosphorous concentration of leaves was the highest in May on the seedling rootstock than MM106 rootstock (0.23 and 0.22%, respectively), fruits significantly revealed the highest P content in August for the two rootstocks which was 0.15% in seedling rootstock and 0.18% in MM106. The K content was the highest for shoots and leaves in May for the two rootstocks, and seedling rootstock revealed higher concentration than MM106. Likewise, fruits significantly revealed the highest K content in August in trees grafted on seedling rootstock (1.15%). Consequently, this investigation showed different responses of rootstocks for uptake and accumulation of N, P and K mineral elements during growth season which lead to establish the correct strategy for fertilization management according to the planted rootstock under rainfed conditions.

Keywords: MM106, seedling rootstock, apple, N, P and K.

INTRODUCTION

Apple rootstocks show different responses to mineral uptake, which considered as the main factor affecting tree growth. Kennedy et al. (1980) reported that leaf mineral concentration was more influenced by environmental factors than by rootstock genotype. On the other hand, rootstocks effect flower

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development, yield and fruit quality of apple cultivars (Gao et al., 1992; Fallahi et al., 1994; Hirst and Ferree 1995). The influence of apple rootstock on tree size reflects the effect of rootstock on nutrient requirements (Fallahi, 2002). MM106 which classified as semi vigorous vegetative rootstock revealed higher content of K than M9 dwarf rootstock (Lockard, 1976). Fallahi et al.(2002) stated that the M9 rootstock revealed the lowest concentration of k in the comparison with M7 and M26. Cong et al.(2014) evaluated the efficiency of various apple (Malus domestica Borkh) rootstocks in their K uptake , they found that M. sieversii and M. rockii are K-inefficient genotypes; M. prunifolia is K-efficient genotype; M. hupehensis and M. robusta have moderate levels of potassium efficiency. Sotiropoulos (2008) studied the influence of five rootstocks grafted with Imperial Double Red Delicious on leaf mineral content, he found that the concentration of N and K in leaves were significantly lower in M7 and MM106 in comparison with seedling rootstock, while MM106 revealed the highest concentration of P. Likewise, Amiri et al. (2014) found that Golden delicious which grafted on seedling rootstock revealed high efficiency in K uptake in comparison with vegetative rootstocks, and showed the highest accumulation of N content on M9 rootstock, While revealed high efficiency in P uptake on MM106 rootstock.

Apple tree considered as the main fruit tree in Syria, and most of apple cultures are rainfed and depends on seedling rootstocks, in addition to start new planting of the semi vigorous rootstock MM106.Thus, the current study aimed to evaluate the response of the two rootstocks to uptake mineral nutrients under local conditions and to establish a guideline to estimate tree requirements of (N, P and K) nutrients which lead to an effective fertilization management.

MATERIAL AND METHODS

The present investigation was carried out at the Pome and grapevine division –GCSAR in Sweida province, which is located 1525m altitude at the south of Syria. The soil is clay with low content of organic material and nitrogen, high content of phosphorous and moderate content of potassium, pH 6.5 to 6.8, the rainfall 525mm.

Plant material

-Seedling rootstock Malus domestica Borkh: Vigorous rootstock with deep roots has good tolerance to frost and drought conditions can grow in different soil types.

-MM106 rootstock: semi vigorous vegetative rootstock, derived from the hybridization between M1 and Northern spy, resistant to wooly apple aphid, has moderate tolerance for frost and drought.

-Golden delicious cultivar: Produced by seed selection in America, vigorous cultivar, fruits are globose- conical in shape with good flavor, maturity time during October under the conditions of target area.

Soil analysis

It was achieved two times, the first analysis was at autumn before adding the nutritional elements and the second one was achieved after adding the

nutritional elements and organic material at the beginning of growth season to determine the soil content of organic material, N, P, and K according to (Jackson, 1962) N, P and K contents in the vegetative parts (Shoots, leaves and fruits) 15 years old apple trees Golden delicious cultivar which grafted on seedling and MM106 rootstocks were studied under rainfed conditions monthly during growth season:

-Shoots and leaves: 5 shoots and 30 leaves from each tree in each replicate were collected, washed with distilled water, dried on 68°c, and powdery grinded for chemical analysis.

-Fruits: 5 fruits from each tree in each replicate were collected monthly from June until October, Washed with distilled water and dried, then prepared as slices and dried on 68°c until weight stability and powdery grinded for chemical analysis.

-Nitrogen content: Kjeldahl method was used to determine the nitrogen content by humid digestion according to (Van Schouwenberg and Walinge , 1973).

-Phosphorous content: Total phosphorous was measured by colorimetric method after humid digestion. (Jones et al., 2001)

-Potassium content: Samples were prepared by humid digestion, the potassium content was determined using flame photometer apparatus (Benton, 2001).

Statistical analysis

Completely randomized block design to compare the two rootstocks. The analysis of variance was done using two way ANOVA to compare means of measured parameters by LSD test ($p < 0.05$).

RESULTS AND DISCUSSION

Soil analysis

Table 1, showed that the organic material was raised in the spring but still low than the normal content which was less than 2%, (Nelson and Sommers,1982) stated that the poor soils contain less than 2% organic material, moderate soils contain 2-3%, while rich soils contain more than 3%. Phosphorous was in high concentration for the two treatments in the two times, depending on Olsen et al. (1954) the soil content of phosphorous is very high if reached more than 20 ppm. Potassium content was very high in MM106 rootstock treatment, while it was moderate in seedling rootstock treatment. Thomas (1982) stated that the soil content of potassium is moderate when it was 240-320 ppm, high from 320 to 400 ppm and very high (more than 400 ppm).

N, P and K contents in the vegetative parts mineral analysis based on whole tree is an effective method to determine tree nutrient requirements (Weinbaum et al. 2001). In general, vegetative parts content of N, P, and K decreased along the apple tree vegetative cycle (Nachtigall and Dechen, 2006).

Table 1. Soil content of organic material, Nitrogen (N),Phosphorous (P) and Potassium (K)

Time	Treatment	Organic material%	(ppm) N	(ppm) P	(ppm) K
Autumn	Seedling rootstock	0.96	240	60	118
Autumn	MM106 rootstock	0.92	230	59.7	245
Spring	Seedling rootstock	1.508	372	88.5	260
Spring	MM106 rootstock	1.856	464	74	500

Nitrogen (N) Content

The results showed that the shoots of Golden delicious cultivar grafted on MM106 significantly has higher accumulation of N than the seedling rootstock, the highest significant concentration of N in the two rootstocks was in May, then continuously decreased until July to arise again in August, after that the seedling rootstock showed stability of N content until October to arise again in November, while MM 106 rootstock revealed continuously decreasing of N accumulation until October, to arise again in November with high accumulation than the seedling rootstock . The high accumulation of N in shoots during November may due to the mobility of N contents from leaves to the shoots. Leaves, also, revealed the highest significant accumulation of N in May for the two rootstocks, and the seedling rootstock significantly revealed high accumulation than MM106 (2.81% and 2.71%,respectively), the two rootstocks showed different behaviors of N accumulation during the growth season (Table 2). N content continuously decreased in seedling rootstock until September to arise again in October, while MM106 showed an increasing of N accumulation in August in significant variance with seedling rootstock (2.21% and 2.07%, respectively) then decrease in September to arise again in October with no significant variation between the two rootstocks. Kucukyumuk and Erdal. (2011) stated that MM106 rootstock revealed the highest accumulation of N in leaves during July, then decreased in August. Fruits also, significantly revealed the highest concentration of N in June for the two rootstocks, seedling rootstock showed higher content of N than MM106 with no significant variance (0.76% and 0.74%,respectively). The two rootstocks showed the same track by continuously decreased until August, to arise in September, then decreased again in October with no significant variance between the two rootstocks. Thomas and Drake (1997) showed that fruit N contents was negatively related to N content in leaves. Likewise, Casero et al., (2005) stated that there is negative correlation between leaf N content and fruit N content at harvesting time.

Phosphorous (P) Content

P requirements in apple trees are small relative to other nutrients (Jackson, 2003).P is the factor in energy transfer and is a constituent of nucleic acids (Salisbury and Ross, 1992), and always required at stages of meristematic activity (Neilsen and Neilsen, 2003). The highest significant accumulation of P in shoots of Golden delicious cultivar grafted on MM106 rootstock was in May and June, while the seedling rootstock revealed the highest significant accumulation of P in June in the comparison with the other growth months. MM106 revealed higher accumulation of P than the Seedling rootstock except in October and November with significant variance. Somehow, the rate of P uptake by the two rootstocks was variable during the growth season; In seedling rootstock, the P content was continuously decreased until August which significantly revealed the lowest content (0.13%), to arise in September and October to decrease again in November, in MM 106 rootstock, the P content still decreased until July, then arise in August and September to decrease again in October and November which showed low concentration than seedling rootstock with significant variance in November (Table 2). In leaves, Seedling rootstock showed High significant concentration of P in May than MM106, also, the two rootstocks significantly revealed the highest concentration of P in May in the comparison with other growth months, then continuously decreased until July, which was in agreement with Nachtigall and Dechen (2006). P content increased again in August for MM106, and then decreased in September and October, while the seedling rootstock continued decreasing of P content until September to arise again in October. Sotiropoulos (2008) found that the concentration of P in apple leaves during July was higher in MM106 than seedling rootstocks which was disagree with our results. Fruits revealed the highest P content in August for the two rootstocks which was 0.15% in seedling rootstock and 0.18% in MM106 with significant variance. The two rootstocks showed the same behavior for P uptake during all growth months and the seedling rootstock revealed high accumulation of P in October than MM106 (0.07 and 0.06, respectively). Nachtigall and Dechen, (2006) obtained significant positive linear regressions in Golden Delicious' for total P in the fruits, and the total P nutrient quantities removed by fresh fruits at harvest time of Golden Delicious cultivar was 0.005% which was in agreement with our results.

Potassium (K) content

Potassium is the most abundant cation in the cytoplasm and plays an important role in pH stabilization, osmoregulation, enzyme activation, protein synthesis, stomatal movement, photosynthesis and cell extension (Faust,1989).Potassium deficiency is harmful to the physiological functions as well as fruit development (Stassen et al.,1999). As in N and P the results showed that the two rootstocks revealed the highest significant accumulation of K in shoots during May in the comparison with all other growth months, while there was no significant variation between the two rootstocks. In the seedling rootstock the amount of K continuously decreased until September to arise again

until November which revealed higher accumulation than MM106 (0.58% and 0.56%, respectively). MM 106 revealed the same track as seedling rootstock until July to arise in August then decreased in September to arise again in October and decreased in November. Stassen and Stadler (1982) indicated two stages of K uptake, the first one three weeks after bud break and the second at leaves drop. Leaves, also showed the highest amount of K in May for the two rootstocks, and seedling rootstock significantly revealed high accumulation of K during the vegetative growth cycle in the comparison with MM106.

Table 2. N, P and K contents in the vegetative parts of Golden Delicious trees grafted on seedling and MM106 rootstocks

Month	Rootstock	N%			P%			K%		
		shoots	leaves	fruits	shoots	leaves	fruits	shoots	leaves	fruits
May	seedling	1.55b	2.81a	-	0.19ab	0.29a	-	0.91a	1.96a	-
	MM106	1.70 a	2.71 b	-	0.21 a	0.24 b	-	0.86 a	1.64 c	-
June	seedling	0.81 f	2.37a	0.76a	0.21a	0.19c	0.13c	0.53bc	1.94a	0.97 b
	MM106	0.88 e	2.53 c	0.74a	0.21a	0.19c	0.13c	0.55b	1.46d	0.87c
July	seedling	0.68g	2.19 ef	0.31b	0.13e	0.19c	0.10 d	0.44cd	1.88b	0.70 e
	MM106	0.79f	2.14f	0.33b	0.16cd	0.18c	0.10 d	0.35de	1.44d	0.75 d
August	seedling	0.79f	2.07g	0.21f	0.13e	0.15d	0.15 b	0.37de	1.14e	1.15 a
	MM106	1.00d	2.21e	0.23ef	0.18b	0.18c	0.18 a	0.39de	0.86f	0.86c
September	seedling	0.80f	1.66k	0.27c	0.17bc	0.10g	0.11 d	0.32e	0.89f	0.47 g
	MM106	0.95d	1.87i	0.27c	0.18b	0.13e	0.13c	0.32e	0.69 g	0.51f
October	seedling	0.80f	1.91h	0.24de	0.17bc	0.12 f	0.07 e	0.53b	0.87f	0.49 f
	MM106	0.89e	1.93h	0.2cd	0.17bc	0.12f	0.06 e	0.58b	0.68g	0.49 fg
November	seedling	0.84 ef	-	-	0.16cd	-	-	0.56b	-	-
	MM106	1.16c	-	-	0.14de	-	-	0.54b	-	-
LSD5%		0.05	0.05	0.02	0.02	0.01	0.01	0.09	0.05	0.02

The accumulation rate was identical for the two rootstocks; The K concentration still decreased from May until October. Our results were in agreement with Nachtigall and Dechen (2006), they found that the leaf K decreased along the vegetative growth cycle. Mengel and Kirkby (2001) explained that the mineral concentration is depending on the leaf status; young leaf tissues usually present lower water content and higher N, P and K concentrations, meanwhile older tissues are rich in Ca, Mn, Fe and B mainly. Fruits revealed high concentration of K in June for the two rootstocks, which decreased in July to show another stage of K accumulation in August which was 0.86% in MM106 while the seedling rootstock significantly revealed the highest value (1.15%) of all growth months, to decreases in September and arises again in October (Table 2). Likewise, MM106 showed continuously decreasing until October. Potassium was the nutrient present in highest quantities in apple tree fruits and thus, the most removed from the soil (Nachtigall and Dechen, 2006).

Faust (1989) stated that the most of K nutrient is accumulated in fruits, and in the absence of fruits it is stored in the leaves, and after harvest the total tree showed a reduction in the K content due to the fruit removal, which is in agreement with our results.

CONCLUSION

As a result, Golden delicious cultivar which grafted on seedling rootstock and MM106 significantly revealed high concentration of N, P and K in May for shoots and leaves, and in June for fruits except K in seedling rootstock. Seedling rootstock showed higher concentration of K in leaves and fruits than MM106, while MM106 revealed higher concentration of N and P in shoots. On the other hand, each rootstock revealed another peak for each mineral nutrition especially shoots but in different times, also, the apple tree fruits removed higher quantities of potassium as compared to the other nutrients. That leads to establish the correct strategy for fertilization management according to the planted rootstock and the type of soils and irrigation. Moreover, these results might be useful as standard reference values of different apple tree phonological stages for the leaf analysis interpretation of current laboratory data.

REFERENCES

Amiri M. E., Fallahi, E., Safi-Songhorabad, M. (2014). Influence of rootstock on mineral uptake and scion growth of‘ golden delicious’ and ‘royal gala’ apples. Journal of Plant Nutrition, 1: 16-29.

Benton, J. J. (2001). Laboratory Guide for Canducting Soil Tests and Plant Analyses. C.R.S Press Washington, U.S.A. 363 P.

Casero., Benavides, A., Puy, J. and Recasens, I. (2005). Relationships Between Leaf and Fruit Nutrients and Fruit Quality Attributes in Golden Smoothee Apples Using Multivariate Regression Techniques. Journal of Plant Nutrition, 27(2): 313-324.

Cong, C., Chao, L., Cui-ying, L., Xiao-yu, K., ZOU Yang-jun, Z. and Feng-wang, M. (2014). Differences in the Efficiency of Potassium (K) Uptake and Use in Five Apple Rootstock Genotypes. Journal of Integrative Agriculture, 13(9): 1934-1942.

Fallahi, E., Colt, W.M., Fallahi, B. and Chun, I. J.(2002). The importance of apple rootstocks for tree growth, yield, fruit quality, leaf nutrition and photosynthesis with an emphasis on "Fuji".Hort. Technology, 12(10): 38-44.

Fallahi, E., S imons, B. R., Fellman, J. K., Longstroth, M. A., and Colt, W.M., (1994). Tree growth and productivity and postharvest fruit quality in various strains of ‘Delicious’ apple. J. Am. Soc. Hort. Sci.,119: 389-395.

Faust, M. (1989). Physiological of temperate zone fruit trees. John Wiley and Sons. Newyork,Pp: 31-53.

Gao, Y., M otosugi, H., and Sugiura, A., (1992).Rootstocks effects on growth and flowering in young apple trees grown with ammonium and nitrate nitrogen. J. Am. Soc. Hort. Sci., 117: 446-452.

Hirst, P. M., and Ferree, D. C. (1995). Rootstock effects on shoot morphology and spur quality of‘Delicious’ apple and relationships with precocity and productivity. J. Am. Soc. Hort. Sci., 120: 622-634.

Jackson, M. L., 1962. Soil Chemical Analysis, Prentice-Hall, Inc., Englewood Cliffs, N.S.

Jackson, J. E. (2003). Biology of apples and pears. Cambridge university press.

Jones, J., Wolf, J. B. and Mills, H. A. (1991). Plant analysis handbook. Micro-Macro Publishing, Inc., Athens, GA, USA.

Kennedy A.T., Rowe P.W. and Samuelson T.J. (1980). The effects of apple rootstock genotypes on mineral content of scion leaves. Euphytica, 29: 477–482.

Kucukyumuk. Z and Erdal, I. (2011). Rootstock and cultivar effect on mineral nutrition, seasonal nutrient variation and correlations among leaf, flower and fruit nutrient concentrations in apple trees. Bulgarian Journal of Agricultural Science, 17 (5) : 633-641.

Lockard, R. J. (1976).Effects\of apple rootstocks and length and type of interstock on leaf nutrient level. J. Hort. Sci., 51: 289-296.

Mengel, K. and Kirkby, E.A. (2001). Principles of plant nutrition. 5.ed. Dordrecht: Kluwer Academic Publishers, pp. 849.

Nachtigall,G. R. and Dechen, A.R. (2006).Seasonality nutrients in leaves and fruits of apple trees. Sci. Agric. (Piracicaba, Braz.), 63 (5): 493-501.

Neilsen, G. H. and Neilsen, D. (2003). Nutritional requirements of apple. In: D. C. Feree and I. J. worrington (eds). Apple: Botany, production and uses. CAB, international, Cammbridge.

Nelson، D.W. and Sommers L.E. (1982). "Total carbon، organic carbon، and organic matter"، In: Page، A. L.، Miller، R. H. and keeney، D. R. (Editors)، Methods of soil analysis، Part II(2nd Edition). Madison، WI., pp. 1159.

Olsen, S. R., Cole, C. V., Watanabe, F. S., and Dean, L. A., 1954. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. US. Dept. Agric. Cric., 939.

Stassen, P. J.C.and Stadler, J. d.(1988).Seasonal uptake of phosphorous, potassium, Calcium and magnesium by young peach trees. Plant and Soil, 5 (1): 19-23.