American-Eurasian J. Agric. & Environ. Sci., 15 (12): 2324-2330, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.12.12826

Effect of Root Pruning on Carbohydrates and Leaf Pigments Content of Le-Conte Pear Trees

[1]*T.A. Yehia,* [1]*A.A. Hegazi,* [2]*Malaka A. Saleh,* [2]*Dorria M. Ahmed,*
[2]*Nagwa S. Zaied and* [2]*S.A.M. Hassan*

[1]Department of Pomology, Faculty of Agriculture, Cairo University, Giza, Egypt
[2]Department of Pomology, National Research Centre, Dokki, Giza, Egypt

Abstract: This study aimed to investigate the effect of root pruning treatments on carbohydrate and chlorophyll content of "Le Conte" pear trees. This study was conducted on 11-year old "Le Conte" pear trees grown in loamy soil during three successive seasons. Root pruning treatments involved 30, 60 and 90 cm at a depth of 50 cm from sides of trunk at bud break and full blood stage during seasons of 2008, 2009 and 2010. Results indicated that the direct and residual effects of 30 cm root pruning treatment at the two seasons of 2008 and 2009 produced the highest significant values of specific leaf dry weight (11.16 and 7.01 mg/cm^2), respectively. Generally, the direct and residual effect of all treatments significantly increased the total carbohydrate percentages in the leaf of "Le Conte" pear trees. Meanwhile, the residual effects of 30 cm root pruning produced the highest significant percentage of total leaf carbohydrates as it reached 42.88% and 41.23% compared with unpruned fruits (control) which exhibited total leaf carbohydrates percentages (21.88 and 20.17) at the two seasons of 2008 and 2009. Moreover, all treatments significantly increased the leaf content of chlorophyll *a* and chlorophyll *b* and also total chlorophylls content in the residual effect of applied treatments. In addition, the lowest total chlorophylls content (22.57 mg/100g) was produced from control trees. On the other hand, the highest chlorophyll content (25.97 mg/100g) resulted from 30 cm root pruning treatments. Thus, it could be recommended from the results of this study by using 30 cm root pruning treatmentas significantly increased the leaf carbohydrate and chlorophyll contents of "Le Conte" pear trees.

Key words: Le Conte pear · Root pruning · Carbohydrates · Chlorophyll *a*, *b* · Total chlorophylls

INTRODUCTION

Le Conte is the main pear cultivar grown in Egypt, resulted as a hybrid between *Pyrus communis* x *Pyrus serotina*. Productivity of pear orchards varies in Egypt from year to year and from location to other. Pruning is an essential cultural practice in the production of pears. Pruning establishes the structure of tree, its shape and form, provides a framework to support the crop and facilitate mechanical operations. Pruning also makes the canopy more open and improves best control by allowing better spray penetration into the tree, air movement throughout the canopy increased, which improves drying condition and reduces severity of many diseases [1]. Root pruning is controlling canopy size, but there are several obvious negative effects associated with this practice. Early studies show that root pruning could reduce the yields of fruit trees due to lowered leaf area index hence a reduced photo-assimilate supply [2, 3]. The energy requirement for the additional root growth following root pruning, comes from the storage components in the above ground parts of the apple trees [4, 5]. The high amounts in the below ground parts of apple trees, suggesting a role for starch as the major storage carbohydrate. There were high levels of starch concentration in the below ground parts compared to the above ground parts (shoot, stem bark) during both seasons after root pruned. Interestingly, there was little difference in starch concentration values for unpruned and root pruned trees. This was consistent for both seasons after root pruning, which suggested that the total amount of carbohydrates relative to the tree size, affects the yield level rather than the concentration of reserves [6].

Corresponding Author: Sayed A.M. Hassan, Department of Pomology, National Research Centre, Dokki, Giza, Egypt. E-mail: sayed_ebead@yahoo.com.

Additionally, it was found that after root pruning at bloom time, bearing reduced the leaf size of apple trees. The presence of fruit would alter tree response through its impact on carbohydrates partitioning [7]. On the other hand, the high total carbohydrates concentrations in the shoot during spring promoted high flower induction which results in high flowers number and high yields in the following year of apple trees [8]. There were few reports on the effects of root pruning on whole canopy photosynthesis of apple trees. Photosynthesis and transpiration on a single leaf basis have been shown to be reduced by root pruning of apple [9, 10]. On the opposite, the root carbohydrates cleared that, not only reserves are higher than reserves in other storage tissues, but also that root reserves do not substantially decrease until bud break of sweet cherry [11].

Therefore, the present study was carried out to investigate the effect of root pruning at bud break, full bloom stages and different distances from trunk on the total carbohydrates and chlorophyll pigments content of "Le Conte" pear trees.

MATERIALS AND METHODS

This study was carried out in the Agricultural and Experimental Research Station of the Faculty of Agriculture, Cairo University, Giza Governorate, Egypt during three successive seasons 2008, 2009 and 2010. Forty two healthy and uniform Le Conte pear trees of 11 years old budded on *Pyrus communis* rootstock (*Pyrus communis* L), grown in loamy soil were selected under the experimental study. Trees were planted at 5x5meters apart and were irrigated with closed basin surface system and received normal fertilization and cultural practices as scheduled in the program of the station.The applied treatments as follow:unpruned trees (control), root pruning at 50 cm depth 30, 60 and 90 cm on both sides of the trunk at bud break stage and at full bloom. Each treatment was comprised of three replicate trees [12]. The present study included experiments as follows:

Physical Leaf Characteristics:

Specific Dry Weight of Leaves: Leaves of known area were dried in an electric oven at 70°C until a constant was weight reached. Then SLDW (mg/cm^2) was calculated from the following formula:

$$SLDW\ (mg/cm^2) = (\text{Leaves dry weight (g)} \times 1000) / \text{Leaves area } (cm^2)$$

Chemical Leaf Characteristics: Leaves from each tree of each considered replicate were picked at leaf maturity. They were chosen from the middle portion of current year shoots. Leaves were mixed roughly and representing samples were selected for determinations of pigments. The other sample was oven dried at 70°C till constant weight and then grounded for determination of total carbohydrates.

Leaf Pigments Content: The following pigments, i.e. chlorophyll *a*, *b* and total chlorophylls as mg/100g were determined by colorimetric determination in fresh leaves samples at wave length of 663 and 645 nm for chlorophyll *a*, *b*, respectively and also the total chlorophylls content was determined according [13].

Leaf Carbohydrates Content: Total carbohydrates, 0.1 (g) from previous dried sample of leaves was used to determine total carbohydrates according to Smith *et al*. [14].

Statistical Analysis: The obtained data was statitictical analyzed by using factorial experiment in randomized complete block design. Results of the measured parameters were subjected to computerized statistical analysis using MSTAT and the significant differences among the various treatments were compared by using LSD at 0.05 according to Snedecor and Cochran [15].

RESULTS AND DISCUSSION

Physical Leaf Characteristics

Specific Dry Weight of Leaves: In both seasons 2008 and 2009, the direct effect of 30 cm root pruning treatment produced the highest significant value of specific leaf dry weight as it reached to 11.16 and 6.22 mg/cm^2 compared to the other treatments (Fig.1). Meanwhile, the lowest levels of specific leaf dry weight (8.48 and 5.70 mg /cm^2) were produced with control trees in both seasons, respectively. During season 2009, the residual effects of 30 cm root pruning treatment produced the highest significant of specific leaf dry weight reached to 7.01 mg/cm^2, followed by the other treatments, while the bud break was higher than full bloom date (Fig.2). At season 2010, the residual effects of 30 cm root pruning produced the highest significant value of specific leaf dry weight reached to 6.13 mg /cm^2 followed by the other treatments and bud break was superior compared with full bloom date.

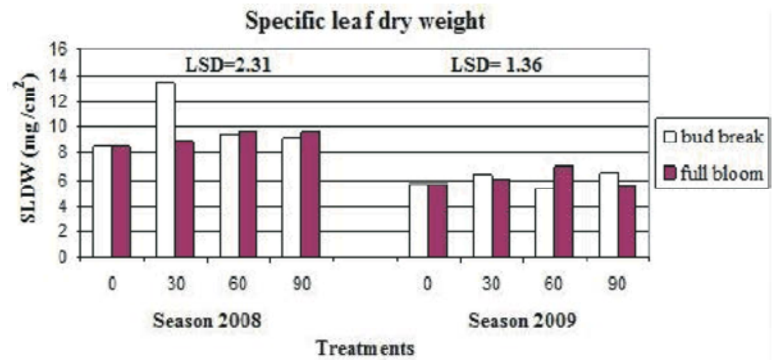

Fig. 1: Direct effect of root pruning distance and dates on specific leaf dry weight of pear 'Le Conte' trees.

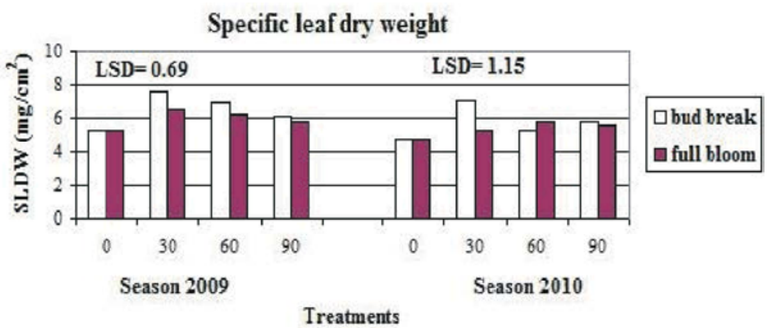

Fig. 2: Residual effect of root pruning distance and dates on specific leaf dry weight of pear 'Le Conte' trees.

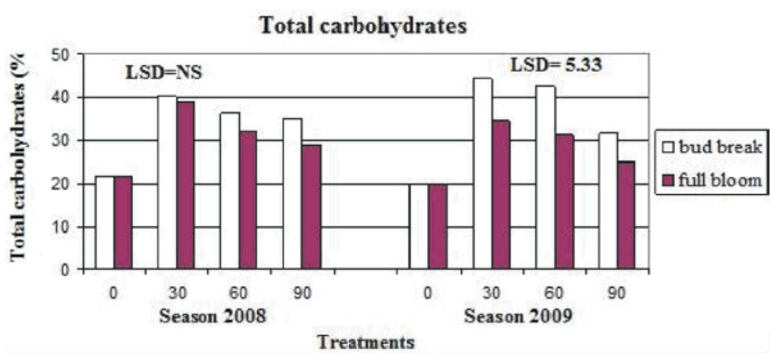

Fig. 3: Direct effect of root pruning distance and dates on total carbohydrates of pear 'Le Conte' trees.

On the other hand, the lowest level of specific leaf dry weight (5.25 and 4.69 mg /cm^2) was produced from control trees in both seasons, respectively. These results partially are in agreement with the findings of Taher *et al*. [16], who reported that root pruned at 30 cm increased leaf area and leaf dry weight at bud break than full bloom of pear trees.

Chemical Leaf Characteristics

Total Carbohydrates: During both seasons 2008 and 2009, the direct effect of all treatments significantly increased total leaf carbohydrates percentage compared to the control trees, which recorded the lowest significant values of these parameters, while bud break date was higher than full bloom (Fig.3). The direct effect of 30 cm root pruning treatment produced the highest significant percentages of total leaf carbohydrates (39.64% and 39.55%) in the 2008 and 2009 seasons, respectively (Fig.3). Meanwhile the lowest significant total carbohydrates percentages (21.88% and 20.17%) were produced with control (unpruned trees) in both seasons, respectively. Similarly, the residual effects of all treatments during 2008 and 2009 seasons of this study significantly increased total carbohydrates percentage in the leaves compared to the control trees, which recorded the lowest significant values of these parameters (Fig.4). The residual effects of 30 cm root pruning produced the highest significant percentage

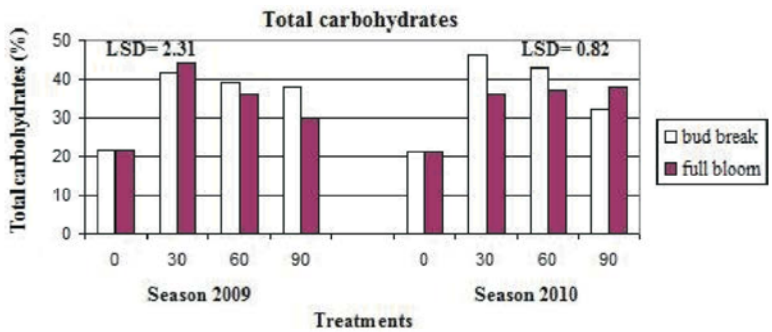

Fig. 4: Residual effect of root pruning distance and dates on total carbohydrates of pear 'Le Conte' trees.

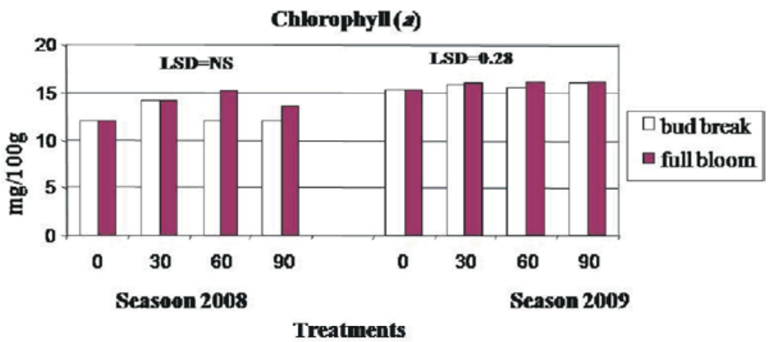

Fig. 5: Direct effect of root pruning distance and dates on chlorophyll *a* of pear 'Le Conte' trees.

of total leaf carbohydrates (42.88% and 41.23%) followed by other treatments, while the bud break was superior to full bloom date in both seasons. On the other hand, the lowest total carbohydrates percentages (21.60% and 21.35%) was produced with control (unpruned trees) in 2009 and 2010 seasons, respectively (Fig.4). Interestingly, there was little difference in starch concentration values for unpruned and root pruned trees. This was consistent for both seasons after root pruning, which suggested that it is the total amount of carbohydrates relative to the tree size that affects yield level rather than the concentration of reserves. Whereas, Khan *et al*. [8] postulated that high total carbohydrates concentrations promotes high flower induction which results in high flowers number and high yields in the following year of apple trees.

All of treatments significantly increased total carbohydrates percentage in leaves. These results could be confirmed with those reported by Yang *et al.* [17], who mentioned that, total sugars were increased in Zhanhuadongzao (*Ziziphus jujube* Mill.) trees were evaluated. In another study, Brown *et al*. [6] found that starch was found in high amounts in the below ground parts of apple trees, suggesting a role for starch as the major storage carbohydrates.

Chlorophyll (*a*): During season 2008, the direct effects of all treatments did not significantly affect chlorophyll *a* content. The highest chlorophyll *a* content (14.15 and 16.03 mg/100g) was produced from all root pruning treatments, while the full bloom was higher than bud break date in the second season (Fig.5). On the other hand, the lowest chlorophyll *a* content (12.04 and 15.27 mg/100g) was produced from control trees in 2008 and 2009 seasons, respectively. The residual effects of all treatments produced the highest significant chlorophyll *a* content in 2009 and 2010 seasons. Meanwhile, the 30 cm root pruning produced the highest significant chlorophyll *a* content (16.38 and 16.41 mg/100g), whereas, the bud break was more superior compared with full bloom in both seasons, respectively (Fig.6).

Chlorophyll (*b*): The highest chlorophyll *b* content (9.36 and 10.12 mg/100g) resulted from all root pruning treatments in the 2009 season (Fig.7),while the lowest (7.23 mg/100g) chlorophyll *b* content was produced from control trees in the second season 2009. The residual effects of all treatments produced the highest significant chlorophyll *b* in the 1st and 2nd season.

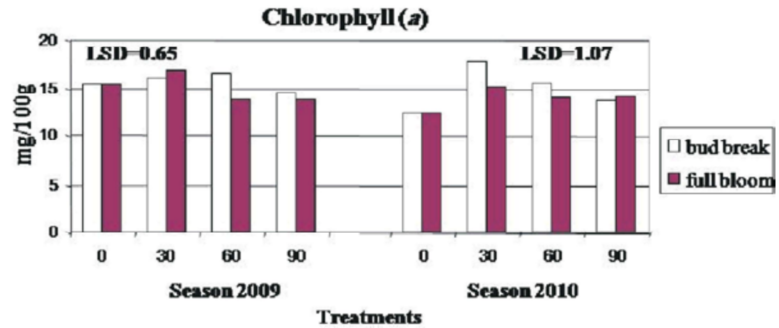

Fig. 6: Residual effect of root pruning distance and dates on chlorophyll *a* of pear 'Le Conte' trees.

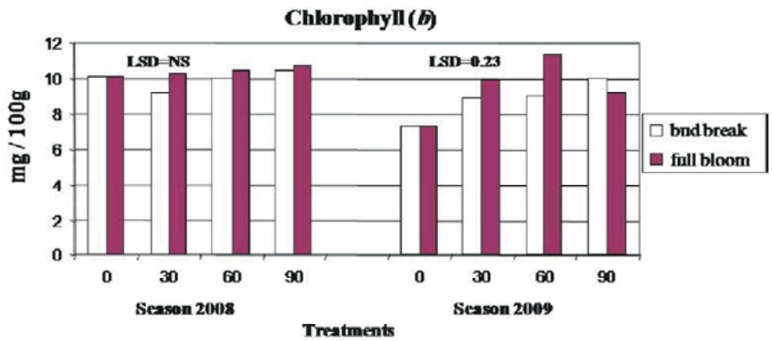

Fig. 7: Direct effect of root pruning distance and dates on chlorophyll *b* of pear 'Le Conte' trees.

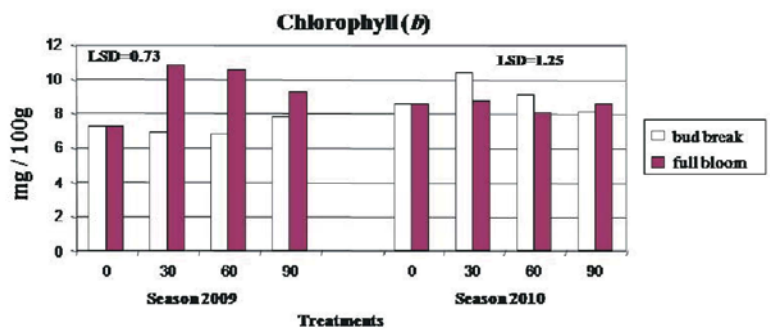

Fig. 8: Residual effect of root pruning distance and dates on chlorophyll *b* of pear 'Le Conte' trees.

Meanwhile, the 30 cm root pruning produced the highest significant chlorophyll *b* content (8.84 and 9.52 mg/100g) in both seasons, respectively (Fig.8).

Total Chlorophylls: The highest content of total chlorophylls (25.32 and 25.97 mg/100g) resulted from all root pruning treatments, while the full bloom was higher than bud break date in the second season (Fig.9). On the other hand, the lowest significant total chlorophylls contents (22.17 and 22.50 mg/100g were produced from control trees in 2008 and 2009 seasons, respectively. The residual effects of all treatments produced the highest significant total chlorophylls content in both seasons. Meanwhile, the highest significant total chlorophylls content (25.22 mg/100g) was produced from 30 cm root pruning, while the full bloom date was higher than bud break in the first season (Fig.10). On the other hand, the lowest significant total chlorophylls content (22.57 mg/100g) was produced from control trees. Similarly, the highest significant total chlorophylls content (25.94 mg/100g) was produced from 30 cm root pruning, whereas the bud break was more superior compared with full bloom in the second season. The lowest significant percentage of total chlorophylls content (20.84 mg/100g) was produced from control trees. Concerning the effect of all root pruning treatments on leaf pigments contents, all treatments significantly increased chlorophyll *a*, chlorophyll *b* and total chlorophylls contents in

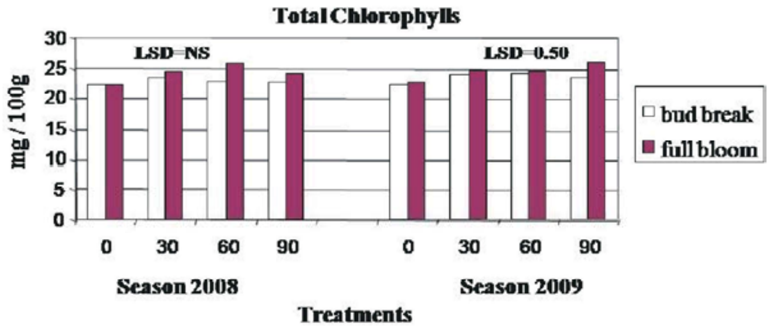

Fig. 9: Direct effect of root pruning distance and dates on total chlorophylls of pear 'Le Conte' trees.

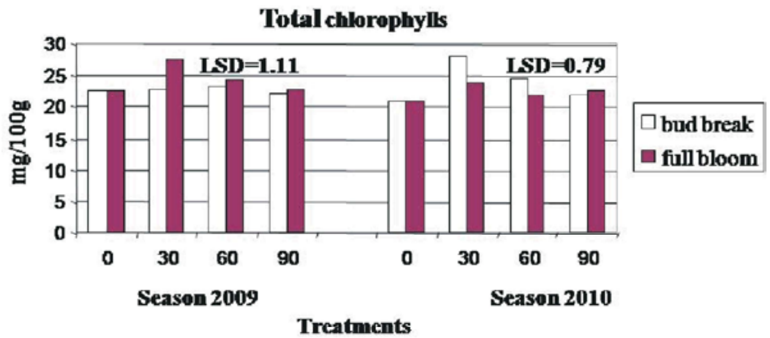

Fig. 10: Residual effect of root pruning distance and dates on total chlorophylls of pear 'Le Conte' trees.

the residual effect of applied treatments. These results are in agreement with those reported by Geisler and Ferree [9] and Schupp and Ferree [10] on the effects of root pruning on whole canopy photosynthesis of apple trees. Photosynthesis and transpiration on a single leaf basis have been shown to be reduced by root pruning of apple.

REFERENCES

1. Richard, P., 2009. Physiology of pruning fruit trees, College of Agriculture and life Sciences, Virginia Polytechnic Institute and State University, pp: 1-8.
2. Ferree, D.C., 1989. Growth and carbohydrate distribution of young apple trees in response to root pruning and tree density. HortScience, 24: 62-65.
3. Khan, Z.U., D.L. McNeil and A. Samad, 1998a. Root pruning reduces the vegetative and reproductive growth of apple trees growing under an ultra high density planting system. Scientia Horticulturae, 77: 165-176.
4. Hansen, P., 1971. 14C-studies on apple trees. VII. The early season growth in leaves, flowers and shoots and depended upon current photosynthesis and existing reserves. Physiol. Plant., 25: 469-473.
5. Hansen, P. and J. Grauslund, 1973. 14C-studies on apple trees, VIII. The seasonal variation and nature of reserves. Physiol. Plant., 28: 24-32.
6. Brown, C.S., E. Young and D.M. Pharr, 1985. Rootstock and scion effects on the seasonal distribution of dry weight and carbohydrates in young apple trees. J. Amer. Soc. Hort. Sci., 110: 696-701.
7. Schupp, J.R., D.C. Ferree and I.J. Warrington, 1992. Interaction of root pruning and deblossoming on growth, development and yield of "Golden Delicious apple. J. Hort. Sci., 67: 464-480.
8. Khan, Z.V., D.L. McNeil and A. Samed, 1998b. Effect of carbohydrate reserves on fruit yield and vegetative growth of apple trees growing in Ultra high density planting system under Canterbury condition. Cited in. http://hdl.handle.net/10182/1872.
9. Geisler, D. and D.C. Ferree, 1984. The influence of root pruning and water relation, net photosynthesis and growth of young Golden Delicious apple trees. J. Amer. Soc. Hort. Sci., 109: 827-831.
10. Schupp, J.R. and D.C. Ferree, 1987. Effect of root pruning at different growth stages on growth fruiting of apple trees. Hort. Sci., 123: 387-390.

11. Keller, J.D. and W.H. Loescher, 1989. Nonstructural, carbohydrate partitioning in perennial parts of sweet cherry. Journal of the Amer. Soc. Hort. Sci., 114: 969-975.
12. Taher A. Yehia, A.A. Hegazi, Malaka A. Saleh, Dorria M. Ahmed, Nagwa S. Zaied and S.A.M. Hassan, 2011. Effect of Root Pruning Flowering and Fruiting of Le Conte Pear Trees. Journal of Horticultural Science and Ornamental Plants, 3(3): 199-206.
13. Richardson, A.D., S.P. Duigan and G.P. Berlyn, 2002. An Evaluation of noninvasive methods to estimate foliar chlorophyll content. New Phyto., 153: 185-194.
14. Simth, F., M.A. Gilles, J.K. Hamilton and P.A. Gedess, 1956. Colorimetric methods for determination of sugar and related substances. Anal. Chem., 28: 350-356.
15. Snedecor, G.W. and W.G. Cochran, 1994. Statistical Methods. 9th Ed. Iowa State University Press, Ames, Iowa, pp: 507.
16. Taher A. Yehia, A.A. Hegazi, Malaka A. Saleh, Dorria M. Ahmed, Nagwa S. Zaied and S.A.M. Hassan, 2014. Effect of Root Pruning on Vegetative Growth and Leaf Mineral Content of Le Conte Pear Trees. World Journal of Agricultural Sciences, 10(5): 253-260.
17. Yang, S., S. Xing, C. Liu, Z. Du, H. Wang and Y. Xu, 2010. Effect of root pruning on the vegetative growth and fruit quality of zhanhuadongzao trees. Hort. Sci., 37(1): 14-21.