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Effects of Training Method, Ligth and Fruit Load on Photosynthesis and Transpiration in Apple

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SUMMARY

In this study, the effects of training method (slender spindles, Y-system), light (light, shade) and fruit load (trees with or without fruits) on the rates of photosynthesis and transpiration of leaves on long and short shoots, flower formation and yield in apple cv. Cox's Orange were investigated.

As a result of the research, non-fruiting trees in 1994 gave more the rates of photosynthesis and transpiration in 1995. And Y-systems and light conditions were found more effective with respect to flower formation, yield, rates of photosynthesis and transpiration in both fruiting and non-fruiting trees than slender spindles and shade conditions.

Key words: Apple, photosynthesis, transpiration.

ÖZET

Elma'da Fotosentez ve Transpirasyon Üzerine Terbiye Metodu, Işık ve Ürün Yükünün Etkileri

Bu çalışmada "Cox's Orange" elma çeşidinde uzun ve kısa sürgünlerde bulunan yapraklardaki fotosentez ve transpirasyon oranları, çiçek oluşumu ve verim üzerine terbiye metodunun (Slender spindles, Y-

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sistem), ışığın (ışık, gölge) ve ürün yükünün (meyveli ve meyvesiz ağaçlar) etkileri araştırılmıştır.

Araştırma sonucunda, 1994 yılında ürün alınamayan ağaçlarda 1995 yılında daha fazla fotosentez ve transpirasyon oranları görülmüştür. Ayrıca hem meyveli hem de meyvesiz ağaçlarda, Slender spindles ve gölge ortamlarına göre, Y-sistem ve ışık òrtamlarında çiçek oluşumu, verim ile fotosentez ve transpirasyon oranları açısından daha etkili sonuçlar elde edilmiştir.

Anahtar Kelimeler: Elma, fotosentez, transpirasyon.

INTRODUCTION

A lot of exogenous and endogenous factors role on flower formation, photosynthesis and transpiration in fruit species. Some of the these factors are training method, light and fruit load in apple (Leopold and Kriedemann 1975, Childers 1976, Monselise and Goldschmidt 1982).

The training method can influence the vegetative development, flower bud formation, flowering, yield and hence Photosynthesis and transpiration since it directly affects the number of branches and leaves irradiation and air circulation (Teskey and Shoemaker 1978).

In apple orchards, solar radiation and particularly pohotosynthetically active radiation (PAR) is a primary environmental factor limiting regularity of flowering and cropping as well as fruit quality. The intensity of light within the canopy is strongly decreased by matual shading of leaves (Palmer 1977, Blanke and Notton 1992).

It has been suggested that fruit load influences photosynthetic rates of apple leaves. This has been obtained mostly by determining photosynthetic rates of single leaves, by translocational studies, or by methods of growh analysis. Nearby it is a fact that the fruit load in apple tree is effective on the root and leaf development of plant (Hansen 1970, Lenz 1978, Monselise and Lenz 1980, Lenz 1986, Sritharan and Lenz 1989, Buwalda and Lenz 1992, Wibbe et al. 1993).

In the following paper, the effects of training method, light and fruit load are shown on the flower formation, the rates photosynthesis and transpiration of leaves on short and long shoots.

MATERIAL AND METHODS

The research was carried out at "The Institut für Obstbau und Gemüsebau der Universitat Bonn (Germany)" in 1995. Three-year-old apple (*Malus domestica* Borkh. cv. Cox's Orange) trees on M9 rootstock were used.

The trees were irrigated by drip irrigation and the fertilization was achieved through irrigation. The nutrient solution contained 4.5 mM $Ca(NO_3)_2.4H20$, 1.0 mM NH_4NO_3, 1.0 mM KH_2PO_4, 2.0 mM $MgSO_4.7H20$, 1.5 mM K_2SO_4 and Fe chelate.

The study was conducted on two training methods (Slender Spindles and Y-system) under day light and shading (artificial shade fabric which admitted only 42 % of full sky light). For each application fruting (+Fr) and non-fruting (-Fr) trees in 1994 were used.

In May 1995 photosynthesis and transpiration rates per tree were measured. Moreover the data of 1994 related to yield and total flower formation per tree were utilized.

In the measurements related to photosynthesis and transpiration, the leaves on long and short shoots of trees were used independently. For this purpose, 5 leaves were sampled from short and long shoots each.

Photosynthesis and transpiration were measured outdoors between 10.00-16.00 hr at three sunny days by prometry under natural solar irradiance. A portable steady state porometer system type LCA 2 (The Analytical Development Company, ADC, Hoddesdon, England) with attached data logger type D11 was connected to an Epson HX 20 computer and data were processed using a commercial on line photosynthesis programme type ADC 1200. A leaf surface of 6.25 cm2 was enclosed in a 16 cm^3 volume cuvette, type PLC broad, to measure leaf gas exchange. Boundary layer resistance was kept below 0.015 m^2Smol-1 with the aid of a fan to prevent CO_2 gradients within the leaf cuvette. All measurements were made by using the atmospheric air at a flow rate of 300 mlmin-1 by the infra red gas analyser in the LCA-2 using differential measurement, while temperature and light photon flux were simultaneously recorded with the PLC sensors, processed by computer, and data such as transpiration rate and photosynthetic rate were obtained. Mean air temperature and relative humudity on the first sampling date May 22, 1995 was 24.2°C and 35.2 %, and second sampling date May 25, 1995 was 25.3°C and 38.2 % third sampling date May 26, 1995 was 26.6°C and 40.2 %, respectively.

RESULTS

Flower Formation

Number of flowers per tree related to fruiting and non fruiting trees in 1994 are given in Table 1.

As can be seen in Table 1, the flower formation in both training methods was more in light conditions compared with shade in general. When the training methods are compared, it is possible to see that Y system produced more flowers than slender spindles. Also in the observations of 1995, more flowers were determined on the trees trained Y-system and in light conditions. It was observed that the non fruiting trees in 1994 produced to many flowers in 1995 (-Fr) as a result of alternate bearing.

Table: 1
The Effects of Training Method, Light and Fruit Load on The Average of the Flower Number Per Tree in 1994

Treatment	Light		Shade	
	-Fr	+Fr	-Fr	+Fr
Slender Spindles	1.7	2049.0	0.3	414.0
Y - System	127.5	2832.0	21.7	598.5

- Fr : without fruit in 1994
+ Fr : with fruit in 1994

The relation between yield per tree in 1994 and different training methods, light conditions are given Table 2.

Table: 2
The Effects of Training Method and Light on the Avarage of Yield (kg) Per Tree in 1994

Treatment	Light	Shade
Slender Spindles	10.2	4.7
Y - System	23.6	8.5

The highest yield was recorded for Y-shaped trees in both light and shade conditions when compared with slender spindles. The lowest yield per tree was observed from slender spindles in shade.

Photosynthesis

As demonstrated in Table 3 photosynthetic rates of 1995 were higher in leaves of plant having non fruit (-Fr) in the previous year (1994) as compared to those in plant having fruit load (+Fr) in 1994.

It is noticeable that photosynthetic rate was higher in the trees under light conditions than those under shade. Furthermore, it is observed that the leaves on short shoots produced more assimilates than ones on long shoots except the Y systems (-Fr) under light conditions.

Tablo: 3

The Effects of Training Method, Light and Fruit Load on Photosynthetic Rates of Leaves in Short and Long Shoots in 1995

Treatment	Photosynthesis (μmol CO_2 m-2 s-1)			
	Light		Shade	
	-Fr	+Fr	-Fr	+Fr
Slender Spindles	L 10.21 S 16.20	4.10 4.20	12.27 15.40	3.51 4.10
Y-System	L 18.10 S 17.41	5.18 7.40	12.10 14.40	2.20 3.40

\- Fr : without fruit in 1994
\+ Fr : with fruit in 1994

Transpiration

The transpiration rate of the leaves on long and short shoots in 1995 are given in Table 4.

Table: 4

The Effects of Training Method, Light and Fruit Load on Transpiration Rate of Leaves on Short and Long Shoots in 1995

Treatment	Transpiration (mMol H2O m-2 s-1)			
	Light		Shade	
	-Fr	+Fr	-Fr	+Fr
Slender Spindles	L 6.11 S 6.12	5.40 5.32	5.11 5.41	4.10 4.17
Y-System	L 8.11 S 7.12	6.14 6.12	6.46 6.83	5.20 5.84

\- Fr : without fruit in 1994
\+ Fr : with fruit in 1994

The transpiration rate was found higher in non-fruiting (-Fr) trees than the fruiting ones (+Fr). The transpiration rates of leaves on long or short shoots were similar to each other either in Slender Spindles or in Y-system.

DISCUSSION

With this research it was indicated that there was a close relation between the factors of fruit load, training method, light and the rates of photosynthesis and transpiration in apple cv. Cox Orange. As a matter of fact many researchers mentioned about the effects of training methods (Teskey and Shoemaker 1978), light (Palmer 1977, Blanke and Notton 1992) and fruit load (Hansen 1970, Lenz 1978, Monselise and Lenz 1980, Lenz 1986, Sritharan and Lenz 1989, Buwalda and Lenz 1992, Wibbe et al. 1993) on this subject.

In this study it was observed that the trees produced few flowers and fruit in the previous year (1994) gave a photosynthetic rate tree-fold higher in 1995. This situation was probably orginated from the fact that the plant in (+Fr) of 1995 period produced more carbohydrates in order to form more flower and fruits. The increased photosynthesis in the trees (+Fr) of 1995, hastened the water vapour exchange from leaves, i.e, the transpiration.

In general the higher yields in Y system compared with slender spindles (both in -Fr and +Fr periods) and the higher rate of photosynthesis orginates from the more number of leaves, and more utilization from light in this system. Therefore, it will be beneficialy to use traning systems which will produce more leaf area and that will provide more subjection to light. In this situation, the flower formation and number of fruits will increase, especially due to the increase in leaf area and induction of photosynthesis rate.

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REFERENCES

BLANKE, M.M., NOTTON, B.A. 192. Light Transmission into Apple Fruit and Leaves. *Sci. Hort.* 51: 43-53.

BUWALDA, J.G., LENZ, F. 1992. Effects of Cropping, Nutrition and Water Supply on Accumulation and Distribution of Biomass and Nutrients for Apple Trees on M9 Root Systems. *Physiol. Plant.* 84: 21-28.

CHILDERS, N.F. 1976. Modern Fruit Science. Horticultural Publications, 3906 NW 31 Place, Gainesville, Florida, p. 583.

HANSEN, P. 1970. C-14 Studies on Apple Trees: VI. The Influence of The Fruit on The Photosynthesis of Leaves, and The Relative Photosynthetic Yields of Fruits and Leaves. *Physiol. Plant.*, 23: 805-810.

LENZ, F. 1978. Photosynthesis and Respiration of Citrus as Dependent Upon Fruit Load. Proc. Int. *Soc. Citruculture,* 70-71.

LENZ, F. 1986. Fruit Effects on Transpiration and Dry Matter Production in Apples. p. 101-104. In: A. Lakso und F. Lenz (Eds). The Regulation of Photosynthesis in Fruit Trees. Symp. Poc. Publ. N.Y. State Agr. Expt. Sta, Geneva, New York.

LEOPALD, A.C., KRIEDEMANN, P.E. 1975. Plant Growth and Development. Mc Growth Hill, INC, USA, p. 545.

MONSELISE, S.P., LENZ, F. 1980. Effect of Fruit Load on Photosynthetic Rates of Budded Apple Trees. *Gartenbauwissenschaft,* 45(5): 220-224.

MONSELISE, S.P., GOLDSCHIMIDT, E.E. 1982. Alternate Bearing in Fruit Trees. In: Jules Janick (Ed). Horticultural Reviews, AVI Publishing Company, INC Westport, USA, 128-166.

PALMER, J.W. 1977. Light Transmittance by Apple Leaves and Canopies. *J. Appl. Ecol.* 14: 505-513.

SRITHARAN, R., LENZ, F. 1989. The Influence of Long-Term Water Stress and Fruiting on Photosynthesis and Transpiration in Apple. *Gartenbauwissenschaft,* 54(4): 150-154.

TESKEY, B.J.E., SHOEMAKER, J.S. 1978. Tree Fruit Production. AVI Publishing Company, INC., Westport, Connecticut, USA, p. 409.

WIBBE, M.L., BLANKE, M.M., LENZ, F. 1993. Effect of Fruiting on Carbon Budgets of Apple Tree Canopies. Trees, 8: 56-60.