



# Review Report on Irrigation Management Scheme

---

*ORGANIKO LIFE+ PROJECT*

*Revamping organic farming and its products in the context of climate change mitigation strategies*

*Type of deliverable: Report*

*Partner: Agricultural Research Institute*

*Author: Damianos Neocleous*

*Contributors: Michalis Omirou, Dionysia Fasoula*



## Table of Contents

<b>Executive Summary.....</b>	<b>3</b>
<b>Introduction .....</b>	<b>5</b>
<b>Estimation of apple trees net irrigation demands .....</b>	<b>7</b>
<b>Understanding tree water needs during the growing season .....</b>	<b>7</b>
<b>Irrigation systems in Cyprus.....</b>	<b>8</b>
<b>Apple orchards irrigation scheduling in Cyprus .....</b>	<b>9</b>
<b>Ways of better usage of water resources .....</b>	<b>12</b>
Soil Moisture Monitoring for a more precise irrigation scheduling.....	12
Crop Management Practices .....	12
<b>Conclusions.....</b>	<b>13</b>
<b>Literature.....</b>	<b>13</b>



## Executive Summary

### Σκοπός

Στόχος του παραδοτέου είναι παροχή λεπτομερών πληροφοριών για τις στρατηγικές άρδευσης στην βιολογική καλλιέργεια των μήλων και του κριθαριού στα πλαίσια της δράσης C1. Συγκεκριμένα τα παραδοτέα “Review Report of Irrigation Management Scheme” και “Irrigation Scheme for each crop” συνενώθηκαν για σκοπούς συνοχής.

### Αντίκτυπος

Για την ολοκλήρωση της έκθεσης, πραγματοποιήθηκε ανασκόπηση όλων των διαθέσιμων μεθόδων άρδευσης σήμερα στην Κύπρο και για τα δύο καλλιεργούμενα είδη σύμφωνα με τα διαθέσιμα στοιχεία του Ινστιτούτου Γεωργικών Ερευνών.

### Αποτελέσματα

Η παραγωγή και η ποιότητα των παραγόμενων προϊόντων σε ξηρικές καλλιέργειες όπως το κριθάρι εξαρτάται πλήρως από την ετήσια βροχόπτωση (χρονικά και ποσοτικά). Από την άλλη πλευρά, η παραγωγή βιολογικών μήλων μειώνεται δραματικά χωρίς την χορήγηση στα δέντρα καλής ποιότητας νερού άρδευσης και για το λόγο αυτό οι πλήστοι παραγωγοί έχουν εγκατεστημένα βελτιωμένα συστήματα άρδευσης. Οι αρδευτικές ανάγκες των καλλιεργειών υπολογίζονται σύμφωνα με τις μεθόδους που προτείνονται από την FAO.

### Συμπεράσματα

Ωστόσο υπάρχουν σημαντικά περιθώρια βελτίωσης της αποδοτικότητας χρήσης του νερού και της διαχείριση άρδευσης των καλλιεργειών. Για παράδειγμα η παρακολούθηση των επιπέδων υγρασίας στα εδάφη για την βελτιστοποίηση του προγραμματισμού για την άρδευση αναμένεται να βελτιώσει περαιτέρω την αποδοτικότητα χρήσης του νερού. Πρακτικές όπως η κάλυψη του εδάφους με οργανικά υλικά, το κλάδευμα, η αφαίρεση καρπών στο κατάλληλο στάδιο, η ενσωμάτωση κομπόστας και η μείωση των εισροών N αναμένεται να βελτιστοποιήσουν την αποδοτικότητα χρήσης νερού της καλλιέργειας.



## **Purpose**

The aim of the deliverable is to provide detailed information on irrigation strategies in organic cultivation of apples and barley under Action C1. In particular, the "Report of Irrigation Management Scheme" and "Irrigation Scheme for each crop" have been brought together for consistency purposes.

## **Outcome**

For the completion of the deliverable, we reviewed all available irrigation methods currently available in Cyprus for both cultivated species (apples and barley) the irrigation management schemes and schedules were developed according to the available data from the Agricultural Research Institute.

## **Results**

Water availability and its quality are amongst the most important factors for sustainable and environmentally friendly agriculture in semi-arid regions. The productivity of rainfed crops like organic barley relies mainly on annual precipitation while apple orchards cannot produce adequately without irrigation. In Cyprus, most of the organic apple farmers have already installed improved irrigation systems thereby reducing the amount of water needed for the crop. The irrigation needs of the crop are calculated according to the methodology developed and suggested by FAO.

## **Conclusion**

However, there is ample scope for improving water use and irrigation management in organic apple orchards. For example, the inclusion of soil moisture monitoring systems to optimize the irrigation scheduling it is expected to further improve the water use efficiency of organic apple orchards. Practices like mulching, pruning and fruit removals at a proper growth stage, compost incorporation and reduced N inputs is also expected to improve water use efficiency of the crop.



## Introduction

Water availability and its quality are amongst the most important factors for sustainable and environmentally friendly agriculture in semi-arid regions. Water as a resource is crucial not only for agriculture but also for the industry as well as other sectors of the economy like tourism. Water is a critical component of human health, and due to the increase in human population and the climate change, it is expected that significant amount of fresh water will be diverted from agriculture to domestic use. By 2050, the water demand of agriculture worldwide is estimated to increase by 19% due to irrigational needs. Currently, almost 40% of the world's food produced in artificially irrigated areas. Thus sustainable water use management in irrigated and rainfed agricultural systems will be vital in meeting future demands for agricultural goods (Dietrich et al., 2013).

In semi-arid regions, rainfall and particular annual precipitation determine crop growth, productivity, and products quality. In Cyprus, the annual rainfall ranges from 400 to 600 mm and the wet period take place during winter and in principle during this period the amount of precipitation is higher than the evapotranspiration. However, climate change already affected Cyprus climatic conditions and their impact on precipitation and temperature are obvious. The mean annual rainfall since 1990 reduced by 9% compared to that of the period between 1960-1989 while a further decrease of 10 to 15% is expected (Meteorological Service of Cyprus, 2017). In Cyprus, irrigation is needed during the dry season, but due to the climate change, irrigation is required more often depending on the microclimate conditions of the interested region.

Cereals production is depended upon rainfall during winter and the challenge for barley despite its drought tolerance, is to overcome the negative effects of extensive and prolonged drought that are resulting in a substantial reduction of seed and hay production. Our survey showed that is extremely important for the farmers to have varieties with increased tolerance to drought. Fruit crops are dependent upon the soil capacity of storing water during the rainfall season and on irrigation of the crop during the summer period. In organic farming the challenge is to implement practices that will increase the water use efficiency in a climate changing



environment. Additionally, measures should be adopted to ensure water supply for an economically viable agriculture.

In this review report we present the management irrigation scheme for apples in to cover the demands of the crop during the growing season.



## Estimation of apple trees net irrigation demands

Water management in apple orchards is a key component for the sustainable and viable productivity of the system. This is particularly important for environmental friendly schemes like that of organic farming. A main challenge for organic apple farmers is their need to adopt and implement efficient and improved management practices to reduce the water footprint of the crop and increase the viability of their agricultural activity. Thereby, farmers should know when and how much water must be supplied to the crop. To achieve this task farmers should be aware about the (i) critical growth stages of the crop, (ii) the different irrigation systems and their characteristics in Cyprus, (iii) the irrigation scheduling and (iii) ways of better usage of limited water supply.

### Understanding tree water needs during the growing season

The yield and the quality of apples is the result of environmental inputs, cultural practices and physiological process. Water has a central role in all these procedures and it is important for the farmer to understand the water status of the crop over seasons and in particular to identify the critical growth stages that are related to productivity and quality. In apple trees there are 3 growth stages during which the crop is susceptible to drought and are described below:

1. **Budburst and flowering:** Flowering in apples occurs either before or after of the vegetative growth depending on the variety and environmental conditions. Adequate soil moisture is needed 3 to 4 weeks after full bloom in apple trees to maximize cell division and to enhance root growth of the trees. This will support normal fruitlet growth.
2. **Rapid shoot growth:** During this stage water availability is important but not critical. During this stage, fruit grows slowly while shoot biomass increases rapidly and the bud formation for next year fruit and leaves occurs.
3. **Fruit fill:** During this stage rapid fruit growth take place by cell enlargement. In detail fruit cells begin to fill with carbohydrates and water resulting in a rapid increase of fruit size. In Cyprus, this period ranged between 5 to 7 weeks before harvest and it is dependent on apple variety and the cultivation



area. Water availability during this growth stage is critical, since any shortage results in a substantial reduction of yields and quality.

During and after harvest, irrigation is substantially reduced and is only necessary in early-harvesting varieties where shoot and root growth still occurs. During this period, nutrients are stored in trees and water availability is a factor, which control nutrient uptake from the crop. Finally, during the dormancy period (leaf fall) irrigation is not needed.

Besides harvest time, the type of rootstock is a critical factor for the irrigation needs of the crop. In Cyprus, the use of dwarf type rootstocks is limited. Only recently, new organic farming orchards are using these rootstocks to increase the yield per cultivated area. Generally, varieties crafted in dwarf rootstocks are developing shallow root system and the orchard is much more dense compare to the traditional orchard schemes leading to increased irrigation needs.

### **Irrigation systems in Cyprus**

A key component of sustainable water management is to match water availability and water needs in quantity and quality in space and time (Paranychianakis and Chartzoulakis, 2005). Besides, irrigation method has a decisive effect on irrigation scheduling and determines along with environmental parameters, crop characteristics and soil type the frequency of irrigation and the amount of water that should be applied. In Cyprus, due to the prolonged drought periods, farmers are using localized irrigation methods and particularly a) trickle, b) drip and c) micro-sprayers (mini-sprinklers). Furrow irrigation is not a common irrigation practice in Cyprus due to the high water demand for this method, the low water use efficiency and accuracy, the high on-going management requirement. The main components of the irrigation systems used in apple orchards in Cyprus are the following

1. Water source (pressurized local water network, pumping station or elevated water storage tank that is located in rural areas)
2. Control head of the system, which includes particle filters, flow meters, pressure regulators and valves. In conventional farming systems, the irrigation



system is connected with fertilizer tank and constant feeding methods are also implemented.

3. Water pipeline network, which includes main and secondary water transfer pipelines, manifolds and laterals. In the pipeline network, several types of emitters are installed and in apple orchards, drippers and mini-sprinklers are usually installed.

### **Apple orchards irrigation scheduling in Cyprus**

In Cyprus potential evapotranspiration of crops is usually estimated from pan evaporation measurements, following the procedure suggested by FAO. The evaporimeter used is the screened USWB Class A Pan, which has been tested more than any other worldwide. The methods using meteorological measurements are usually preferred because they are easier, and meteorological measurements are usually readily available. The estimates obtained by this method, however, express in reality the evaporative demand of the atmosphere. Particularly, six methods estimating the evaporative demand of the atmosphere were tested under Cyprus conditions in the past. The methods used were the screened USWB Class A Pan evaporimeter, and the formulae of Penman, Turc, Jensen&Haise, Thornthwait, and Blaney and Criddle. The estimates obtained with the above methods were tested against potential evapotranspiration values, determined by the water balance of the soil profile in field plots. Pan evaporation gave the best estimates and has successfully been used in Cyprus to guide irrigation and it has been established as a standard instrument in meteorological stations.

Particularly, crop evapotranspiration (ET<sub>c</sub>) was calculated directly from pan evaporation (E<sub>pan</sub>) measurements using a single coefficient, which expresses the ratio of ET<sub>c</sub> to E<sub>pan</sub> (Metochis, 1997). Briefly, the basic pan evaporation measurements were converted to reference evapotranspiration (ET<sub>o</sub>) records using Eq. 1, where K<sub>p</sub> is the pan coefficient which takes into account the type of the pan, its environment and climate (Doorenbos and Kassam 1979). Crop evapotranspiration (ET<sub>c</sub>; mm) was calculated from potential evapotranspiration (ET<sub>o</sub>; mm) based on micrometeorological data obtained from the weather stations using Eq. 2, where K<sub>c</sub> is the crop coefficient



which depends on the crop under consideration and stage of development (Allen et al. 1998),

$$\text{Equation 1} \quad ETo = Kp \times Epan$$

$$\text{Equation 2} \quad ETc = Kc \times ETo$$

By substituting Eq. 1 in Eq. 2 the following Eq. is obtained:

$$\text{Equation 3} \quad ETc = KcxKp \times Epan$$

The procedure described so far is the general one suggested by FAO and values of the coefficients to be used can be derived from the literature (FAO Irrigation and drainage paper 56). However, in Cyprus the value of Kp coefficient for a specific area is constant over the irrigation season (April to November); its values are 0.85 for the inland and coastal plain areas and 0.75 for the mountain areas (Metochis and Orphanos 1997). Therefore, the product Kc x Kp in Eq. 3 can be substituted by the single coefficient C. The resulting equation is:

$$\text{Equation 4} \quad ETc = C \times Epan$$

where,  $C=Kc \times Kp$

Crop parameters, however, were adjusted under local climatic conditions and crop management practices. The C coefficient values have been extensively studied for a long period in field experiments conducted at the Agricultural Research Institute of Cyprus, and vary among plant species, as well as among plants' growth stage (Metochis, 1997). Particularly, the C value for apple trees it ranges from 0.4 during spring to 0.6-0.7 during the summer and autumn. Moreover, in order to compute the net irrigation requirements (NIR) of the crops, the effective rainfall during the growing period was subtracted from actual water requirements (ETc values).



Monthly irrigation requirement ( $\text{m}^3/10000 \text{ m}^2$ ) in the area of Kyperounta

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Efective rainfall ( $\text{m}^3/\text{ha}$ )	631	454	328	112	52	43	16	8	8	107	366	701	
Water needs ( $\text{m}^3/\text{ha}$ )	0	0	0	0	628	1758	1806	1804	825	0	0	0	6821
Irrigation needs ( $\text{m}^3/\text{ha}$ )	0	0	0	0	575	1715	1790	1796	816	0	0	0	6694
Irrigation events ( $\text{m}^3/\text{ha}$ )					1	3	6	5	3				18



## **Ways of better usage of water resources**

To avoid the detrimental effects of water deficit on apple yields and quality organic farmers should employ specific strategies and practices. In this section we describe the different tools that should be included in the irrigation management scheme under the realities and the climatic conditions of Cyprus apple organic farming sector. These tools could be used supplementary to the well established and locally calibrated evapotranspiration scheduling method.

### **Soil Moisture Monitoring for a more precise irrigation scheduling**

The implementation and the adoption of soil moisture monitoring techniques it is expected to increase the water use efficiency of the apple orchards. Soil water availability directly affects plant water uptake and the availability of such information could be used to schedule irrigation of the orchards. For example, the installation of tensiometers for the indirect measurement of soil moisture tension could provide important information regarding soil water conditions while soil salinity is not affecting the readings and the decision making of the farmer. In each measurement location in the field, at least two tensiometers of different length should be installed in the zone of greatest root density and at about 1/4 to 1/3 of the functional root depth of the trees (usually 20 to 60 cm).

### **Crop Management Practices**

Crop management practices that are affecting plant biomass production could be improved tailored to the water needs of the crop. For example, nitrogen based fertilization strategy increases shoot biomass production thereby increasing water uptake and transpiration. Instead, incorporation of composts and stable organic carbon in soils gradually improves the water holding capacity of the crop. Thus the sustainable nutrient management will also enhance water use efficiency particularly under water limited conditions. Pruning and fruit thinning are important practices affecting water needs of the crop. During drought periods, farmers should perform heavy pruning particularly in trees with low yields to reduce their water needs. Similarly, thinning is a practice that could substantially improve water use efficiency of the trees due to the competition reduction within trees for water during the fast



growing stage of the fruits. Soil mulching and sustainable weed management is expected to reduce water evaporation and diminish the competition between weeds and apple trees. In particular, mechanical incorporation of summer weeds with-in rows is expected to reduce the competition for water resources.

## Conclusions

Irrigation is a fundamental practice to maintain productivity and quality of organic apple orchards. The irrigation strategy should aim to increase the use efficiency of this valuable resource without reducing crop productivity and quality. In Cyprus, most of the organic apple farmers have already installed improved irrigation systems thereby reducing the amount of water needed for the crop. The irrigation needs of the crop are calculated according the methodology developed and suggested by FAO. However, there is ample scope for improving water use and irrigation management in organic apple orchards. For example, the inclusion of soil moisture monitoring systems to optimize the irrigation scheduling it is expected to further improve the water use efficiency of organic apple orchards. Practices like mulching, pruning and fruit removals at a proper growth stage, compost incorporation and reduced N inputs is also expected to improve water use efficiency of the crop.

## Literature

Allen, R.G., L.S. Pereira, D. Raes and M. Smith. 1998. Crop evapotranspiration – Guidelines for computing crop water requirements. *FAO Irrigation and Drainage Paper*, No. 56, FAO, Rome.

Dietrich, J. P., C. Schmitz, H. Lotze-Campen, A. Popp, and C. Müller (2013), Forecasting technological change in agriculture—An endogenous implementation in a global land use model, *Technol. Forecasting Soc. Change*, 81, 236–249, doi:10.1016/j.techfore.2013.02.003.

Doorenbos, J. and A.H. Kassam. 1979. Yield response to water. *FAO Irrigation and Drainage Paper* No. 33. Rome, FAO.

Metochis, C. and P.I. Orphanos. 1997. Yield of barley under Mediterranean conditions of variable rainfall. *Agricultural and Forest Meteorology* 85: 251-258.



Metochis, C., 1997: Assessment of irrigation water needs of main crops of Cyprus *Cyprus Agricultural Research Institute Series, Ministry of Agriculture, Natural Resources and Environment*. Cyprus, Nicosia