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Water needs in citrus fruit in a dry region of Morocco

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Abstract: An irrigation plan for citrus fruit in the climatic context of the area studied seems possible on the basis of evaporation from a class A pan. In principle, a coefficient value of 0.6 could be retained.
Indeed, the use of this coefficient together with a high frequency of irrigation has made it possible not only to satisfy the water requirements of the citrus fruit, but also to obtain a good yield, namely 40 tons per hectare. In addition, it has been possible to achieve a great economy in water in comparison to the considerably larger quantities otherwise needed by many farmers. Hence, a great saving in water compared to quantities commonly bought by other farmers.
This was reflected not only in the yield but also in the quality of the fruit, which turned out to be even better, as indicated by its size, since the quantity of water was closer to that needed. A poor yield was obtained when the water deficit was severe.

Keywords: water needs, citrus, Dry Region, Marrakech

Introduction

Due to water scarcity and its increasingly high price, rationalization has become crucial. Attempts to reduce waste by the use of up-to-date techniques, such as localized irrigation, have resulted in considerable improvement. However, water use at the level of the plot has several weaknesses. A common problem is identifying the needs of the crops and planning irrigation accordingly in order to optimize water use, and hence, a return on investment. Originating from regions characterized by strong rainfall, citrus fruit are among crops whose requirements in water are very high. Irrigation is therefore n whenever the necessary quantities are not reached through rainfall. Several research papers have demonstrated that irrigation is required in areas where rainfall is below 1200 mm as is the case in Morocco. Thus, Rebour (1966) estimated that the amount of water necessary to fully cover citrus fruit needs in Morocco ranged between 1000 and 1200 mm, with 600 mm between May and October. According to Parloran (1971), these needs, which may attain 1600 mm in the Haouz and the Souss regions, should be distributed all year round with July and August as the most sensitive periods. Raymond (1987), however, argued that in theory the needs of citrus fruit in the Mediterranean basin were well below 1200 mm per year. Peres and Veliz (1978) showed, in a 15-year study of the Cuban climate, that evapotranspiration (ETr) of citrus fruit varied enormously between dry and humid years, and that reasoned irrigation should be implemented. There was a 15-day interval from November to May and during July and August. In the same country, Cardenas and Toledo (1988) found that the actual evapotranspiration of citrus fruits (Valencia) varied according to the ground humidity. In this case, the maximal and minimal values of actual evapotranspiration (ETr) were 658 and 1448 mm per year when irrigation was planned at 65% and 85% of humidity, respectively. These values constitute a good estimate, especially for practical purposes. However, they cannot claim to represent water needs independently of climatic context. Scale tests per region remain necessary to quantify real needs, identify appropriate methods of evaluation and to determine planning techniques that best adapt to the climate.

Materials and Methods

Climatic conditions

In the Haouz region, average annual rainfall is approximately 250 to 300 mm (O.R.M.V.A.H, 1975). Over 60 years' observation, the average was 236 mm. Precipitations vary from one year to another. The rainy season is commonly October to April with a maximum rainfall in November and February. The dry season is about five months (May to September). Minimal and maximal temperatures are 12.6 and 26.8°C, respectively. These values clearly indicate the continental character of the climate. The temperature never drops below 0°C. Several times a year, in summer, the temperature can reach the maximum of 45°C. The relative humidity is low for most of the year, especially in summer when it declines considerably. It drops to 25%, on average whereas, in winter, it can be relatively high.

Experiment

The study was undertaken in an area called 'N'fis', located 12 km west of Marrakech in an orchard of citrus fruit planted in 1964. A net area of 4320 m^2 was divided into four plots each measuring 1080 m^2 (18 m by 60 m). Each plot had three rows of citrus fruit (ten trees per row) irrigated each by a door-slope equipped with 30 micro-sprinklers (3 micro-sprinklers per tree).

The door-slope was equipped with a tap and volumeter. The debit of each micro-jet throw was 30 1/h at 1 bar. Treatment was defined on the basis of the reduction coefficient compared to the evaporation of the vat used determine the required amount of water for irrigation. The values of the latter were 0.3, 0.4, 0.5 and 0.6 for treatments 1, 2, 3 and 4, respectively. The choice of these coefficients was based on research previously undertaken in the region of study.

For each plot, the dose of irrigation was determined by the following equation:

$$D = C * E - 0.9 * P$$

Where D represents the amount of water needed for irrigation (mm), C the reduction coefficient, E evaporation, and P the amount of precipitation fallen since the previous irrigation (mm).

Treatments were irrigated daily except when the irrigation time was inferior to 20 mm, an initial fixed threshold corresponding to evaporation of 3 mm, or in the case of major constraints such as system failure.

Each elementary plot was equipped with a 150 cm long access tube for the neutron probe, and twelve tensiometers, installed in pairs around the access tube at depths of 10, 20, 30, 45, 60 and 75 cm. The humidity measures and water potential of the soil served to determine the quantity of water consumed by the crop. The study period was 13 months.

Similarly, daily values of initial evapotranspiration (ETo) were calculated on the basis of three slightly different empirical methods, namely those of Blaney-Criddle and Penman modified. In addition, evaporation from a class A pan, randomly installed on the farm was recorded daily in order to serve as an average for irrigation.

Probe calibration was undertaken *in situ* at three different sites and different depths. Similarly, apparent density was determined for six different profiles. Water conductivity, in an unsaturated environment, was measured in a 2 x 2 m square situated in treatment 1. The internal drainage method was also used to this.

Results and Discussion

Actual evapotranspiration (ETr) results are presented in Table 1. They are determined by the assessment of water at the level of the plot. This method is not sensitive to daily variations, and the results are given for monthly intervals. However, calculations are made on a daily basis. (ETr) values during the period extending from May 1, 1996 to April 30, 1997, are 650, 750, 836 and 1,045 mm, for plots T1, T2, T3 and T4 respectively; which correspond to a daily average of 1.74, 2.12, 2.33 and 2.86 mm/day. The average rainfall fluctuated between a minimum of 0.69 mm/day in January, for plot P1, and a maximum of 5.35 mm/day in August, for T4.

Table 1 - Daily real evapotranspiration (ETr) of the different treatments per month

	T1	T2	T3	T4
May	1,78	2,29	2,95	2,99
June	2,24	2,55	2,88	3,64
July	2,43	3,61	3,35	4,50
August	3,84	3,78	3,97	5,35
September	2,50	3,19	3,09	3,60
October	1,55	2,03	2,42	2,47
November	0,77	0,53	1,04	1,46
December	0,85	1,02	1,25	1,58
January	0,69	1,25	1,00	0,94
February	0,97	1,27	1,64	1,78
Mars	2,00	2,13	2,43	2,91
April	1,67	2,35	2,63	3,05
AVERAGE	1,74	2,12	2,33	2,86

The water quantities consumed by the different plots increased with those utilised for irrigation. Treatment of 4 shows the highest values throughout the period of study. This difference indicates a degree of stress strain with respect to treatments, 37.8, 28 and 20 % for T1, T2 and T3. For all treatments, ETr 4 increased fom December, reaching a maximum in August before gradually falling off towards the end of the year.

Toledo *et al.* (1982) found, in a climatically similar context to that of the area of Marrakech, values of ETr varying between 3.78 and 4.42 mm/day for citrus trees irrigated at 85% of Moisture at field capacity (HCC), and 1.30-1.46 mm/day when the irrigation takes place at 65% of HCC.

Because the period of experimentation had exceptional precipitation levels during the second week of February and also the first week of April, ETr values corresponding to these two periods appear to be erroneous, probably because streaming was not determined accurately. Outside these periods, the water assessment method gave results which seemed to reproduce reality with precision. Indeed, analysis of the results of the global water assessment mode over the period of study shows that only 6% of water supplies are not accounted for by the different types of export (ETr), drainage and streaming; this is well below the degree of precision given for the method adopted. The ETr values found are thus within the range of 6% in the worst conditions.

The methods used to evaluate ETm gave similar values and corresponded to the real evapotranspiration of the most watered plots, except for a slight misinterpretation in March and August and two underestimations, one in May and one in June. Besides, the underestimation during the month of August, it seems that ETr values as measured by the water assessment method are slightly faulty. Indeed, the appearance of the ETm curves, and hence ETo, seem to reproduce the facts much better than the ETr of treatment T4. For practical purposes, however, the difference recorded between ETm as estimated by any of these methods and ETm remain acceptable even in the worst case. During the critical month of August, the greatest difference remained well below 9%, that is, if it is admitted that there is no limitation in water at the level of treatment P4. The correlation coefficient between measured ETr and estimated ETm is well above 90% in the three cases (92.5% in the case of Penman's) (Table 2).

These results are confirmed by other tests which show that all three methods are capable of predicting water use in citrus fruit in semi-arid areas of the country.

Table 2 - Maximal evapotanspiration estimated by the three methods and real evapotranspiration of T4.

Months	B-C	Ray.	Penman-m	T4
1	045,8	046,9	037.6	029,2
2	036,8	042,2	037,7	049,7
3	060,3	070,6	068,1	090,3
4	079,4	095,1	085,7	091,4
5	109.9	115,5	108,3	072,7
6	143,3	146,8	129,4	109,2
7	159,6	153,4	146,5	139,6
8	159,4	151,3	153,9	165,8
9	114,9	101,1	102,3	107,9
10	091,7	089,2	077,2	076,7
11	060,0	058,9	050,7	043,9
12	044,3	042,7	034,8	048,9
Total	1105,4	1113,7	1032,2	1045,3

Conclusion

In this study, some possible answers are proposed to questions that remain unanswered to date. However, conclusions remain tentative as the study was carried out on the basis of data from one area only. Awaiting further lysimeter-based research that should be undertaken over several seasons, the citrus fruit coefficients proposed by Doorenbos and Pruitt (1977) appear to be well adapted to study requirements; empirical methods to estimate water requirements (Blaney-Criddle, radiation method, and, more particularly, the modified Penman method) give good estimates of these needs. An irrigation plan for citrus fruit in the climatic context of the area studied seems possible on the basis of evaporation from a class A pan. In principle, a coefficient value of 0.6 could be retained.
Indeed, the use of this coefficient together with a high frequency of irrigation has

made it possible not only to satisfy the water requirements of the citrus fruit, but also to obtain a good yield, namely 40 tons per hectare. In addition, it has been possible to achieve a great economy in water in comparison to the considerably larger quantities otherwise needed by many farmers. This was reflected not only in the yield but also in the quality of the fruit, which turned out to be even better, as indicated by its size, since the quantity of water was close to that needed. A poor yield was obtained when the water deficit was severe.

Water reduction compared to need was reflected not only on output, but also on fruit quality, as shown by caliber. This improved as contributions were closer to needs. Poor yield was obtained when water deficit was severe.

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Bibliography

Aboukhaled A., Alfaro J.F. and Smith, 1986. *Lysimeters. Irrigation and Drainage*. Paper No 39. FAO. Rome.

Bazza M., 1982. *Possibilités d'utilisation des tensiomètres pour l'avertissement et la programmation des irrigations au goutte à goutte*. Hommes, Terre et Eaux. 12 (47): 111–118.

Bazza M. et Elmsieh J., 1988. *Caractéristiques physiques et hydrodynamiques du sol et leur rôle dans le bilan et la gestion de l'eau d'irrigation: cas du sol le plus répandu dans le périmètre du Tadla*. Hommes, Terre et Eaux. 18 (71): 65.

Benmoumen A., 1988. *Détermination de l'ETR de la canne à sucre par la méthode du bilan hydrique, essai de réduction et comparaison avec les méthodes empiriques couramment utilisées*. Mémoire de 3ème cycle. Option Génie Rural. IAV. Hassan II. Rabat.

Chapot H., 1963. *La Clémentine*. Rev. " A1 Awamia ". INRA. Maroc. No 7.

Da Silva A. et Julia Santos M., 1982. *Le potentiel de l'eau dans le contrôle d'irrigation*. Hommes, Terre et Eaux. 12 (47): 93-100.

Daudet F.A. et Vachaud G., 1977. *La mesure neutronique du stock d'eau du sol et de ses variations. Application à la détermination du bilan hydrique*. Ann. Agron. 28 (5): 503- 519.

Doorenbos J. et Kassam A.H., 1980. *Réponse des rendements à l'eau*. Bulletin d'irrigation et de drainage numéro 33. FAO. Rome.

Doorenbos J. et Pruitt W.O., 1985. *Les besoins en eau des cultures*. Bulletin d'irrigation et de drainage numéro 24. FAO. Rome.

El Hallani H., 1990. *Gestion des eaux d'irrigation dans le Haouz*. Diplôme d'Etudes Supérieures. ISCAE. Casablanca.

El Hari A., 1989. *Contrôle de l'irrigation et de salinité sur le site de la station de Ras El Ain. Haouz*. Certificat d'Etudes Approfondies. Université Cadi Ayyad. Marrakech. Faculté des Sciences.

El Hari.A., 1992. *Besoin des Agrumes dans le Haouz effet du stress hydrique sur le rendement et le calibre*. Thèse de troisième cycle. Option irrigation. Département de physique. Faculté des sciences. Samlalia. Marrakech

Hdidou M., 1989. *Détermination de l'ETM de la canne à sucre par la méthode lysimètrique. Essai de réduction en vue d'élaborer la courbe de réponse à l'eau*. Mémoire de 3ème cycle. Option Génie Rural. IAV. Hassan II. Rabat.

Hillel D., Kreutos V.D. and Stylianon Y., 1972. *Procedure and test of an internal drainage method for measuring soil hydraulic characteristics* in-situ. Soil Sci. 114: 385-400.

Kutsch H.G., 1978. *Le pouvoir d'évaporation du climat marocain*. Pub. DRA. MARA. Rabat.

Lakbaibi A., 1990. *Besoins en eau du blé tendre dans la vallée du Draa par la méthode lysimètrique: contribution à l'optimisation de la productivité de l'eau*. Mémoire du troisième cycle. Option Génie Rural. IAV. Hassan II. Rabat.

Leguen C., 1982. *Limites de l'irrigation localisée observées sur quelques vergers du sud est de la France*. D.A.A Hydraulique et climatologie agricole. E.N.S.A.

Morrero L.P. and Herrera Soler M., 1987. *Determination of the water requirements of citrus by an agro-climatic method*. Documentos de ciencia. Agropecuarias de La Habana. No. 2.

Oulahcen M., Bourga L., El Quessouar M. et Boukhamen J., 1987. *Résultats des tests Zing réalisés sur clémentine. L'amélioration du calibre des fruits d'agrumes*. SASMA.

O. R. M. V. A. H., 1983. *Un aménagement adopté aux conditions locales : cas de N'fis*. 354 p.

O. R. M. V. A. H., 1985. *Canevas hydraulique du secteur Nl*. " Mémoire explicatif ". 412 p.

O. R. M. V. A. H., 1986. *Aménagement hydro agricole du Haouz central. Périmètre du N'fis : " Bilan des eaux "*. 288 p.

Perez Pozo I.R. and Veliz Garcia L., 1978. *An irrigation regime for citrus growing areas*. Voluntad Hidraulica. Vol. 15. No. 45.

Praloran, J.C., 1971. *Les Agrumes. Technique Agricole et production tropicale*. 312 p.

Raymond L., 1987. *Les Agrumes. Techniques Agricoles Méditerranéennes*. 227 p.

Rebour H., 1966. *Les Agrumes. Manuel de culture de Citrus pour le bassin méditerranéen*. 365 p.

Ricardo G., Heber I., 1995. *Yield Performance of banabe Irrigated witch Fraction of class A pan evaporation in semiarid environment.* Agron. J. 87: 172-176.

Wiegand C.L. and Swanson W.A., 1982. *Citrus responses to irrigation: I. Irrigation requirements; daily, monthly, and annual evapotranspiration amounts and water management recommendations*. Journal of the Rio Grande Valley Horticultural Society. Vol. 3: 73-85.