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EFFICIENT MANAGEMENT OF IRRIGATION WATER IN AGRICULTURAL PRODUCTION OF PENINSULA SANTA ELENA - ECUADOR

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Abstract

F.J. Del Cioppo, N. Puño, and F.R. Rodriguez. 2016. Efficient management of irrigation water in agricultural production of Peninsula Santa Elena - Ecuador Cien. Inv. Agr. Agricultural production worldwide faces more demanding standards framed in the autonomy that each country sets own policies for food processes. The fact that an universal growing population, which requires of basic needs, results in an accelerated exploitation of natural resources including water, therefore its demanding efficient use.

This gathering information in irrigated areas such as: Chongón, Playas and El Azúcar Peninsula Santa Elena, Ecuador, as well as the main crops in the area, seeks to propose a schedule irrigation based on climatic factors, crops and irrigation system. Two important factors were determined and advice for farmers to consider when applying irrigation in their fields: First, the calculation of water needs, estimating the monthly potential evapotranspiration by pan evaporation in each of the areas of irrigation, with determining and adjusting the crop coefficient Kc statement by FAO. As well as the second parameter, which is the determination of the coefficient of distribution uniformity, this process will provide important information to estimate the amount of water that each plant will need to receive in an specific period of time.

Through this method important scheduling irrigation for crops information is obtained. Information sheet irrigation is obtained in millimeters, sheet of water per plant per day, water volume per plot in cubic meters, time watering in hours is obtained. One advantage of this process results in saving of water resources of the productive areas of the region and most importantly of the country.

Keywords: Crops, climate, water needs, uniformity coefficient

Resumen

F.J. Del Cioppo, and F.R. Rodríguez. 2016. Manejo eficiente del agua de riego en la producción agrícola de la Península Santa Elena - Ecuador Cien. Inv. Agr. La producción agrícola a nivel mundial se encuentran sometidos a procesos más exigentes, enmarcados en la soberanía alimentaria de países, todo ello bajo la presión de necesidades básicas del crecimiento poblacional a nivel mundial, ocasionando una explotación acelerada de los recursos naturales entre ellos el agua y demandando su uso eficiente.

Recopilando información en las zonas de riego Chongón, Playas y El Azúcar de la Península de Santa Elena, Ecuador, así como de los principales cultivos de la zona, se busca proponer una programación de riego en base a los factores climáticos, los cultivos y el sistema de riego. Se determinaron dos factores importantes que los agricultores deben consideran en el momento de aplicar riego en sus parcelas como son: el cálculo de las necesidades hídricas, estimando la evapotranspiración potencial mensual mediante la tina de evaporación en cada una de las zonas de riego, junto a la determinación y ajuste del coeficiente del cultivo Kc enunciado por la FAO, además como segundo parámetro la determinación del coeficiente de uniformidad de distribución, permitiendo así estimar la cantidad de agua que deberá recibir cada planta en un espacio de tiempo determinado.

De esta forma, se obtiene como resultado la programación del riego para los cultivos, donde se obtiene información de lámina de riego en milímetros, lámina de agua por planta por día, volumen de agua por parcela en metros cúbicos, el tiempo a regar en horas que conlleva a un ahorro del recurso hídrico de las zonas productivas de la región y el país.

Palabras claves: cultivos, clima, necesidades hídricas, coeficiente de uniformidad.

Introduction

It is necessary to insist in the true importance of the technological actions for the handle of irrigation in the agricultural production of the Ecuador, all this because of the impact in productive fields, environmental, social and economic of the zone agro productive of the country; actions based in the relation am used to – water – plants – climate of the crops.

Inside this relation and irrigation has posed a big challenge in the countries where is increasing the shortage of water, already was by his irregular distribution in the time and in the spaces; or by the unsuitable technology for his catchment, distribution and application in the agricultural production.

(Calderón and Calvache, 2006; Coello and Calvache, 2006; Pacheco and Calvache, 2006) Manifest if the irrigation is very operated and handled produces big economic indexes for the users, instead, the contrary, produces considerable losses to the society. In the Ecuador the bad use of the water comes it to him observing from the catchment and regulation until the application of the water to the different plots by means of methods of irrigation improvised and badly scheduled, what does that they reach efficiencies of use of the water in the systems, in the order of a 20 to 30%. The utilization of methods of irrigation very structured and scheduled to level piece of ground, practically are very restricted in our country since the greater surface irrigates by grooves underused the water, reaching efficiencies of application of water from 15% until a 50 %.

For (Avidan 1994) the agriculturalist, before scheduling his systems of irrigation or to determine the needs of irrigation of his crops, confronts to some fundamental questions Because irrigate? That profits pretends to obtain of the irrigation? How much irrigate? Which is the dose of water of irrigation for applying? When irrigate? Which is the interval of irrigation? Like irrigating? Which method of irrigation select?

The correct answers to these questions will allow to do rational and efficient use of the water – and will avoid irrigation in excess or in deficiency, conditions that have to repercussions negatively on the floor and the performance of the crops.

The practice of the irrigation consists essentially in replacing to the profile of the floor, the water consumed by the crop. This concept bases in a knowledge of the relations am used to – water – plants and in the calculation of the needs of irrigation of the crops from pertinent data on floor, the climate, the crop and the system of irrigation.

The knowledge of the evapotranspiration of the crops (Etc) is essential for a handle efficient of the irrigation adjusting the volume and the frequency of the irrigation to the requests of the crops. A handle correct of the irrigation allows to aim to high performances, with stability between years, and to an optimum quality of the product harvested, making possible a rational use of the water and of the energy, minimizing the waste of both resources and the pollution of the environment. Likewise this data is fundamental for a correct design of the systems of irrigation (Puppo And García Petillo, 2010).

The technological development recently experienced by the irrigations has been remarkable regarding a better knowledge of agronomy, of the water required by the crops and of the means, programs and suitable methods to apply it. The interpretation of functions of relative production to the factor waters is a valuable instrument to evaluate and orient practices of irrigation to criteria of handle of the water that optimize the productivity of the crops.

In economic terms, could pretend that a possible reduction of production was accompanied by the one of the costs of the irrigation (aguto, energy, hand of work, etc.). Likewise, that the no used water was allocated to alternative uses, and that the costs of opportunity of the water, properly valued, compensated the lower production. (Orlov, D. 1985).

Nevertheless the timely application of methodology of handle of the irrigation in the agricultural production would generate the contrary effect a to improvement of the performances of the crops, saving of energetic resources (water-energy); as well as a handle adapted of the floor and of the systems of irrigation, improving the criteria of production allowing take discretionary decisions to the agriculturalist whose purpose is to improve the economic performances of the crops.

The management of the water constitutes an important challenge in the actuality, especially in zones of shortage water. The agriculture is the activity that more water consumes, and from here the need to design strategies that do a more efficient use of this resource. One of these strategies of saving of hydric is the irrigation deficit controlled (RDC), that consists in reducing the contributions hydric in some phases of the cycle of crop without altering the performances of considerable form. But so that these strategies are adopted by the agriculturalists have to be technical and economically profitable (Fernández, 2015).

In the handle of irrigation there are not norms unbending, by the contrary, there are a lot of forms to tackle the distinct problems that present in the practice. All programming of the irrigation has to answer to two fundamental questions: How much and When irrigate?, that is to say it has to allow know the dose and the frequency of the irrigation, the tendency is to that every time they take part fewer subjective factors and that attain a lower efficiency in the handle of the water, or that, in the practice, wants to say that it achieve the lower possible saving of water without diminishing the performances of the crops.

Salcedo et al. (2005) they signal the coefficients of uniformity in systems of irrigation pressurized are due to numerous factors, such as an unsuitable design of irrigation and selection of emitters by which is of great importance know the Coefficient of Uniformity of Distribution in the handle of the irrigation. The present work too like aim study the handle and control of the irrigation pressurized and the form to determine irrigation depth to apply to the crops in the Peninsula of Santa Elena - Ecuador in base to his needs hydric like a tool of query for producers of the zone.

Materials and Methods

The work made gathering climatic information of zones of irrigation of Chongón – Beaches and The Sugar of the Peninsula of Santa Elena – Ecuador, as well as of you main crops of the zone, looking for propose a programming of irrigation in base to the climatic factors, the crops and the system of irrigation.

The needs WATER in the agricultural production comport to know the technical and technological processes required, in this section, gives to know the methodological processes to calculate and those that the farmer should take into consideration in irrigation management in their plots are: the calculation of water needs, estimating the monthly potential evapotranspiration by pan evaporation in each of the areas of irrigation, with determining and adjusting the crop coefficient Kc statement by FAO, as well as the second parameter determination of the coefficient of distribution uniformity, thus allowing to estimate the amount of water to be received by each plant in a space of time.

(Image 1).

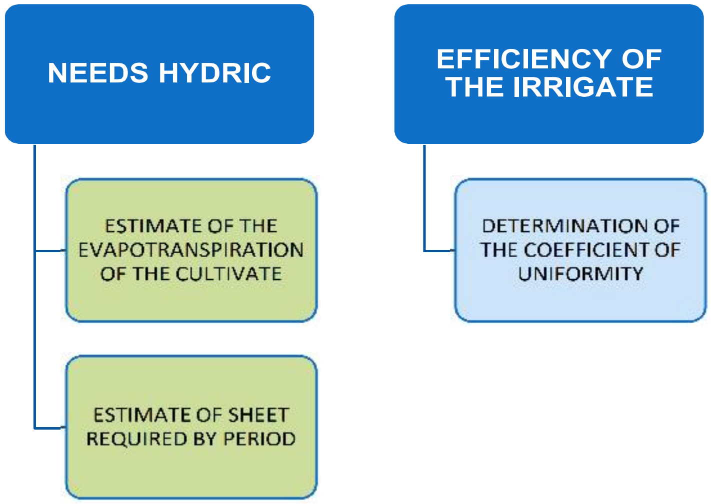

Image 1: *Needs hydric of crops.*

The dose of water that consumes a plant, to the beginning is lower and increases according to the stage of physiological development, the quantity of water applied to the crops through the irrigation goes to depend of the type of floor, the depth radicular, the stage of development and of the system of irrigation to use.

Regarding the floor will depend on the texture of the surface of seed, a sandy floor retains lower quantity waters that a floor clayey and therefore the availability of the water is lower. The parameter of the depth radicular influences because of the frequency of the irrigations, if we take in consideration crops like the vegetables whose roots are superficial thiss plates will be lower but with a lot of more frequencies, occurring the contrary in the crops fruit where the plates are greater and with frequencies more spaced.

The majority of the crops are sensitive to the drought and/or to the excess of the water motivate by which is of vital importance effect a handle adapted of the irrigation in the agriculture.

Estimate of the evapotranspiration of the crop

The transpiration of a plant is greater to the retained by the plant be part of them (used in processes of development and photosynthesis), therefore, the transpiration can consider like the use of water by the plant Of equal way the surface of the floor exposed to the climatic factors produce effects of evaporation of the water that is delivered to the crops through the floor in his more superficial layers.

The quantity of water of both processes, transpiration and evaporation, is used to consider in shape conjoint, simply because it is costly to calculate it separately for the agriculturalist. Therefore, it considers that the needs of water of the crops are represented by the sum of the direct evaporation of the water from the floor more the transpiration of the plants, in what it designates evapotranspiration Et (figure 2). The evapotranspiration is used to express in millimeters of height of water evapotranspirada in each day (mm/day) and is a quantity that will vary according to the climate and the stage of development of the crop corrected by means of a coefficient of the crop (Kc) estimated by the World-wide Organization for the Agriculture (FAO) in base to climatic data and location of seed of the crop.

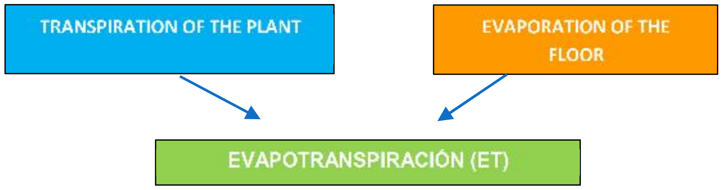

Image 2: *Potential Evapotranspiration.*

To be able to calculate the evapotranspiration of the crops, and first instance calculates the evaporation by means of the method of the tank evaporímetro or vat of evaporation class "A" standard (Figure 3) is to circulate with a diameter of 120.5 cm (47.5") and 25.4 cm (10") of depth, of iron galvanized and painted with a layer of painting of aluminum goes mounted on a wooden platform.

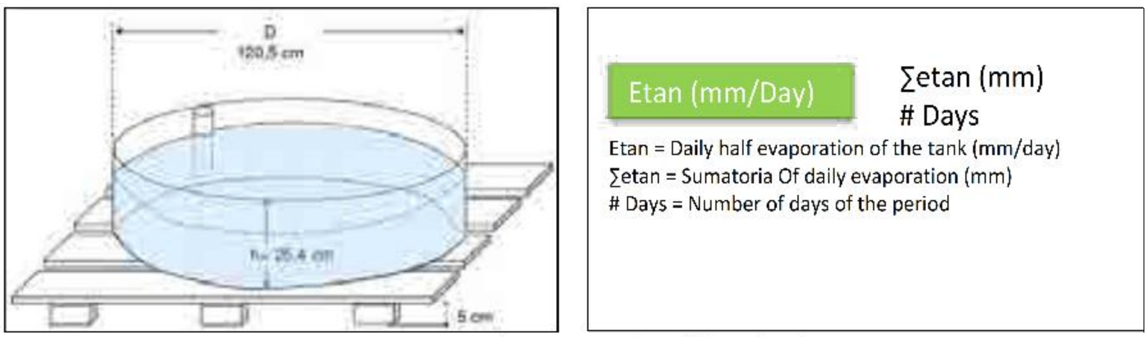

Image 3: *Vat of evaporation class "A" standard*

It allows to estimate the integrated effects of the climate (the radiation, the temperature, the wind and the relative humidity of the air) in function of the evaporation of a free surface of standard dimensions. (Avidan. A. 1994)

With frequency, the estimate of the evapotranspiration of reference (ETo), is not inside the possibilities of the farmer, the one who to obtain it has to resort to proportionate information by public entities or associative, centers of investigation and experimentation, resorting to tables of meteorological information of the country through the INHAMI. In the (Table 1) is the information of potential evapotranspiration in millimeter/ day for the months of the year in the study areas and its graphical representation (figure 4 and 5).

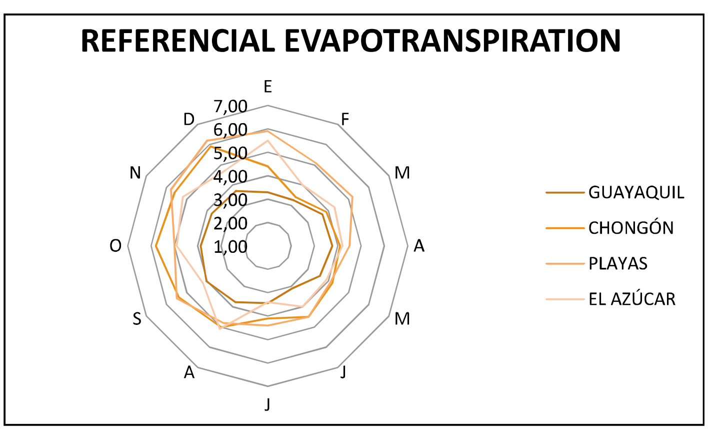

Image 4: *Graphical representation of referential evapotranspiration*

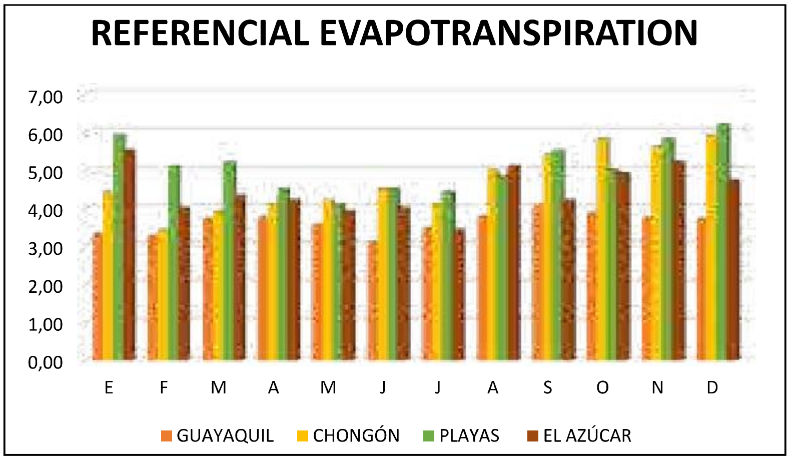

Image 5: *Graphical representation of referential evapotranspiration*

Table 1. METEOROLOGICAL DATA EXPERIMENTAL FARMS CEDEGE

EVAPOTRANSPIRACIÓN POTENCIAL EN MM/DÍA													
zona /mes	E	F	M	A	M	J	J	A	S	O	N	D	ANUAL
GUAYAQUIL	3,29	3,25	3,71	3,77	3,58	3,10	3,45	3,77	4,03	3,87	3,77	3,71	3,62
CHONGÓN	4,40	3,40	3,90	4,10	4,20	4,50	4,10	5,00	5,40	5,80	5,60	5,90	4,69
PLAYAS	5,90	5,10	5,20	4,50	4,10	4,5	4,40	4,80	5,50	5,00	5,80	6,20	5,08
EL AZÚCAR	5,50	4,00	4,30	4,20	3,90	4,00	3,40	5,10	4,20	4,90	5,20	4,70	4,45

Coefficient of crop (kc)

The world-wide organization for the agriculture (FAO) has developed widely the methodology of calculation of the coefficient of the crop (Kc) where collect data of climate to world-wide level, however, these coefficients are referents for other latitudes and climatic regions, by such reason is of a lot of importance establish the coefficients of the crop (Kc) and with climatic data of the zones of production. The coefficient of crop Kc (Table 2) describes the variations in quantity of water that the plants extract of the floor to measure that go developing, from seeds it until the harvest. It expresses the relation between the evapotranspiration of the crop and the evapotranspiration of reference.

Table 2. COEFFICIENT OF THE CROP KC.

CULTIVOS	Kc por etapas			
	Inicial	Desarrollo	Media	Maduración
CEBOLLA	0,50	0,70	1,00	1,00
TOMATE	0,45	0,75	1,15	0,80
PIMIENTO	0,45	0,70	0,90	0,75
MAIZ	0,40	0,80	1,15	0,70
MELÓN	0,45	0,75	1,00	0,75
CACAO	0,90	0,90	0,90	0,90
CÍTRICOS	0,60	0,65	0,70	0,75
GUANÁBANA	0,60	0,60	0,60	0,60
GUAYABA	0,60	0,75	0,85	0,45
MANGO	0,40	0,50	0,70	0,60
PLÁTANO	0,90	1,00	1,00	1,11
UVA	0,60	0,65	0,70	0,75

Usually in the annual crops, differentiate four stages or phases of the crop:

- Initial: from it seeds it until the crop covers 10% of the floor roughly.
- Development: from 10% of coverage and during the active growth of the plant.
- Average: between flowering and fructification, corresponds in majority of the cases to the 70 – 80 % of maximum coverage of each crop.
- Maturation: from the maturity until the harvest.

The coefficients of crop (Kc) in permanent crops (fruit), expresses it to him by months in function of the degree of coverage of the floor (% of shadow that covers the arboreal mass in the surface of the floor). (Figure 6)

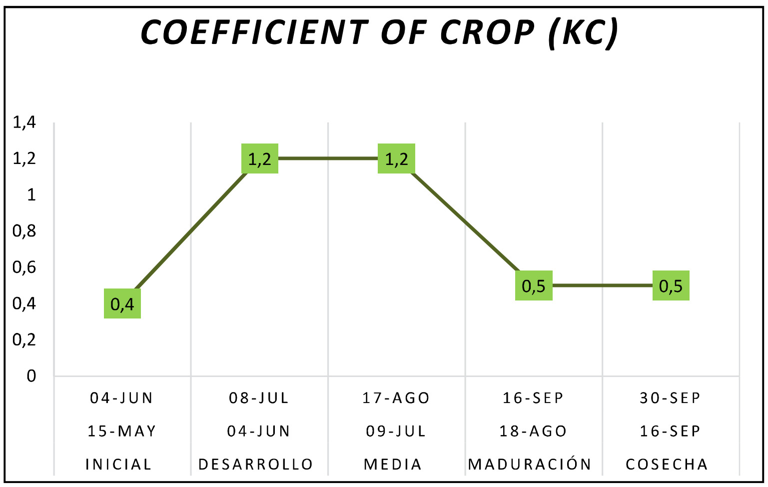

Image 6: *Coefficient of crop (kc)*

Efficiency of irrigation

Once determined the Evapotranspiration of the crop (Etc), effects the evaluation of the system of irrigation through the determination of the coefficient of uniformity of distribution, allowing like this estimate the quantity dandy water received by each plant in a space of determinate time.

$$CUC = \left(1 - \frac{\sum_{i=1}^{N} |x_i - \bar{x}|}{N\bar{x}}\right) \times 100$$

Where:
CUC= Coefficient of uniformity of Christiansen
Xi= Each one of the observations from i=1 until N
X= Average of the Observations
N= Number of observations

For a handle adapted of the programming of irrigation has to make the estimate of the Coefficient of Uniformity of Distribution (CU) of the system in the field of production, said process carries it out to him in the module of irrigation more representative of the zone of production and was calculated through the coefficient of uniformity of Christiansen (Christiansen, 1942) from the recollection of the water in diverse points of the plot in a determinate time in sides situated in the module: initial, to 1/3, 2/3 of distance and at the end, of equal way of each side selects the outlet situated to the start, 1/3, 2/3 of distance and at the end.

Salcedo et al. (2005) appointment to Haman et al. (1997) where indicate that the low coefficients of Uniformity in systems pressurized are due to numerous factors, such as: The unsuitable selection of diameters of pipe of delivery, to unsuitable selection of measures, and translated unsuitable of measures, you effects of the wind in the measures; you changes in the components of system with time, obstruction of filter of the miser, tolerations in the pressure of operation.

Programming of irrigation

When making a programming of irrigation is necessary to have climatic data of the zone or the evapotranspiration of the zone in study, estimate the efficiency of delivery of the system of irrigation through the estimate of the coefficient of uniformity (C.Or), know the coefficients of the crop (Kc) based in to stage of development of the crop and the existent data such as: spacing between rows, spacing between plants and cultured total surface. Once obtained this basic information determine parameters eat: Lamina of Irrigation (LR), Volume of Water by plant (Vap), Time of irrigation (You), Volume to use in the plot (V); by means of the utilization of the following formulas:

Irrigation depth

$$LR = \frac{100}{Ef} X (Eto \times Kc)$$

Where:
Eto: Evapotranspiración Of Reference (mm/day)
Kc: Coefficient of the Crop
Ef: Efficiency of irrigation in percentage

Volume of water by plant

$$Vap = \frac{R((Eh \times Ep) \times Pas))}{D}$$

Where:
Vap: Volume of water by plant in litres by plant by day (lt/plan/day)
Eh: Espaciamiento Between rows in metres (m)
Ep: Espaciamiento Between plants in metres (m)
Pas: Percentage of area under shadow of the crop in hundredth (80%=0.8)

Time of irrigation in hours

$$Ti = \frac{Vap}{Qe \times Nep}$$

Where:
You: Time of irrigation in hours
Vap: Volume of water by plant in litres by plant by day (lt/plan/day)
Qe: Half discharge of the emisor in litres by hour (lts/h)
Nep: Number of Emisores by plant

Volume of water by plot

$$V = \frac{Vap \times Pha \times A}{1000}$$

Where:
V: Volume to use in the plot in cubic metres by day (m^3
Vap: Volume of water by plant in litres by plant by day (lt/plan/day)
Pha: Number of plants by hectare
To: Area of the plot in hectares (has)

Results and Discussion

If a plantation of 20 hectares of Cocoa seeded in the zone of Chongón, presents the following data of the crop, climatic and the system of irrigation:

Eto: 3.75 mm/day
Kc: 0.90
Qe: 24 lt/h
Ef: 80 %
Eh: 3 m
Ep: 3 m
Nep: 0.5
Pas: 60%
Pha: 1111 plants
Area: 20 hectares

The results:

Eto: 3.75 mm/día
LR: 4.22 mm
Vap: 22.79 lt/pla/día
Ti: 1.90 hours = 1 hour 54 minutes
V: 506.40 m3/ 20 has

Irrigation scheduling for cocoa cultivation is presented in Table 3.

Table 3. IRRIGATION SCHEDULING FOR COCOA FARMING

IRRIGATION SCHEDULING FOR COCOA FARMING										
Irrigation systems:	mini sprinklers		Flow outlet:		24 lts/h		spacing:		9 m^2	
Phase:	Third		Days:		1		Planting Area:		20 Ha.	
Evaporation (mm)	k tina	Eto (mm/día)	kc crop	Etc (mm/día)	Irrigation Factor (%)	Irrigation depth (mm)	Vpa (mm/pla/dia)	water volume per plot (m^3)	Time (hours)	Time (h / m)
1,0	0,75	0,75	0,9	0,68	1,25	0,84	4,56	101,24	0,38	0 : 23 m
1,5	0,75	1,13	0,9	1,01	1,25	1,27	6,83	151,86	0,57	0 : 34 m
2,0	0,75	1,50	0,9	1,35	1,25	1,69	9,11	202,48	0,76	0: 46 m
2,5	0,75	1,88	0,9	1,69	1,25	2,11	11,39	253,10	0,95	0: 57 m
3,0	0,75	2,25	0,9	2,03	1,25	2,53	13,67	303,72	1,14	1: 08 m
3,5	0,75	2,63	0,9	2,36	1,25	2,95	15,95	354,34	1,33	1: 20 m
4,0	0,75	3,00	0,9	2,70	1,25	3,38	18,23	404,96	1,52	1: 31 m
4,5	0,75	3,38	0,9	3,04	1,25	3,80	20,50	455,58	1,71	1: 43 m
5,0	0,75	3,75	0,9	3,38	1,25	4,22	22,78	506,20	1,90	1: 54 m
5,5	0,75	4,13	0,9	3,71	1,25	4,64	25,06	556,82	2,09	2: 06 m
6,0	0,75	4,50	0,9	4,05	1,25	5,06	27,34	607,44	2,28	2: 17 m
6,5	0,75	4,88	0,9	4,39	1,25	5,48	29,62	658,06	2,47	2: 28 m
7,0	0,75	5,25		0,00	1,25	0,00	0,00	0,00	0,00	2: 40 m
7,5	0,75	5,63	0,9	5,06	1,25	6,33	34,17	759,30	2,85	2: 51 m
8,0	0,75	6,00	0,9	5,40	1,25	6,75	36,45	809,92	3,04	3: 02 m
8,5	0,75	6,38	0,9	5,74	1,25	7,17	38,73	860,54	3,23	3: 14 m
9,0	0,75	6,75	0,9	6,08	1,25	7,59	41,01	911,16	3,42	3: 25 m
9,5	0,75	7,13	0,9	6,41	1,25	8,02	43,28	961,78	3,61	3: 37 m
10,0	0,75	7,50	0,9	6,75	1,25	8,44	45,56	1012,40	3,80	3: 48 m
Elaborado: Autor										

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