11-Calculate for your location the certainty of minimum temperature not being lower than -13ºC in a period of 20 years.

In Belmez we have data from January 1, 2001 to December 31, 2013 (13 years). The minimum temperature occurs during autumn-winter so for each year we look for the minimum temperature in the period from September 1 to May 1, thus we have only 12 years. The data are shown in the Table below:

Season	Min T (ºC)
2001/2002	-5
2002/2003	-5.5
2003/2004	-4.5
2004/2005	-8.7
2005/2006	-4.3
2006/2007	-3.6
2007/2008	-6.6
2008/2009	-6.5
2009/2010	-6.9
2010/2011	-5.4
2011/2012	-8.9
2012/2013	-3.9
MEAN	-5.82
SD	1.75

Then the certainty is calculated using eq. 29.6:

$$C = \left\{exp\left[-exp\left(\frac{T_c - \beta}{\alpha}\right)\right]\right\}^{n_d}$$

Where $\alpha = \sigma/1.283 = 1.36$ºC and $\beta = \mu + 0.577\ \alpha = -5.82 + 0.577 \cdot 1.36 = -5.03$ºC

$$C = \left\{exp\left[-exp\left(\frac{-13-(-5.03)}{1.36}\right)\right]\right\}^{20} = 0.94$$

12-Calculate for your location the date for the first autumn frost with probability 5% (the earliest frost in 20 years).

In the Table below the dates of the first frost in autumn (expressed as days from September 1st) for Belmez are shown. The calculated mean and standard deviation are shown at the bottom.

YEAR	first frost in autumn
	days after 1 Sept
2001	72
2002	79
2003	93
2004	78
2005	67
2006	105
2007	75
2008	76
2009	85
2010	94
2011	90
2012	92
2013	78
MEAN	83.38
SD	10.77

Now we use eq. 29.3 of Villalobos and Fereres (2016):

$$P(frost\ before\ \ t) = P_y \ \cdot P\left[z < \frac{t - \ m_{FF}}{s_{FF}}\right]$$

As we have frost every year P_y=1. So we want to solve the equation:

$$0.05 = P\left[z < \frac{t - \ m_{FF}}{s_{FF}}\right]$$

The probability is calculated using: $P(z \leq \ x) = 0.5\left(1\ \pm\sqrt{1 - exp\left(\frac{-2\,x^2}{\pi}\right)}\right)$

We take the negative root as x<0. So we deduce x=-1.615

As $x=(t-m_{FF})/s_{FF}$ we deduce t=66 days after Sept 1, which is November 5.

13-Calculate for your location the maximum ET that should be considered for designing the irrigation system. Consider that the rotation may include summer crops as maize or cotton.

The maximum ET_0 in our location (Belmez) occurs in July (7.7 mm/d). At that time summer crops have already achieved maximum cover so expansion is no longer critical for crop productivity. In that case we can adopt AD=0.67 for those crops.

In a medium texture soil we assume PAW=120 mm/m. Maximum root depth is restricted by soil depth (1 m). Therefore the critical SWD will be:

$SWD_c = 0.67 \times 120 \times 1 = 80$ mm

This will be the typical irrigation dose. On the other hand maximum K_c is 1.2 for summer crops, when ET_0=7.7 mm/d, so daily ET=9.2 mm/d.

The climate in our location is semi-arid (climate type 1 in section 10.6 of Villalobos and Fereres, 2016) so C=1.21

Therefore

$$\frac{ET_{75}}{ET_{avg}} = C - 0.06\,(C-1)\,\sqrt{I_a} = 1.21 - 0.06\,(1.21-1)\,\sqrt{80} = 1.097$$

So:

$$ET_{75} = 1.097\,ET_{avg} = 10.1\,mm/d$$

14-Calculate in your location what would be the ET of a tomato crop in May with full ground cover inside an unheated greenhouse with polyethylene cover (transmissivity for solar radiation 0.7).

First we calculate reference ET inside the greenhouse as:

$$ET_0 = \frac{1}{2.45}\,0.68\,\frac{\Delta}{\Delta+\gamma}\;R_{si}$$

where R_{si} (MJ m^{-2} d^{-1}) is the solar radiation inside the greenhouse, which can also be estimated from the solar radiation measured in the open if the transmissivity of the cover (τ_{gc}) is known ($R_{si}= \tau_{gc} R_s$). In Belmez during May we have an average R_s=24.9 MJ/m^2/d so

R_{si}= 0.7 x R_s = 17.4 MJ/m^2/d

Average temperature in May is 17.3ºC so Δ=0.12 kPa/K. Therefore

$$ET_0 = \frac{1}{2.45}\,0.68\,\frac{0.12}{0.12+0.067}\;17.4 = 3.1\,mm/d$$

Tomato in the open may have maximum K_c=1.2. In a greenhouse the crop coefficient is 10-20% higher so we adopt an increase of 15% and the K_c=1.2 x1.15 = 1.38.

Finally

ET = ET_0 K_c =3.1 x 1.38 = 4.3 mm/d

15-Calculate in your location what would be the maximum temperature on a clear day of May inside an unheated greenhouse with polyethylene cover (transmissivity for solar radiation 0.7). The greenhouse has a height of 3 m and is occupied by a tomato crop with full ground cover. The air inside is renewed 25 times per hour.

We will use eq. 28.12 of Villalobos and Fereres (2016):

$$T_{in} - T_{out} = \frac{(1-k_L)\,\Delta + \gamma}{\Delta + \gamma}\ \frac{3600}{\rho C_p}\ \frac{k_{RN}\,R_{si}}{h_g\ RR}$$

Maximum temperature in May is 24.9ºC and solar radiation on clear days is 29.8 $MJ/m^2/d$

$R_{s\ in}$= 0.7 x R_s = 20.86 $MJ/m^2/d$

Solar radiation at the time of maximum temperature will be (eq. 28.8, Villalobos and Fereres, 2016):

$$R_{sx\ in} = 0.84 \cdot \frac{\pi}{2} \cdot \frac{10^6 R_{s\ in}}{3600\ N} = \ 0.84 \cdot \frac{\pi}{2} \cdot \frac{10^6\ \cdot 20.86}{3600 \cdot\ 14.1} = \ 542\ W/m^2$$

With a temperature of 24.9ºC, Δ=0.19 kPa/K

As vapor pressure in May is 0.89 kPa and with temperature 24.9ºC, $\rho\ C_p$ =1207 $J/m^3/K$

k_{RN}=0.7, k_L=1

$$T_{in} - T_{out} = \frac{0.067}{0.19 + 0.067}\ \frac{3600}{1207}\ \frac{0.7 \cdot 542}{3 \cdot 25} = 3.9\ K$$

So the maximum temperature inside will be:

T_{in} =3.9 + 24.9 = 28.8 ºC

16-Calculate the optimal Leaching Requirement (to maximize Crop Water Productivity) for the two crops.

We will use eq. 22.13 of Villalobos and Fereres (2016):

$$LR_{opt} = \sqrt{\frac{0.2\ B'EC_w}{1 + B'(EC_{eu} - 0.2\ EC_w)}}$$

Which is valid when it is lower than the LR at which maximum yield is achieved.

$$\frac{1}{5\ \frac{EC_{eu}}{EC_w} - 1}$$

Where $B' = B_s/100$.

a) Leek.

Table 22.1 does not include leek. We will adopt the parameters of a closely related species, onion. The threshold EC_e is 1.2 dS/m and the slope is B_s=16.1 %/(dS/m). So B'=0.161.

The LR at which maximum yield is achieved is given by $\frac{1}{5\frac{1.2}{1.5} - 1} = 0.33$

$$LR_{opt} = \sqrt{\frac{0.2 \cdot 0.161 \cdot 1.5}{1 + 0.161\ (1.2 - 0.2 \cdot 1.5)}} = 0.20$$

Which is the true optimum as it is lower than 0.33.

b) Pepper.

According to Appendix 22.1 the threshold EC_e is 1.5 dS/m and the slope is B_s=14 %/(dS/m). So B'=0.14.

The LR at which maximum yield is achieved is given by $\frac{1}{5\frac{1.5}{1.5} - 1} = 0.25$

$$LR_{opt} = \sqrt{\frac{0.2 \cdot 0.14 \cdot 1.5}{1 + 0.14\ (1.5 - 0.2 \cdot 1.5)}} = 0.19$$

Which is the true optimum as it is lower than 0.25.

17-If you establish a windbreak with E-W orientation and height 3 m in your location, what would be the width of the shade at solar noon on December 21 and June 21?

Our location is Belmez (Spain) with latitude 38.27ºN.

The zenith angle is given by:

$$\cos\theta = \sin\lambda_s \sin\delta_s + \cos\lambda_s \cos\delta_s \ \cos h_a$$

At solar noon h=0 and on December 21 the solar declination is -23.45º, so:

Cos θ = sin(38.27) sin(-23.45) + cos(38.27) cos(-23.45)= 0.47

Therefore θ=1.08 rad (61.7º).

The width of the shade is given by 3 x tg(61.7)=5.58 m

At solar noon h=0 and on June 21 the solar declination is 23.45º, so:

Cos θ = sin(38.27) sin(23.45) + cos(38.27) cos(23.45)= 0.97

Therefore θ=0.26 rad (14.8º).

The width of the shade is given by 3 x tg(14.8)=0.79 m

It would be simpler to use the following equation which is valid for solar noon:

Cos $\theta = \cos(\lambda_s-\delta_s)$ so $\theta = \lambda_s-\delta_s$

December 21, δ_s=-23.45º so θ=38.27+23.45 = 61.7º

June 21, δ_s=23.45º so θ= 38.27-23.45 =14.8º

18-Calculate the exports of sulfur in your rotation. Modify the fertilizer program to compensate for these exports. Assume that the average yield of your crop is 80% of the value calculated in 3c.

Sulfur exports:

Leek

Yield = 0.8 x 819 g m^{-2} = 655 g m^{-2} = 6550 kg ha^{-1}

Now we look for S concentrations for leek (http://www.uco.es/fitotecnia/contents/sulfur_concentration.pdf) : 0.8% S

Therefore, exported sulfur will be:

S : 6550 kg ha^{-1} x 0.008 kg S/kg dm = 52.4 kg S ha^{-1}

Pepper

Yield = 0.8 x 797 g m^{-2} = 637.6 g m^{-2} = 6376 kg ha^{-1}

Now we look for S concentrations for pepper (http://www.uco.es/fitotecnia/contents/sulfur_concentration.pdf) : 0.24% S

Therefore, exported sulfur will be:

S : 6376 kg ha^{-1} x 0.0024 kg S/kg dm = 15.3 kg S ha^{-1}

The mean exportation of sulfur is 33.9 kg S/ha/year.

In section 4 we had calculated the P and K fertilizer program for the rotation:

82.5 kg triple superphosphate/ha/year and 222.5 kg potassium chloride/ha/year.

To compensate for the exported sulfur we have several alternatives:

a) use superphosphate instead of triple superphosphate.

82.5 kg TS x 0.2 kg P/kg TS = 16.5 kg P

16.5 kg P / 0.08 kg P/kg superphosphate = 206 kg superphosphate

206 kg superphosphate x 0.12 kg S/kg superphosphate = 24.75 kg S

b) use potassium sulfate instead of potassium chloride

222.5 kg potassium chloride x 0.5 = 111.3 kg K

111.3 kg K /.415 kg K/kg potassium sulfate = 268 kg potassium sulfate

268 kg potassium sulfate x 0.17 kg S/kg PS = 45.6 kg S

c) use ammonium sulfate (21%N, 24%S) or ammonium nitrosulfate (26% N,12%S) instead of urea.

We require 138 kg N/ha /year (section 4.3).

ammonium sulfate 138 kg N/ha /0.21 kg N/kg AS = 657 kg AS/ha

657 kg AS/ha x 0.24 kg S/kg AS = 158 kg S/ha

ammonium nitrosulfate 138 kg N/ha /0.26 kg N/kg ANS = 531 kg ANS/ha

531 kg ANS/ha x 0.12 kg S/kg ANS = 64 kg S/ha

Comparing the different alternatives we see that option b (potassium sulfate) is the one closest to the objective of compensating exported sulfur.

19-Calculate the transpiration of an isolated cypress with a crown of height 6 m and width 1 m in your location during July.

In Belmez during July the mean ET_0=7.7 mm/d. We assume that the tree crown is a spheroid with length h=6 m and horizontal radius 0.5 m. First we calculate the projected envelope area for 1 rad:

$$PEA_1 = \pi\, r^2 \left(a_p + b_p\ {}^{h}/_{r}\right) = \pi\ 0.5^2 \left(0.3 + 0.35\ {}^{6}/_{0.5}\right) = 3.53\ m^2$$

For spheroids: a_p=0.3, b_p=0.35. Now we calculate the fraction of radiation intercepted (not transmitted) using eqs. 3.25 and 3.26. We assume Leaf Area Density 2 m^2/m^3 (medium-high). As it is a spheroid c_p=0.64, d_p=0.026

$$c_1 = 1 - t_{c1} = 1 - exp\left[-c_p A + d_p\ A^2\right] = 1 - exp[-0.64 \cdot 0.667 + 0.026 \cdot\ 0.667^2]$$
$$= 0.34$$

$$A = \frac{\mu\, \pi\, r^3 h}{2\ PEA_1} = \frac{2 \cdot \pi \cdot 0.5^3\ \cdot 6}{2\ \cdot 3.53} = 0.667$$

Mean solar radiation in July is 29.9 $MJ/m^2/d$ and mean extraterrestrial radiation is 40.4 $MJ/m^2/d$, so:

$$\alpha' = 2\ \frac{R_s}{R_A} - 0.5 = 2\ \frac{29.9}{40.4} - 0.5 = 0.98$$

Daylength is 14.3 hours, so:

$$RR_i = c_1\ PEA_1 \left[1 - \alpha' + \alpha' \left(1.84 - \frac{0.75\ R_A}{3.6\ N_s}\right)\right]$$
$$= 0.34 \cdot 3.53 \left[1 - 0.98 + 0.98 \left(1.84 - \frac{0.75\ 40.4}{3.6 \cdot\ 14.3}\right)\right] = 1.50\ m^2$$

$$E_{p\ tree} = RR_i\ K_{tf}\ ET_0 = 1.50\ \cdot 1.1 \cdot 7.7 = 12.7\ L\ day^{-1}$$

We have taken K_{tf}=1.1 which is the value of olive trees (Table 9.1), as cypress trees are also well adapted to Mediterranean areas.

20-Calculate the optimum irrigation efficiency in 2012/2013 for your crops considering prices of water 0.05 €/m^3 and 0.50 €/m^3. Assume that the average yields of your crops under no water stress are 80% of the values calculated in 3c. The irrigation uniformity is 0.80. Assume that soil evaporation is 25% of ET.

After searching for prices for the farmer we find values of 0.25 €/kg for pepper and 0.255 €/kg for leek. Using the values of percent dry matter found in Appendix 24.1 we can calculate the prices per kg of dry product:

0.255 / 0.17 = 1.5 €/kg (leek)

0.25 / 0.125 = 2 €/kg (pepper)

Dry yields:

Yield = 0.8 x 819 g m^{-2} = 655 g m^{-2} = 6550 kg ha^{-1} (leek)

Yield = 0.8 x 797 g m^{-2} = 637.6 g m^{-2} = 6376 kg ha^{-1} (pepper)

In section 5 we calculated the ET of the two crops. The seasonal values are 398 mm (leek) and 619 mm (pepper). We calculate E_s=0.25 ET= 99.5 mm (leek) or 155 mm (pepper). Now we apply eq. 21.9 (chapter 21):

$$\frac{IWR_n}{I_{opt}} = \sqrt{\frac{10\ Q_I (ET - E_s)\ 8\ (1 - U_{cc})}{P_H\ Y_x} + (2\ U_{cc} - 1)^2}$$

For leek, and Q_I=0.05 €/m^3

$$\frac{IWR_n}{I_{opt}} = \sqrt{\frac{10 \cdot 0.05\ (398 - 99.5) 8\ (1 - 0.80)}{1.5 \cdot 6500} + (2 \cdot 0.8\ - 1)^2} = 0.62$$

For leek, and Q_I=0.5 €/m^3, IWR_n/I_{opt} = 0.78.

For pepper, and Q_I=0.05 €/m^3, IWR_n/I_{opt} = 0.62.

For pepper, and Q_I=0.5 €/m^3, IWR_n/I_{opt} = 0.81.

In section 5 we calculated the net irrigation required for leek (116 mm) and pepper (504 mm) in the 2012/2013 campaign. According to the calculations above with cheap water we should apply a gross amount of 192 mm to leek and 813 to pepper. With expensive water the gross amounts should be 153 (leek) and 622 mm (pepper).

21-The prices of different fertilizers are shown in the Table below. A) Calculate the best combination for your rotation assuming that around 30% of N and all P and K are applied before planting. B) Repeat the calculations if sulfur exports have to be compensated with fertilizers.

	price €/t
Superphosphate	264
Ammonium sulfate	289
Potassium chloride	359
Urea	378
Triple superphosphate (TSP)	403
Mono-ammonium phosphate (MAP)	481
Di-ammonium phosphate (DAP)	485
Potassium sulfate	988
Potassium nitrate	999

In section 18 we calculated for our rotation a mean export of sulfur of 33.9 kg S/ha/year. In section 5 we calculated the mean requirements of P and K (16.5 kg P/ha/year, 111 kg K/ha/year). The N fertilizer requirements are 130 kg N/ha (leek) and 145 kg N/ha (pepper).

A) In general the most economic option is based on straight fertilizers. For P, however, DAP is competitive with TSP, as it includes also some N. This is shown in the Table below.

	applied (kg/ha)	price	cost (€/ha)	total (€/ha)
Di-ammonium phosphate (DAP)	82.5	545	45	
Urea	266.6	425	113	
Potassium chloride	222.0	403	89	248
Triple superphosphate (TSP)	82.5	453	37	
Urea	298.9	425	127	
Potassium chloride	222.0	403	89	254

B) Taking into account sulfur exports.

In the Table below different combinations of 3-4 products are shown. The most expensive option is the one that includes potassium sulfate. The cheapest alternative includes ammonium sulfate, DAP, urea and potassium chloride. In this case ammonium sulfate, DAP and potassium chloride would be applied before planting and all the urea would be applied as top dressing. Note that DAP is slightly better than TSP (compare options 2 and 4).

	applied (kg/ha)	price	cost (€/ha)	total (€/ha)
Superphosphate	282.5	297	84	
Urea	298.9	425	127	
Potassium chloride	222.0	403	89	300
Ammonium sulfate	141.3	325	46	
Urea	234.4	425	100	
Potassium chloride	222.0	403	89	
Triple superphosphate (TSP)	82.5	453	37	272
Potassium sulfate	199.4	1110	221	
Potassium chloride	56.0	403	23	
Urea	298.9	425	127	
Triple superphosphate (TSP)	82.5	453	37	408
Ammonium sulfate	141.3	325	46	
Di-ammonium phosphate (DAP)	82.5	545	45	
Urea	202.1	425	86	
Potassium chloride	222.0	403	89	266

22-The cost of pumping (energy + depreciation cost) is 0.10 €/m^3. You have two offers of irrigation water. Water A has EC_w=1 dS/m and price 0.10 €/m^3. Water B has EC_w=1.5 dS/m and price 0.05 €/m^3. Select the best option for your crops. Assume that the average yields of your crops under no water stress are 80% of the values calculated in 3c.

After searching for prices for the farmer we find values of 0.25 €/kg for pepper and 0.255 €/kg for leek. Using the values of percent dry matter found in Appendix 24.1 we can calculate the prices per kg of dry product:

0.255 / 0.17 = 1.5 €/kg (leek)

0.25 / 0.125 = 2 €/kg (pepper)

Dry yields:

Yield = 0.8 x 819 g m^{-2} = 655 g m^{-2} = 6550 kg ha^{-1} (leek)

Yield = 0.8 x 797 g m^{-2} = 637.6 g m^{-2} = 6376 kg ha^{-1} (pepper)

We have to maximize the following function:

$$f(I) = PP\ Y_x \left\{1 - B' \left[EC_w \frac{2\ I - IWR_n}{5\ (I - IWR_n)} - EC_{eu}\right]\right\} - q\ I$$

where B'=B_s/100, PP is the selling price of harvest (€/kg), Y_x is maximum yield (kg/ha), I is irrigation applied (m^3/ha), IWR_n is net irrigation requirement (m^3/ha), q is the price of water (€/m^3). The function is maximized when:

$$I_{opt} = IWR_n + \sqrt{\frac{PP \cdot Y_x \cdot B' \cdot EC_w \cdot IWR_n}{5\ q}} < \frac{IWR_n\ (5\frac{EC_{eu}}{EC_w} - 1)}{5\frac{EC_{eu}}{EC_w} - 2}$$

As the inequality indicates, the solution is valid below the value of I at which maximum yield is achieved. Now, applying the previous equation we get the following results:

Water	EC_w	Price+cost	Crop	I_{opt}	f max
	dS/m	€/m^3		m^3/ha	€/ha
A	1.5	0.15	Leek	3068	9945
A	1.5	0.15	Pepper	9282	12330
B	1	0.2	Leek	2509	10234
B	1	0.2	Pepper	8040	12507

For both crops we get a higher benefit using water B.

23-Calculate the frequency of days suitable for applying pesticides in your location.

Assume that wind speed during the daytime can be calculated as

$$U_d = \frac{2}{N/_{24} + 1} U_{avg}$$

Where U_{avg} is the average daily (24-h) wind speed and N is the daylength (hours).

As indicated in section 31.4 we should not apply pesticides on rainy days, when wind speed exceeds 2.5 m/s or when air temperature is higher than 32-35ºC. For the calculation we will consider as days not suitable for applications those that have rainfall, or with daytime wind speed greater than 2.5 m/s or with maximum temperature exceeding 35ºC.

We perform the calculations for our location (Belmez) with Excel 2007 and obtain the frequency of days suitable for pesticide treatments:

Month	Frequency
1	0.24
2	0.27
3	0.28
4	0.34
5	0.46
6	0.40
7	0.16
8	0.21
9	0.48
10	0.40
11	0.28
12	0.23

24-Calculate the Leaching Index in your location

The LI is calculated as the product of a Percolation Index (PI) and a Seasonal Index (SI):

$$LI = PI \cdot SI$$

The Percolation Index is calculated as:

$$PI = \frac{\left(P - {}^{10160}/_{CN'} + 101.6\right)^2}{P + {}^{15240}/_{CN'} - 152.4} \quad if\ P - {}^{10160}/_{CN'} + 101.6 > 0$$

where P is annual rainfall (mm) and CN' is a modified curve number with values 28, 21, 17 and 15 for hydrologic groups A, B, C and D, respectively (chapter 8). If the condition stated in the equation is not met then PI=0.

Our soil is of medium texture so the hydrological group is B and CN'=21. In our location (Belmez) the mean annual rainfall is 533 mm. So:

$$PI = \frac{\left(533 - {}^{10160}/_{21} + 101.6\right)^2}{533 + {}^{15240}/_{21} - 152.4} = 20.55\ mm$$

The Seasonal Index represents the concentration of rainfall during the winter period:

$$SI = \left(\frac{2\ P_w}{P}\right)^{1/3}$$

where P_w is total rainfall (mm) during autumn and winter (1 October-31 March in N latitudes). In Belmez P_w=376.6 mm. So:

$$SI = \left(\frac{2 \cdot 376.6}{533}\right)^{1/3} = 1.12$$

And then LI = PI x SI = 20.55 x 1.12 = 23 mm, which is low.

25-Calculate soil erosion for your rotation. Assume that the slope is 2% and the slope length is 100 m. Tillage is performed in the direction of the slope. Consider also that in Andalucia, rainfall erosivity may be calculated as

$$\mathbf{R_1 = 1.26\ \Sigma(P_i^2/P) - 25}$$

(Villalobos and Testi, unpublished)

where Pi is mean monthly rainfall of month i and P is total annual rainfall.

In Belmez $\Sigma(P_i^2/P)=58.2$ so $R_1=48$

In Table 18.1 we look for values of K_1. However the right values may be found in http://www.uco.es/fitotecnia/corrigenda/tab18_1.pdf

For a sandy loam soil with low OM $K_1=0.31$.

With slope 2% NT=0.3 (Table 18.1) so:

$$L_1S_1 = [0.065 + 0.0456\ p_t + 0.006541\ p_t^2]\ (l_t/22.1)^{NT} = 0.29$$

In Table 18.1 we look also for C_1. With plow we have values between 0.35 and 0.39. We take the mid value 0.37. Finally with tillage in the direction of the slope $P_1=1$ (Table 18.1).

The soil loss by erosion is then:

$$SLE = R_1\ K_1\ L_1\ S_1\ C_1\ P_1 = 48 \times 0.31 \times 0.29 \times 0.37 \times 1.0 = 1.6\ \text{t/ha/ year}$$

According to table 18.2 this value is considered to be very low soil erosion.

26-Calculate runoff for the first day with rainfall greater than 30 mm in your location starting on the first year of the weather data set. Consider separately the two crops of your rotation. Assume that the soil is very wet.

Our soil is medium texture so we assume that the hydrologic group is B.

In our location, Belmez, we have a rainfall of 51.8 mm on January 11, 2001. We have two crops, leek and pepper.

a) Leek.

At the time of the rainfall event the crop is in the field so the hydrologic condition is good. In Table 8.2 we take row crops in straight rows for hydrologic group B with good hydrologic conditions so CN_2=78. As the soil is wet we need to calculate CN_3:

$$CN = CN_3 = CN_2\, e^{0.00673\,(100-\,CN_2)} = 78\;\, e^{0.00673\,(100-\,CN_2)} = \;90$$

We calculate SMX:

$$SMX = 254\,\left(\frac{100}{CN} - 1\right) = \;254\,\left(\frac{100}{90} - 1\right) = 28.2$$

As 0.2 SMX is lower than rainfall, runoff will occur:

$$SR = \frac{(P - 0.2\,SMX)^2}{P + 0.8\,SMX} = 28.6\,mm$$

b) Pepper.

At the time of the rainfall event the crop is not in the field. In Table 8.2 we take bare soil for hydrologic group B (first row of Table 8.2) so CN_2=86. As the soil is wet we need to calculate CN_3:

$$CN_3 = \;86\,e^{0.00673\,(100-\,86)} = 94$$

We calculate SMX:

$SMX = 254\,\left(\frac{100}{CN} - 1\right) = \;254\,\left(\frac{100}{94} - 1\right) = 16.2$ mm

As 0.2 SMX is lower than rainfall, runoff will occur:

$$SR = \frac{(P - 0.2\,SMX)^2}{P + 0.8\,SMX} = 36.4\,mm$$