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College of Soil Physics

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Water balance 1

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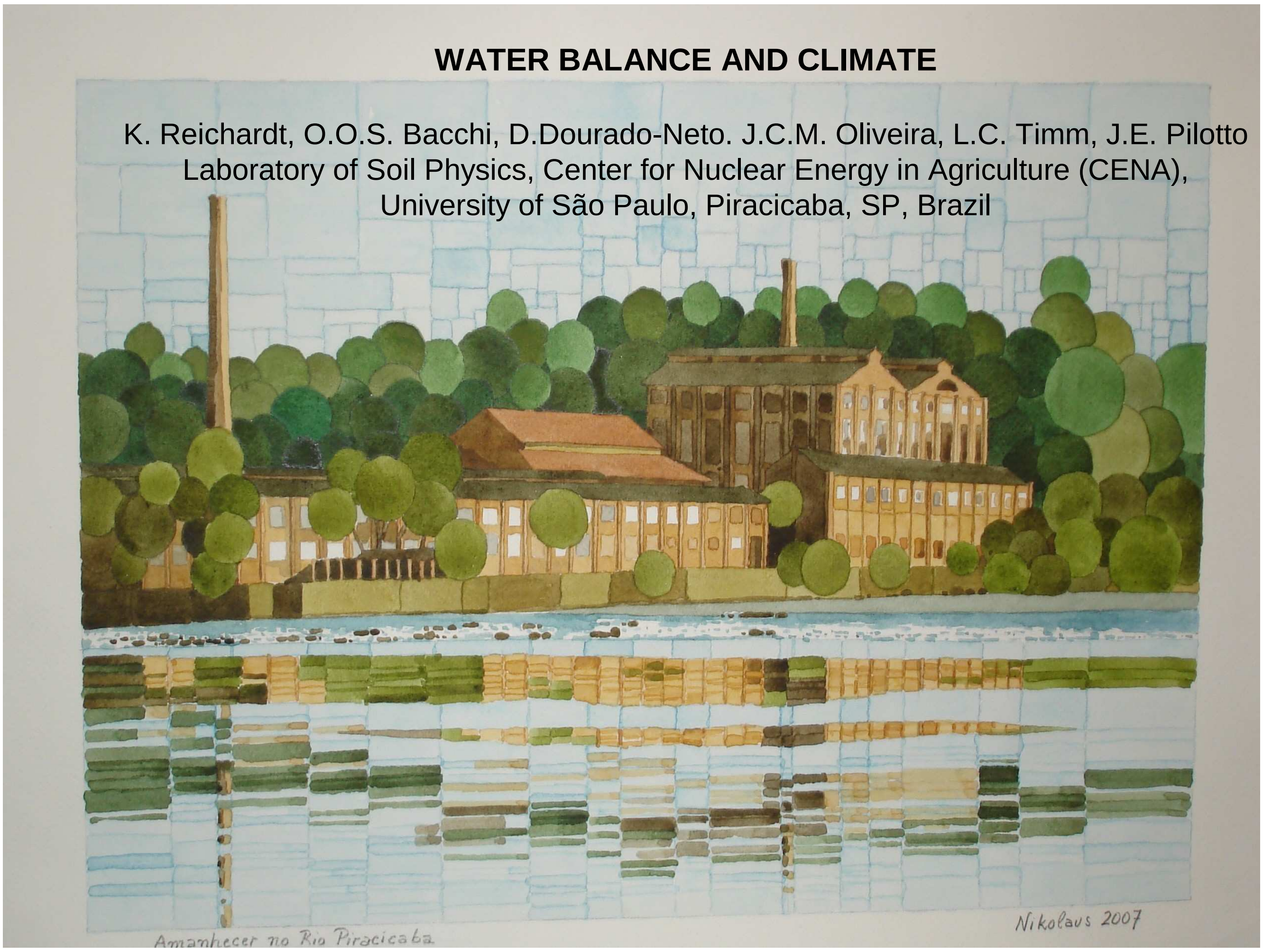

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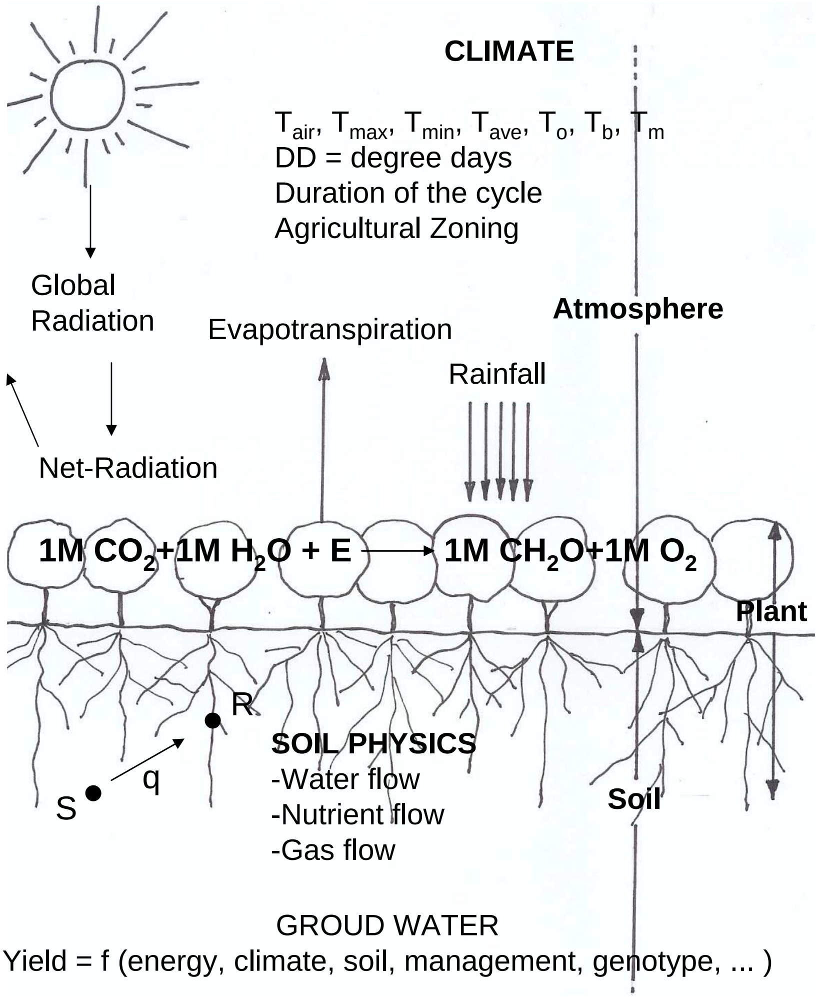
Introduction

Water cycling in a watershed or in a cropped field can be characterized and quantified by a water balance, which is the computation of all water fluxes at the boundaries of the system under consideration. It is an itemized statement of all gains, losses and changes of water storage within a specified elementary volume of soil. Its knowledge is of extreme importance for the correct water management of natural and agro-systems. Gives an indication of the strength of each component, which is important for their control and to ensure the utmost productivity with a minimum interference on the environment.

Let us make a panoramic overview of the SOIL-PLANT-ATMOSPHERE system in relation to agricultural production. The atmosphere rests over the soil and the plant connects both, growing upwards (shoot) and downwards (root). Our interest lies in the plant, more specifically in its yield, which is a function of the available energy, the climate, the soil, the crop management, the genotype, (Figure 1). The fundamental reaction is:

$$\frac{1M\ CO_2}{atmosphere} + \frac{1M\ H_2O}{soil} + \frac{E}{atmosphere} \quad \rightarrow \quad \frac{1M\ CH_2O}{yield} + \frac{1M\ O_2}{atmosphere}$$



CLIMATE

T_{air}, T_{max}, T_{min}, T_{ave}, T_o, T_b, T_m
DD = degree days
Duration of the cycle
Agricultural Zoning

Global Radiation

Evapotranspiration

Atmosphere

Rainfall

Net-Radiation

$1M\ CO_2 + 1M\ H_2O + E \longrightarrow 1M\ CH_2O + 1M\ O_2$

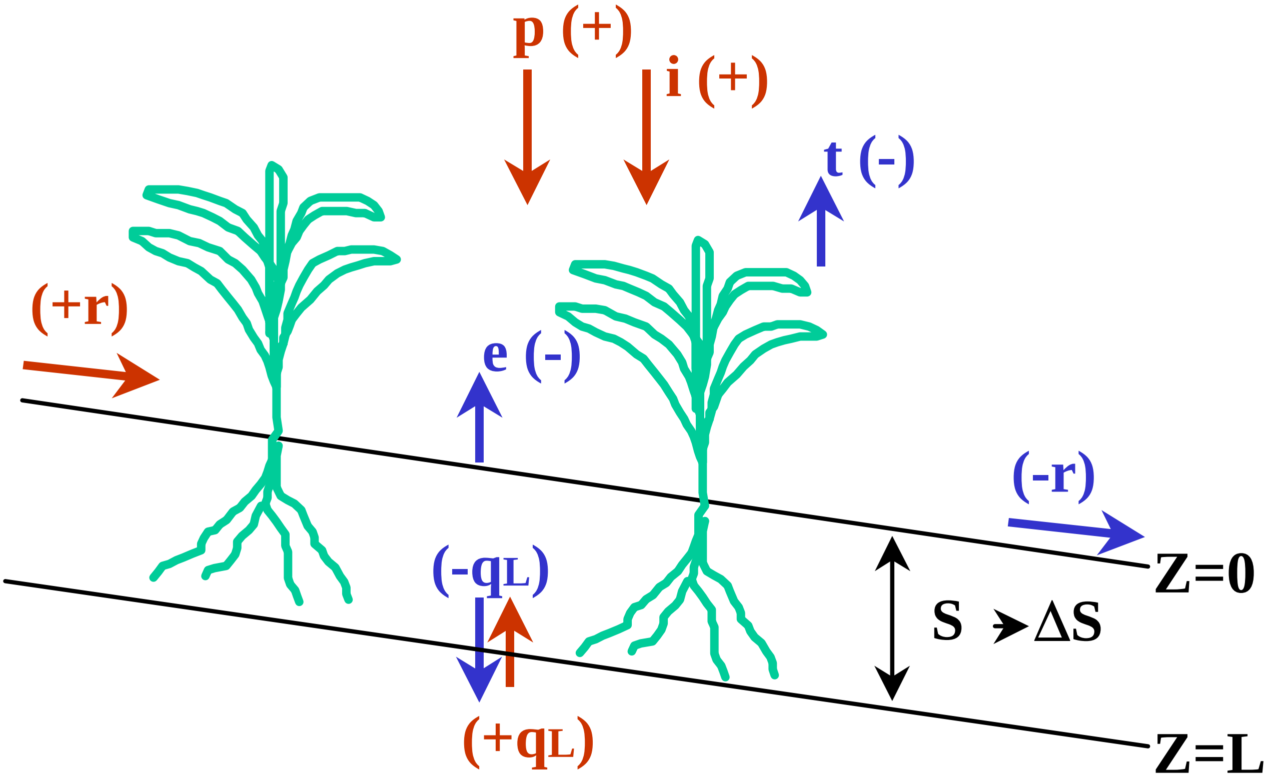
Plant

SOIL PHYSICS
-Water flow
-Nutrient flow
-Gas flow

Soil

GROUD WATER

Yield = f (energy, climate, soil, management, genotype, ...)



The balance is an expression of the mass conservation law, which can be written for the elemental volume as follows:

$$\sum f = \int_0^L \frac{\partial\theta}{\partial t} dz \qquad (1)$$

where θ is the soil water content (m3.m-3), t the time (day) and **f** stands for the flux densities **p**, **i**, **t**, **e** (or **et**), **r** and **q**. The entrance or leave of the fluxes **f** in the elemental volume give rise to changes in soil water contents ∂θ/∂t, which integrated over the depth interval, z = 0 and z = L, represent changes in soil water storage S. Therefore, equation (1) can be rewritten as:

$$p + i - et \pm r \pm q_L = \frac{\partial S}{\partial t} \qquad (1a)$$

where

$$S = \int_0^L \theta dz \qquad (2)$$

Equation (1a) is an instantaneous view of the balance. When integrated over a time interval Δt = tf – ti, in days, yields amounts of water (mm):

$$\int_{t_i}^{t_f} (p + i - et \pm r \pm q_L) dt = \int_{t_i}^{t_f}\int_0^L \frac{\partial\theta}{\partial t} dzdt \qquad (3)$$

$$\mathbf{P + I - ET \pm R \pm Q = \Delta S = S(t_f) - S(t_i)} \qquad \mathbf{(3a)}$$

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1. A soil profile stores 280 mm of water and receives 10 mm of rain and 30 mm of irrigation. It looses 40 mm by evapotranspiration. Neglecting runoff and soil water fluxes below the root zone, what is its new storage?
2. A soybean crop looses 35 mm by evapotranspiration in a period without rainfall and irrigation. It looses also 8 mm through deep drainage. What is its change in storage?
3. During a rainy period, a plot receives 56 mm of rain, of which 14 mm are lost by runoff. Deep drainage amounts to 5 mm. Neglecting evapotranspiration, what is the storage change?
4. Calculate the daily evapotranspiration of a bean crop which, in a period of 10 days, received 15 mm of rainfall and two irrigations of 10 mm each. In the same period, the deep drainage was 2 mm and the change in storage –5 mm.
5. How much water was given to a crop through irrigation, knowing that in a dry period its evapotranspiration was 42 mm and the change in storage was –12 mm? Soil was at field capacity and no runoff occurred during irrigation.

SOLUTIONS

nº	**P**	**+**	**I**	**-**	**ET**	**±R**	**±Q_L**	**=**	**ΔS_L**	**Answer**
1	10		30		-40	0	0		0	280 mm
2	0		0		-35	0	-8		-43	-43 mm
3	56		0		0	-14	-5		+37	+37 mm
4	15		20		-38	0	-2		-5	-3.8 mm.day^{-1}
5	0		30		-42	0	0		-12	+30 mm

Rainfall

Rainfall is easily measured with simple rain gauges which consist of containers of a cross sectional area A (m2), which collect a volume V (liters) of rain, corresponding to a rainfall depth h (mm) equal to h = V/A. The problem in its measurement lies mostly in the variability of the rain in space and time. In the case of whole watersheds, rain gauges have to be well distributed, following a scheme based on rainfall variability data. For the case of small experimental fields, attention must be given to the distance of the gauge in relation to the water balance plots. Reichardt et al. (1995) is an example of a rainfall variability study, carried out in a tropical zone, where localized thunder-storms play an important role.

Irrigation

The measurement of the irrigation depth that effectively infiltrates into a given soil at a given area is not an easy task. Different methods of irrigation (sprinkler, furrow, drip, flooding, etc....) present great space variability in supplying water to the soil, which has to be taken into account.

Evapotranspiration (ET)

Evapotranspiration can be measured independently or estimated from the balance, if all other components are known. In the first case, a great number of reports is found in the literature, covering classical methods like those proposed by Thornthwaite, Braney-Criddle and Penmann, which are based on atmospheric parameters such as air temperature and humidity, wind, solar radiation, etc. These methods have all their own shortcomings, mainly because they do not take into account plant and soil factors. Several models, however, include aspects of plant and soil, and yield much better results.

The main problem of estimating ET from the balance lies in the separation of the contribution of the components ET and QL, since both lead to negative changes in soil water storage ΔS. One important thing is that the depth L has to be such that it includes the whole root system. If there are roots below z = L, ET is under estimated. If L covers the whole root system and QL is well estimated, which is difficult as will be seen below, ET can be estimated from the balance. Villagra et al. (1995) discuss these problems in detail.

Runoff (R)

Runoff is difficult to be estimated since its magnitude depends on the slope of the land, the length of the slope, soil type, soil cover, etc. For very small slopes, runoff is in general neglected. If the soil is managed correctly, using contour lines, even with significant slopes runoff can be neglected. In cases it can not be neglected, runoff is measured using ramps, about 20 m long and 2 m wide, covering an area of 40 to 50 m^2, with a water collector at the lower end. Again, the runoff depth h (mm) is the volume V (liters) of the collected water, divided by the area A (m^2) of the ramp. Several reports in the literature cover the measurement of R, and its extrapolation to different situations of soil, slope, cover, etc. This is a subject very well considered in other opportunities of this College.

Soil Water Fluxes at z = L, QL

The estimation of soil water fluxes at the lower boundary z = L, can be estimated using Darcy-Buckingham´s equation, integrated over the time:

$$Q_L = \int_{t_i}^{t_f} \left[K(\theta) \partial H / \partial z \right] dt \qquad (4)$$

where $K(\theta)$, ($mm.day^{-1}$), is the hydraulic conductivity estimated at the depth z = L, and $\partial H/\partial z$ ($m.m^{-1}$) the hydraulic potential head gradient, H (m) being assumed to be the sum of the gravitational potential head z (m), and the matric potential head h (m). Therefore it is necessary to measure $K(\theta)$ at z = L and the most common procedures used are those presented by Hillel et al. (1972), Libardi et al. (1980), and Sisson et al. (1980). These methods present several problems, discussed in detail in Reichardt et al. (1998). The use of these $K(\theta)$ relations involves two main constraints: (i.) the strong dependence of K upon θ, which leads to exponential or power models, and (ii.) soil spatial variability.
Two commonly used $K(\theta)$ relations are:

$$K = K_o \exp[\beta(\theta - \theta_o)] \qquad (5)$$

and

$$K = a\theta^b \qquad (6)$$

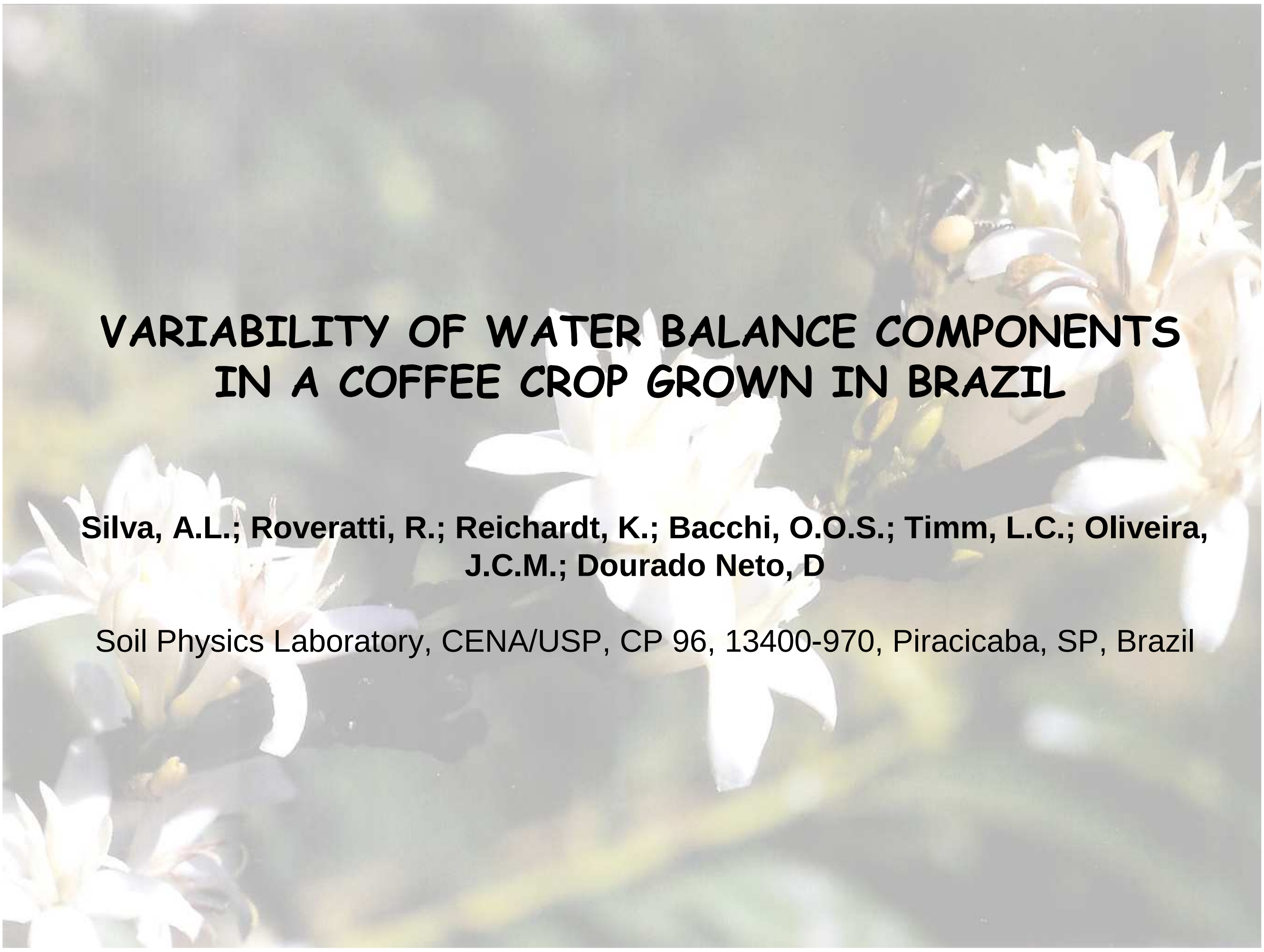
in which β, a and b are fitting parameters, Ko the saturated hydraulic conductivity, and θo the soil water content saturation. Reichardt et al. (1993) used model (5), and for 25 observation points of a transect on a homogeneous dark red latosol, obtained an average equation with K_o average = 144.38 ± 35.33 mm.day^{-1}, and β average = 111.88 ± 33.16. Assuming θ_o = 0.442 m^3.m^{-3}, the value of K is 1.04 mm. day^{-1} for θ = 0.4 m^3.m^{-3}. If this value of θ has an error of 2%, which is very small for field conditions, we could have θ ranging from 0.392 to 0.408 m^3.m^{-3}, and the corresponding values of K are: 0.43 and 2.55 mm.day^{-1}, with a difference of almost 500%. This example shows in a simple manner the effect of the exponential character of the K(θ) relations. The standard deviations of K_o and β, shown above, reflect the problem of spatial variability. Added to this is the spatial variability of θ itself.

Changes in Soil Water Storage ΔS

Soil water storage S, defined by equation (2) is, in general, estimated either by: (i) direct auger sampling; (ii) tensiometry, using soil water characteristic curves; (iii) using neutron probes; and (iv) using TDR probes. The direct sampling is the most disadvantageous due to soil perforations left behind after each sampling event. Tensiometry embeds the problem of the establishment of soil water characteristic curves, and neutron probes and TDR have calibration problems. Once θ versus z data at fixed times are available, S is estimated by numerical integration, the trapezoidal rule being an excellent approach, and in this case, equation (2) becomes:

$$S = \int_0^L \theta dz \cong \sum \theta \Delta z = \bar{\theta} L \qquad (2a)$$

The changes ΔS are simply the difference of S values obtained at the different times ti and tf.



VARIABILITY OF WATER BALANCE COMPONENTS IN A COFFEE CROP GROWN IN BRAZIL

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INTRODUCTION

Water balances are of extreme importance to follow water dynamics in agricultural and natural ecosystems. They indicate, in space and time, the conditions under which plants grow and develop, being useful in the interpretation of plant behavior during periods that differ from the normal climatic condition of the place in question, such as periods of water excess or deficit. These aspects are of great importance for crop management and the understanding of the behavior of natural ecosystems. A non-response of a crop to a fertilizer or the disappearance of a given natural species, can be partially explained in light of consistent water balances.

The coffee crop is among the most important crops in Brazil, being cultivated over an area of almost 3 million ha, with a production of 34 million bags of dry beans (60 Kg each) per year (FNP, 2002). Among the several factors that affect the productivity of this crop, of extreme importance are the water relations in the soil-plant-atmosphere system and the availability of nutrients, mainly nitrogen. The establishment of water balances is an excellent tool to better understand these water relations with respect to the growth and development of the crop, and to quantify important nitrogen losses by leaching, volatilization and run-off. The establishment of field water balances is time consuming and costly due to the required equipment. For this reason they are seldomly replicated in order to obtain significant average values.

Since the water balance is an addition of several components, each of them having its own space and time variability, error propagation can lead to inconsistent results. Villagra et al. (1995) discuss this variability problem in a study comprising 25 balance replicates, their main problem being the estimation of soil water fluxes below the rootzone.

With the objective of contributing to a better understanding of water relations of the coffee crop, we present the variability of the water balance components, using five replicates distributed within a 0.2ha coffee crop.

MATERIAL AND METHODS

Experimental Field

The experiment was carried out in Piracicaba, SP, Brazil, (22º 42`S, 47º38`W, 580m above sea level) on a soil classified as Rhodic Kandiudalf, locally called “Nitossolo Vermelho Eutroférrico”, A moderate and clayey texture. The climate is Cwa, according to Köppen’s classification, mesothermic with a dry winter, in which the average temperature during the coldest month is below 18ºC and during the hottest month, is over 22ºC. The annual average temperatures, rainfall, and relative humidity are 21.1ºC, 1,257 mm, and 74%, respectively. The dry season is between April and September; July is the driest month along the year. The wettest period is between January and February. The amount of rainfall during the driest month is not over 30 mm (Villa Nova, 1989).

Coffee plants (*Coffea arabica* L.), cultivar “Catuaí Vermelho” (IAC-44) were planted in line along contour-lines in May 2001. The spacing in rows was 1.75 m and 0.75 m between plants. The total coffee area of 0.2 ha was divided into 15 plots with nearly 120 plants each. This arrangement was used in order to distribute randomly three treatments of a parallel Nitrogen Balance study, with five replicates.

The experimental evaluations started on September 1, 2003 at 8.00am. The following dates received the code DAB (days after beginning, since the crop is perenial) followed by the number of days. It is important to mention that a field day starts at 8.00am and finishes in the following day at 8:00am.

Only the five replicates of the treatment with highest rate of N-fertilizer (T_2) were used in order to establish the water balances, made in sub-plots with nine plants covering an area of 11.8125 m^2, on a 10 ± 2 % slope. These plots were fenced to perform the nitrogen balance, fertilizing the area with enriched ammonium sulphate. The experimental area is located under the edge of a central-pivot irrigation system which, therefore, did not permit very regular applications of water depths. An automatic meteorological station was installed nearby (about 200 m).

The experimental design, used in the parallel N study consisted of randomized blocks with three treatments of N, T_0, T^1 (1/2 rate), and T_2 (1 rate), receiving 280 $kg.ha^{-1}$ of N split into 4 applications (DAB-0, DAB-63, DAB-105, and DAB-151), with a regular P and K fertilization.

Water Balance

Water balances started on September 1, 2003 (DAB-0) and continued to be established for 14 day periods , continually, until August 30, 2004 (DAB-364), completing one year. The classical water balance equation representing the mass conservation law was used, considering water fluxes entering and leaving a soil volume element, integrated over time for 14 day periods $\Delta t = t_{i+14} - t_i$:

$$\int_{t_i}^{t_{i+14}} p\,dt + \int_{t_i}^{t_{i+14}} i\,dt - \int_{t_i}^{t_{i+14}} e\,dt - \int_{t_i}^{t_{i+14}} r\,dt \pm \int_{t_i}^{t_{i+14}} q_L\,dt + S_{i+14} - S_i = 0 \qquad (1)$$

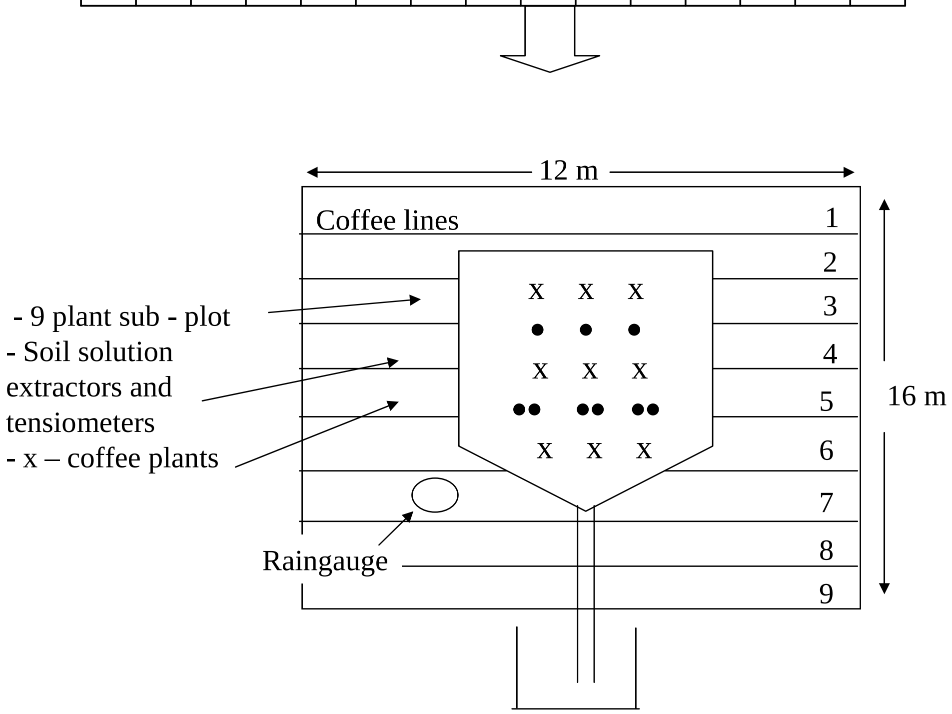
which by solving the integrals results in:

$$P + I - ER - RO - Q_L + \Delta S = 0 \qquad (2)$$

where P=rainfall; I=irrigation; ER=actual evapotranspiration; $\Delta S = S_{i+14} - S_i$ = soil water storage changes in the soil 0–L layer; RO = runoff; and Q_L = deep drainage at the lower boundary of the soil volume at the depth z = L, all expressed in mm.

Rainfall (P) was measured daily and integrated over Δt at each replicate, using traditional rain-gauges (“Ville de Paris”) with 0.04047 m^2 collecting areas, installed in the sub-plots 1.2 m above soil surface. Due to the presence of obstacles in the neighborhood of the experimental area, such as, a silo, a warehouse, orchards, and tall trees, the rainfall was measured in each T_2 plot using 5 rain-gauges, opening the possibility of obtaining average values ($\overline{P}$) with standard deviations [s(P)] and coefficients of variation (CV).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T_0	T_2	T_2	T_0	T_2	T_2	T_0	T_1	T_2	T_1	T_1	T_0	T_1	T_1	T_0



12 m

16 m

Coffee lines

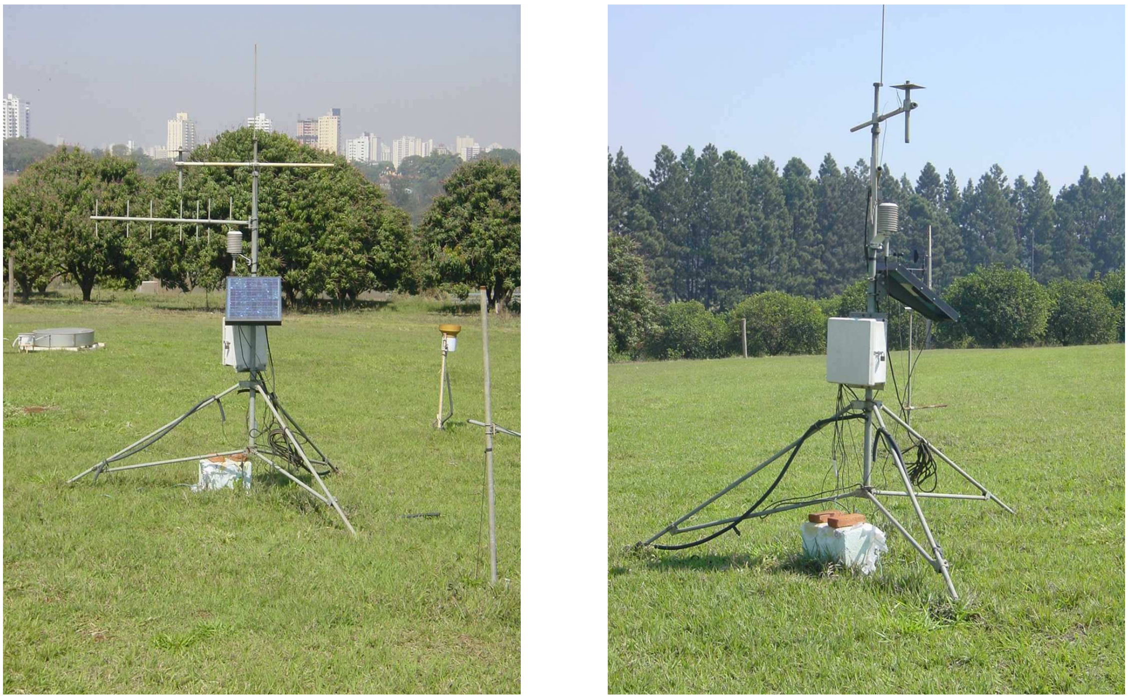
- 9 plant sub - plot
- Soil solution extractors and tensiometers
- x – coffee plants

Raingauge

Irrigation for coffee in this region of Brazil is supplementary, applied only during periods of severe drought, in our case through the central-pivot system. As mentioned above, the coffee crop plots were at the edge of this irrigation system, which increased the variability of water application. This variable was also measured by the 5 rain-gauges installed for rainfall measurement.

The criteria of amount and time of irrigation were mostly based on physiological aspects of the coffee plant that requires a cold and dry winter to blossom, which starts after the first significant rain. After blossoming, an excessive lack of water may cause flower loss. Therefore, the decision to irrigate was taken by visual observation of the water deficit, trying to apply 30 mm of water depth that approximately would wet a 0.6 m soil layer.

The actual crop evapotranspiration (ER) was estimated by difference from all other components, using equation (2). In wet periods, with a drainage (QL) likely to happen and considering it as zero in equation (02), ER, now named ER', was overestimated because it includes QL. Thus, in periods in which ER was larger than the potential evapotranspiration (ET), ER was considered equal to ET and the difference ER–ET=QL. The potential evapotranspiration was estimated from the reference evapotranspiration (ET0) corrected by the crop coefficient (KC). ET0 was calculated using Penman-Monteith equation (Pereira et al., 1997), with meteorological data collected at the automatic weather-station installed near the experimental area. KC was calculated by dividing ER by ET0 along the periods in which the plants were not under stress, when the soil water storage was relatively high and without drainage. The above referred KC was the average value obtained for these periods.



Since ER was calculated from the balance equation (2) its variability was estimated through error propagation:

$$s^2(ER') = s^2(P) + s^2(I) + s^2(RO) + s^2(S_{i+14}) + s^2(S_i) \qquad (3)$$

and was taken equal to since it was calculated by the difference ER'-ET, considering ET an absolute value.

The soil layer 0-1m (L=1m) was chosen to calculate soil water storages since at this stage of the crop this soil layer contains more than 95% of the root system. was estimated from soil water content measurements (θ) obtained by a neutron probe, using three access tubes installed down to the depth of 1.2 m in each plot, making up a total of 15 tubes. The calibration of this probe, model CPN 503 DR, was made in an area close to the experimental field. The moisture contents were measured at 0.20, 0.40, 0.60, 0.80, and 1.00 m at the selected dates ti, during the experimental period, which started at t_i (DAI-0) and continued up to t_{i+14}, Δt = 14 days. was calculated using the trapezoidal rule:

$$S(t_i) = \int_0^L \theta(t_i)\,dz = [\overline{\theta}(t_i)].L \qquad (4)$$

where is the average at time and the soil depth L, in this case taken as 1,000 mm in order to obtain S expressed in mm.

For measuring the runoff, each experimental plot was framed by metal dicks, and the water was collected by gravity in 60L tanks placed downslope.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Balance	Period	DAB	Rainfall (P)							
			1	2	3	4	5	$\overline{P}$	s(P)	CV
1	01/09 to 15/09	0_14	4.0	4.2	4.3	4.2	4.0	4.1	0.1	3.2
2	15/09 to 29/09	14_28	5.8	5.8	6.4	4.8	6.2	5.8	0.6	10.6
3	29/09 to 13/10	28_42	79.0	75.4	80.6	78.0	75.9	77.8	2.2	2.8
4	13/10 to 27/10	42_56	18.2	18.1	18.2	17.6	17.5	17.9	0.3	1.9
5	27/10 to 10/11	56_70	25.4	24.9	26.3	24.5	25.5	25.3	0.7	2.7
6	10/11 to 24/11	70_84	75.7	74.2	78.7	74.2	72.5	75.1	2.3	3.1
7	24/11 to 08/12	84_98	93.9	88.9	91.8	87.4	86.7	89.7	3.0	3.4
8	08/12 to 22/12	98_112	51.0	49.8	49.3	48.5	48.0	49.3	1.2	2.4
9	22/12 to 05/01	112_126	89.2	86.5	85.1	84.4	82.8	85.6	2.4	2.8
10	05/01 to 19/01	126_140	52.4	51.1	50.5	49.6	49.3	50.6	1.2	2.5
11	19/01 to 02/02	140_154	173.7	168.4	165.7	166.7	164.2	167.7	3.7	2.2
12	02/02 to 16/02	154_168	73.9	71.4	69.1	67.9	66.9	69.8	2.8	4.0
13	16/02 to 01/03	168_182	156.6	156.3	153.7	149.2	148.8	152.9	3.7	2.5
14	01/03 to 15/03	182_196	75.9	74.8	72.2	71.4	71.2	73.1	2.1	2.9
15	15/03 to 29/03	196_210	14.4	14.4	14.0	13.8	13.2	14.0	0.5	3.6
16	29/03 to 12/04	210_224	59.4	78.6	62.2	65.0	61.0	65.2	7.7	11.9
17	12/04 to 26/04	224_238	54.7	53.6	51.8	50.9	50.7	52.3	1.7	3.3
18	26/04 to 10/05	238_252	23.9	24.1	22.9	22.3	22.7	23.2	0.8	3.4
19	10/05 to 24/05	252_266	27.4	27.2	25.1	23.9	24.1	25.5	1.7	6.5
20	24/05 to 07/06	266_280	105.5	104.5	101.1	98.5	97.7	101.5	3.5	3.4
21	07/06 to 21/06	280_294	7.6	8.0	7.1	6.7	6.5	7.2	0.6	8.7
22	21/06 to 05/07	294_308	2.4	2.0	1.8	1.6	1.6	1.9	0.3	17.8
23	05/07 to 19/07	308_322	33.2	33.1	32.5	32.2	32.3	32.7	0.5	1.4
24	19/07 to 02/08	322_336	46.8	45.4	43.9	43.6	43.1	44.6	1.5	3.4
25	02/08 to 16/08	336_350	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	16/08 to 30/08	350_364	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	01/09 to 30/08	0-364	1350.0	1340.7	1314.3	1286.9	1272.4	1312.9	33.4	2.5

Balance	**DAB**	$\overline{ER}$` (mm)	**s(ER')**	**CV**	$\overline{ET_0}$ (mm)	**K_C**	$\overline{ET_c}$ (mm)	**ER=ER'-Q_L** (mm)	$\overline{Q_L}$ (mm)
1	0_14	-26.1	33,65	129,0	-45.9	1.1	-50.1	-26.1	0,0
2	14_28	-11.9	29,92	250,9	-56.0	1.1	-61.2	-11.9	0,0
3	28_42	-50.9	31,25	61,3	-53.9	1.1	-58.9	-50.9	0,0
4	42_56	-24.8	32,00	129,1	-65.4	1.1	-71.5	-24.8	0,0
5	56_70	-33.1	33,19	100,3	-47.5	0.7	-33.1	-33.1	0,0
6	70_84	-62.3	32,90	52,8	-60.3	1.0	-62.3	-62.3	0,0
7	84_98	-72.0	30,74	42,7	-50.5	1.4	-72.0	-72.0	0,0
8	98_112	-57.5	31,10	54,1	-62.4	0.9	-57.5	-57.5	0,0
9	112_126	-68.1	33,87	49,7	-57.5	1.2	-68.1	-68.1	0,0
10	126_140	-52.2	33,28	63,7	-63.2	0.8	-52.2	-52.2	0,0
11	140_154	-97.4	33,95	34,9	-39.3	1.1	-42.9	-42.9	-54,4
12	154_168	-95.5	34,66	36,3	-62.0	1.5	-95.5	-95.5	0,0
13	168_182	-130.6	35,80	27,4	-46.8	1.1	-51.2	-51.2	-79,4
14	182_196	-89.3	36,28	40,6	-52.3	1.7	-89.3	-89.3	0,0
15	196_210	-62.4	33,95	54,4	-55.3	1.1	-62.4	-62.4	0,0
16	210_224	-64.2	33,61	52,4	-47.7	1.3	-64.2	-64.2	0,0
17	224_238	-51.7	32,31	62,5	-36.1	1.4	-51.7	-51.7	0,0
18	238_252	-29.6	33,03	111,6	-35.6	0.8	-29.6	-29.6	0,0
19	252_266	-25.6	32,92	128,8	-24.4	1.0	-25.6	-25.6	0,0
20	266_280	-46.8	30,75	65,6	-23.4	1.1	-25.6	-25.6	-21,3
21	280_294	-19.6	31,51	160,5	-29.9	0.7	-19.6	-19.6	0,0
22	294_308	-21.9	33,59	153,2	-35.4	0.6	-21.9	-21.9	0,0
23	308_322	-6.6	31,13	469,1	-27.7	1.1	-30.2	-6.6	0,0
24	322_336	-57.5	30,00	52,2	-35.7	1.1	-39.0	-39.0	-18,5
25	336_350	-11.4	30,48	266,5	-45.1	1.1	-49.3	-11.4	0,0
26	350_364	-46.1	30,26	65,7	-46.7	1.1	-51.0	-46.1	0,0
1_26	0_364	-1315,3	-	-	-1206,0	1.1	-1318,3	-1141,7	-173,6

Balance	**DAB**	**s(P)**	**s(I)**	**s(S_F)**	**s(S_I)**	**s(RO)**	**s(ER')**
1	0_14	0,1	12,0	20,7	23,7	0,0	33,6
2	14_28	0,6	0,0	21,6	20,7	0,0	29,9
3	28_42	2,2	0,0	22,5	21,6	0,3	31,2
4	42_56	0,3	0,0	22,8	22,5	0,0	32,0
5	56_70	0,7	0,0	24,1	22,8	0,0	33,2
6	70_84	2,3	0,0	22,3	24,1	0,4	32,9
7	84_98	3,0	0,0	21,0	22,3	0,3	30,7
8	98_112	1,2	0,0	22,9	21,0	0,0	31,1
9	112_126	2,4	0,0	24,8	22,9	0,8	33,9
10	126_140	1,2	0,0	22,1	24,8	0,1	33,3
11	140_154	3,7	0,0	25,5	22,1	0,7	33,9
12	154_168	2,8	0,0	23,3	25,5	0,4	34,7
13	168_182	3,7	0,0	26,9	23,3	1,1	35,8
14	182_196	2,1	0,0	24,3	26,9	0,7	36,3
15	196_210	0,5	0,0	23,7	24,3	0,0	34,0
16	210_224	7,7	0,0	22,5	23,7	0,3	33,6
17	224_238	1,7	0,0	23,1	22,5	0,1	32,3
18	238_252	0,8	0,0	23,6	23,1	0,1	33,0
19	252_266	1,7	0,0	22,9	23,6	0,0	32,9
20	266_280	3,5	0,0	20,2	22,9	1,1	30,7
21	280_294	0,6	0,0	24,2	20,2	0,0	31,5
22	294_308	0,3	0,0	23,3	24,2	0,0	33,6
23	308_322	0,5	0,0	20,6	23,3	0,1	31,1
24	322_336	1,5	0,0	21,7	20,6	0,0	30,0
25	336_350	0,0	0,0	21,4	21,7	0,0	30,5
26	350_364	0,0	15,6	14,7	21,4	0,7	30,3

Balance	Period	DAB	S_l							
			1	2	3	4	5	$\overline{S_L}$	s(S-$_L$)	CV
1	01/09 to 15/09	0_14	250.2	260.8	203.4	254.6	257.2	245.2	23.7	9.7
2	15/09 to 29/09	14_28	261.0	271.1	221.0	265.6	268.3	257.4	20.7	8.0
3	29/09 to 13/10	28_42	255.9	265.6	213.1	259.3	262.4	251.3	21.6	8.6
4	13/10 to 27/10	42_56	272.3	284.5	242.8	303.0	286.9	277.9	22.5	8.1
5	27/10 to 10/11	56_70	269.9	280.3	232.8	292.2	279.9	271.0	22.8	8.4
6	10/11 to 24/11	70_84	263.2	276.0	221.5	278.7	276.8	263.3	24.1	9.2
7	24/11 to 08/12	84_98	273.0	287.4	238.7	296.3	282.5	275.6	22.3	8.1
8	08/12 to 22/12	98_112	286.3	306.7	262.3	317.2	293.1	293.1	21.0	7.2
9	22/12 to 05/01	112_126	277.9	299.8	249.8	309.2	288.0	284.9	22.9	8.0
10	05/01 to 19/01	126_140	288.3	312.9	271.4	336.9	299.9	301.9	24.8	8.2
11	19/01 to 02/02	140_154	288.0	311.4	270.2	328.0	303.2	300.2	22.1	7.4
12	02/02 to 16/02	154_168	380.0	380.2	324.5	384.3	380.6	369.9	25.5	6.9
13	16/02 to 01/03	168_182	352.1	354.8	302.6	359.5	350.8	344.0	23.3	6.8
14	01/03 to 15/03	182_196	375.4	382.3	317.4	375.2	375.3	365.1	26.9	7.4
15	15/03 to 29/03	196_210	356.2	364.1	305.4	359.2	357.7	348.5	24.3	7.0
16	29/03 to 12/04	210_224	310.5	314.4	258.0	311.5	306.0	300.1	23.7	7.9
17	12/04 to 26/04	224_238	304.5	317.2	261.9	315.4	305.2	300.8	22.5	7.5
18	26/04 to 10/05	238_252	305.0	313.3	261.0	318.2	309.2	301.3	23.1	7.7
19	10/05 to 24/05	252_266	301.0	306.4	253.0	308.7	305.4	294.9	23.6	8.0
20	24/05 to 07/06	266_280	300.2	304.8	254.3	306.1	308.8	294.8	22.9	7.8
21	07/06 to 21/06	280_294	360.1	359.9	312.8	356.2	354.3	348.7	20.2	5.8
22	21/06 to 05/07	294_308	348.4	348.7	293.3	342.0	348.7	336.2	24.2	7.2
23	05/07 to 19/07	308_322	327.7	327.7	274.8	321.6	329.2	316.2	23.3	7.4
24	19/07 to 02/08	322_336	350.7	345.4	306.0	353.7	355.3	342.2	20.6	6.0
25	02/08 to 16/08	336_350	341.4	334.6	290.7	337.9	341.7	329.3	21.7	6.6
26	16/08 to 30/08	350_364	334.1	324.3	280.4	322.9	327.4	317.8	21.4	6.7

Balance	Period	DAB	$\overline{P}$ (mm)	$\overline{I}$ (mm)	$\overline{S_i}$ (mm)	$\overline{\Delta S}$ (mm)	$\overline{RO}$ (mm)	$\overline{Q_L}$ (mm)	$\overline{ER}$ (mm)	$\overline{ET_C}$ (mm)
1	01/09 to 15/09	0_14	4.1	34.2	245.2	12.2	0.0	0.0	-26.1	-50.1
2	15/09 to 29/09	14_28	5.8	0.0	257.4	-6.1	0.0	0.0	-11.9	-61.2
3	29/09 to 13/10	28_42	77.8	0.0	251.3	26.6	-0.2	0.0	-50.9	-58.9
4	13/10 to 27/10	42_56	17.9	0.0	277.9	-6.9	0.0	0.0	-24.8	-71.5
5	27/10 to 10/11	56_70	25.3	0.0	271.0	-7.8	0.0	0.0	-33.1	-33.1
6	10/11 to 24/11	70_84	75.1	0.0	263.3	12.3	-0.4	0.0	-62.3	-62.3
7	24/11 to 08/12	84_98	89.7	0.0	275.6	17.5	-0.2	0.0	-72.0	-72.0
8	08/12 to 22/12	98_112	49.3	0.0	293.1	-8.2	0.0	0.0	-57.5	-57.5
9	22/12 to 05/01	112_126	85.6	0.0	284.9	17.0	-0.5	0.0	-68.1	-68.1
10	05/01 to 19/01	126_140	50.6	0.0	301.9	-1.7	-0.1	0.0	-52.2	-52.2
11	19/01 to 02/02	140_154	167.7	0.0	300.2	69.8	-0.6	-54.4	-42.9	-42.9
12	02/02 to 16/02	154_168	69.8	0.0	369.9	-26.0	-0.3	0.0	-95.5	-95.5
13	16/02 to 01/03	168_182	152.9	0.0	344.0	21.1	-1.2	-79.4	-51.2	-51.2
14	01/03 to 15/03	182_196	73.1	0.0	365.1	-16.6	-0.4	0.0	-89.3	-89.3
15	15/03 to 29/03	196_210	14.0	0.0	348.5	-48.4	0.0	0.0	-62.4	-62.4
16	29/03 to 12/04	210_224	65.2	0.0	300.1	0.7	-0.3	0.0	-64.2	-64.2
17	12/04 to 26/04	224_238	52.3	0.0	300.8	0.5	-0.1	0.0	-51.7	-51.7
18	26/04 to 10/05	238_252	23.2	0.0	301.3	-6.4	-0.1	0.0	-29.6	-29.6
19	10/05 to 24/05	252_266	25.5	0.0	294.9	-0.1	0.0	0.0	-25.6	-25.6
20	24/05 to 07/06	266_280	101.5	0.0	294.8	53.8	-0.8	-21.3	-25.6	-25.6
21	07/06 to 21/06	280_294	7.2	0.0	348.7	-12.4	0.0	0.0	-19.6	-19.6
22	21/06 to 05/07	294_308	1.9	0.0	336.2	-20.0	0.0	0.0	-21.9	-21.9
23	05/07 to 19/07	308_322	32.7	0.0	316.2	26.0	-0.1	0.0	-6.6	-30.2
24	19/07 to 02/08	322_336	44.6	0.0	342.2	-12.9	0.0	-18.5	-39.0	-39.0
25	02/08 to 16/08	336_350	0.0	0.0	329.3	-11.4	0.0	0.0	-11.4	-49.3
26	16/08 to 30/08	350_364	0.0	37.5	317.8	-8.9	-0.4	0.0	-46.1	-51.0
Sum	01/09 to 30/08	0_364	1312.8	71.6	7931.6	63.7	-5.5	-173.6	-1141.7	-1336.1