FARMER'S INCOME AT KAFR EL-SHEIKH GOVERNORATE AS AFFECTED BY WATER UTILIZATION AND USE EFFICIENCIES "CASE STUDY"

Ibrahim, M.A.M.[1]; N.G. Ainer[1] and S.N. Shalan[2]

[1]*Crops, Water Req. Res. Dept., SWERI, ARC, Egypt*
[2]*Director, Soils, Water and Env. Res. Inst. (SWERI), ARC, Egypt*

ABSTRACT

The present study was carried out to find out the impact of water utilization efficiency, W.Ut.E. and water use efficiency , W.U.E. both in kg/m^3 and corresponding value on farmer's revenue.

Following are the main results:

1. January is accompanied with the least value 2.12 mm day^{-1} of reference evapotranspiration (ETo), while the highest value 7.40 m day^{-1} was attached with June. The annual mean of ETo at Kafr El-Sheikh Governorate, north Nile Delta region is 4.51 mm.day^{-1}.
2. For winter field crops, values of either W.Ut.E. or W.U.E. could be arranged in descending order as: Bersim, sugar beet, wheat, flax, barley and beans. While, the arrangement for summer field crops is maize (summer), rice, maize (Nili) cotton and soybean. For vegetables, either applied or consumed unit of irrigation water produced higher Nili crops than the summer ones.
3. From economical evaluation point of view:

a. For winter crops, the impact of either W.Ut.E. or W.U.E. on farmer's income might be arranged as: Beans > wheat > sugar beet > flax > bersim > barley > other crops. The corresponding values regarding W.Ut.E. are: 2.30, 1.28, 1.03, 0.99, 0.93, 0.87 and 0.68 L.E.. Concerning W.U.E., values are: 3.83, 2.39, 1.72, 1.66, 1.56, 1.45 and 1.13 L.E., respectively.

b. For summer crops, the role of either W.Ut.E. or W.U.E. on farmer's revenue is arranged in descending order as: Cotton > maize-sum. > soybean > other crops > rice > maize-Nili . The corresponding values produced with W.Ut.E. in L.E. are: 1.37, 0.80, 0.75, 0.71, 0.69 and 0.63, respectively. Concerning W.U.E., the values in L.E. are: 2.29, 1.33,1 .26, 1.18, 1.15 and 1.05, respectively.

INTRODUCTION

Egypt is forced to implement serious efforts towards the equilibrium between its limited water supply and demand. Water demand is increasing rapidly and should be matched with the integral development which forced the populated area to be increased from the present situation of 5% to about 25% from the national area.

At present, water-capita share for different purposes is less than the water poverty edge of 1000 m^3. In the coming forty years, it is prospected to decrease to less than 500 m^3 which so-called the scarcity level. It is difficult at this level to go for economic development and even it is extremely harsh to implement any strategic policy for human welfare.

Therefore, the necessity to modify the existed national policy of agricultural development which based mainly on the crop yield of each unit of cultivated area, to the marketable yield from unit of applied water and unit area as well becomes a must (Nassar, 2003).

Kafr El-Sheikh Governorate which lies in the middle north of Nile Delta is one of the main Governorates in agricultural production. It is the second largest one in rice production. It is also the pioneer in production of sugar beet. In addition, it has an exceeded rank in cotton production as well as other valuable crops.

On the other hand, concerning status of irrigation water, Kafr El-Sheikh Governorate is considered as the tail end of the Nile River, which in turn suffered from water shortage especially during summer months (Ibrahim *et al.,* 1988).

The role of consumed water by crops in specific or irrigation water in general with crop production from the economical point of view have been studied world wide. As reported by Sonnen *et al.* (1980), the water policy in the Western United States is to increase conservation of irrigation water rather than development of additional sources. Moore and Armstrong (1976) found that increased accuracy of water supply forecasts could increase return per acre by 6.25 $ for Colorado irrigators. Also, Van Bakel (1986), in the Netherlands stated that on the basis of actual yields and prices of products, it has been calculated that 1% increase in actual transpiration means 48.25 DFL per ha. arable land. He also, found that the internal rate of return for water conservation is very high and the investment in water conservation payed back in two years.

So, the target of maximizing crop production per unit of applied irrigation water or so-called more crop per drop becomes urgent. Meaningfully, up-grading the net income of farmers.

Therefore, the main objective of this case study is to evaluate the contribution of irrigation water in farmer's return.

Specific goals are:

1. To compute crop water consumption (ETc) and allied irrigation water (I.W.) for main cultivated crops in Kafr El-Sheikh Governorate.
2. To find out water utilization efficiency (W.Ut.E.) and water use efficiency (W.U.E.) for the important cultivated crops.
3. To carry out an economic analysis based on the impact of W.Ut.E and WU.E. on farmer's income.
4. To arrange the priority in cultivation different crops based on the economic evaluation owing to find out the most proper crop pattern from economical impact of drop of irrigation water.

PROCEDURES

1. To compute crop evapotranspiration (ETc) and irrigation water (I.W) for different crops, following steps were done:

- Agro-climatological elements for a period of 19 years from 1985 through 2003 were collected from the agro-meteorological station in the site.
- Different types of radiation: absolute (Ra), solar (Rs) and net (Rn) were computed based on the specific features of the site (Ibrahim, 1995).
- The recorded and the calculated data were used in computing reference evapotranspiration (ETo).
- Values of crop coefficient (Kc) for the specific crops were quoted from FAO Irri. & Drain. Paper No. 56 (Allen *et al.,* 1998).
- Computation of crop evapotranspiration (ETc).
- Computation of irrigation water (I.W.).

2. Computation of reference evapotranspiration (ETo):

Values of ETo for different months were derived as the average of the five following methods:

1. Hargreaves method:

$$ETo = 0.0023Ra.\ T_D^{0.5}\ (Ta + 17.8)$$

where:

Ra= absolute radiation, Cal. cm^{-2}-day^{-1}
T_D= air temperature difference between max. and min., ^oC
Ta= air temperature average, ^oC

Values of Ra for the area were computed depending upon the local environmental features (Ibrahim, 1995).

2. FAO Penman-Monteith:

$$ETo = \frac{0.408\Delta\,(Rn - G) + \gamma \dfrac{900}{T + 273}\,\mu_2\,(es - ea)}{\Delta + \gamma(1 + 0.34\,\mu_2)}$$

where:

- ETo reference evapotranspiration (mm day^{-1}),
- Rn net radiation at the crop surface (MJm^{-2} day^{-1}).
- G soil heat flux density (MJm^{-2} day^{-1}).
- T mean daily air temperature at 2 m height (^{o}C).
- μ_2 wind speed at 2 m height (ms^{-1}),
- es saturation vapour pressure (KPa),
- ea actual vapour pressure (KPa),
- es-ea saturation vapour pressure deficit (KPa),
- Δ slope vapour pressure curve (KPa C^{o-1}),
- γ psychrometric constant (KPa C^{o-1}),

Values of the stated parameters were either computed (Ibrahim, 2001) at the site or quoted from the standard tables (FAO NO. 56).

3. Jensen and Haise:

$$ETo = (0.025\,T + 0.08)\,Rs$$

As:

- T mean air temperature, ^{o}C.
- Rs solar radiation (cal. cm^{-2}-day^{-1})

Values of Rs for the area were computed (Ibrahim, 2001).

4. Ibrahim:

$$ETo = 0.1642 + 0.8\,Ep$$

As:

- Ep pan evaporation

This method was created for the north Nile Delta where Kafr El-Sheikh Governorate is lies (Ibrahim, 1981).

5. Pan evaporation:

$$ETo = Kp * Ep$$

As:

- Kp pan coefficient, values of Kp affected with the surrounding area, where the pan is located and it was taken as an average value of 0.75.

The reference evapotranspiration, ETo, provides a standard to which:

- Evapotranspiration at different periods of the year or in other regions can be compared;
- Evapotranspiration of other crops can be related.

3. Computation of crop evapotranspiration (ETc):

$$ETc = Kc * ETo$$

The dimension less crop coefficient, Kc is the ratio between the water consumed by specific crop to ETo. values of Kc were quoted from FAO No. 56, 1998.

E. Irrigation water (I.W):

Irrigation water was equaled ETc divided by irrigation efficiency (Ei), which was taken as 50% for rice and 60% for other irrigated crops under surface irrigation.

4. Crop-water functions:

Crop-water functions are commonly defined as:

1. Crop utilization efficiency, C.Ut.E. = $\frac{\text{Yield}}{\text{I.W}}$, and
2. Crop use efficiency, C.U.E. = $\frac{\text{Yield}}{\text{ETc}}$

It should be noticed that the selected crops are the main ones cultivated in Kafr El-Sheikh Governorate, productivity and price of production unit for different crops were obtained from the Governorate's agricultural office.

RESULTS AND DISCUSSIONS

1. Reference evapotranspiration (ETo):

January is assigned with the less value 2.12 mm day^{-1} and 7.40 mm.day^{-1} is the maximum value for June. Mean value during the winter season from October through February is 2.75 mm.day^{-1}. The corresponding mean value for summer and Nili growing seasons is 5.77 mm.day^{-1}. The yearly average value is 4.51 mm day^{-1} (Table 1).

Table (1): Reference evapotranspiration (ETo), mm.day^{-1} calculated with different methods for Kafr El-Sheikh Governorate

Month	ETo method, mm.day^{-1}					Average mm. day^{-1}
	Hargreaves	FAO Pen. & Mon.	Jensen & Haise	Ibrahim	Pan evap.	
January	1.98	1.80	1.72	3.41	1.67	2.12
February	2.56	2.30	2.26	3.92	2.14	2.64
March	3.32	3.30	3.07	4.65	2.82	3.43
April	4.75	4.40	4.99	6.24	4.31	4.94
May	5.84	5.50	6.60	7.93	5.90	6.35
June	6.19	5.90	7.99	9.53	7.40	7.40
July	5.66	6.20	7.88	8.06	6.02	6.76
August	5.37	5.50	7.31	7.51	5.51	6.24
September	4.90	4.50	5.86	6.50	4.55	5.26
October	3.68	3.40	4.41	5.44	3.56	3.92
November	2.67	2.40	2.76	4.19	2.39	2.88
December	1.94	1.70	1.79	3.59	1.82	2.17
Overall mean						**4.51**

2. Irrigation water (I.W.):

For winter field crops, sugar beet received the highest applied I.W. of 2833.4 m^3/fed. (67.5 cm, 1 fed. = 0.42 ha). While, beans is associated with the less amount 1822.7 m^3/fed. (43.4 cm). Other crops have values in between. Concerning winter vegetables, the average applied I.W. is 2337.1 m^3/fed. (55.6 cm). For Orchards, the amount of I.W. during winter season is 3107.8 or 74.0 cm (Table 2). On the other hand, for summer field crops, highest I.W. 6511.5 m^3/fed. (155.1 cm) is for rice, while the least I.W. 3212.2 m^3/fed. (76.5 cm) is for maize-Nili.

3. Crop consumptive use (C.U):

The trend of C.U. values is the same with that of I.W. The calculation of I.W. was based on C.U. The relationship is irrigation efficiency (I.W) which equals 50% in case of rice and 60% for other crops under surface irrigation. Values of C.U. are presented also in Table (2).

4. Crop-water functions:

a. Water utilization efficiency (W.Ut.E., kg. m^{-3}):

Values of the crop yield per each unit of applied irrigation water i.e. W.Ut.E, which shown in Fig. (1) illustrated that one m^3 irrigation water applied for water crops produced the highest yield of 10.6 kg bersim followed with sugar beet of 6.9 kg. The least value 0.77 kg was obtained from beans. Other field crops have values in between. Concerning vegetables crops, average value for such crops is about 3.5 kg/m^3.

Regarding summer and Nili field crops, the highest value of W.Ut.E equaled 0.77 kg/m^3 for maize (summer) and the lowest value 0.25 kg/m^3 for soybean. On the other hand, summer and Nili vegetables have values of 2.26 and 2.37 kg/m^3, respectively. While for orchards, mean value is 1.28 kg/m^3.

Table (2): Irrigation water (I.W), cons. use (C.U), water utilization eff. (W.Ut.E.), and water use eff. (W.U.E.) for different crops and their contribution in farmers revenues at Kafr El-Sheikh Governorate

Crop	I.W.		C.U.		Yield	W.Ut.E.		W.U.E.	
	m^3/fed.	cm.	m^3/fed.	cm.	kg/fed.	kg/m^3	L.E	kg/m^3	L.E
a. <u>Winter crops</u>									
Bersim	2824.5	67.3	1694.7	40.4	30000	10.62	0.93	17.70	1.56
Wheat grain	2482.5	59.1	1489.5	35.5	2902.5	1.17	1.06	1.95	2.15
Wheat straw					2250.0	0.91	0.22	1.01	0.24
Barley	2023.5	48.2	1214.1	28.9	1754.4	0.87	0.87	1.45	1.45
Beans	1822.7	43.4	1093.6	26.0	1396.6	0.77	2.30	1.28	3.83
Flax	2819.3	67.1	1691.6	40.3	4000.0*	1.42	0.99	2.36	1.66
Sugar beet	2833.4	67.5	1700.0	40.5	19450.0	6.86	1.03	11.44	1.72
Other crops	2581.5	61.5	1548.9	36.9	2017.8	0.78	0.68	1.30	1.13
Vegetables	2337.1	55.6	1402.3	33.4	8054.9	3.45	2.17	5.74	3.61
Orchard	3107.8	74.0	1864.7	44.4					
B. <u>Summer(S) & Nili (N) crops:</u>									
Cotton	3909.5	93.1	2345.7	55.9	1401.8	0.36	1.37	0.60	2.29
Rice	6511.5	155.1	3906.9	93.0	4490.0	0.69	0.69	1.15	1.15
Maize (S)	4138.5	98.5	2483.1	59.1	3180.0	0.77	0.80	1.28	1.33
Maize (N)	3212.2	76.5	1927.3	45.9	1952.4	0.61	0.63	1.01	1.05
Soy bean	4124.4	98.2	2474.6	58.9	1036.0	0.25	0.75	0.42	1.26
Other crops	4583.7	109.1	2750.2	65.5	1463.4	0.32	0.71	0.53	1.18
Vegetables (S)	3804.3	90.6	2282.6	54.3	8591.5	2.26	1.11	3.76	1.84
Vegetables (N)	3655.3	87.0	2193.2	52.2	8650.0	2.37	1.75	3.94	2.92
Orchards	5433.2	129.4	3259.9	77.6					
Yearly orchardx	8541.0	203.4	5124.6	122.0	10939	1.28	0.88	2.13	1.47

* seed + straw yield

b. Water use efficiency (W.U.E., kg.m^{-3}):

Values of the crop yield per unit of consumed water, W.U.E., as shown in Fig. (2) illustrated that, for winter crops, the highest value 17.7 kg/m^3 was obtained from bersim, while the lowest one 1.28 kg/m^3 for beans. For vegetable crops, mean value is 5.74 kg/m^3.

Regarding summer and Nili field crops, highest W.U.E. value is 1.28 kg/m^3 produced from summer maize, while the lowest value was obtained from soybean (0.42 kg/m^3). Mean value of vegetables is 3.8 kg/m^3 for summer and Nili ones. A value of 2.13 kg/m^3 was taken as an average for different orchard crops.

5. Economic evaluation crop-water functions:

Regarding W.Ut.E., values of the contribution of it in farmer's income might be arranged in descending order for winter field crops as shown in Fig. (1) as: beans > wheat > sugar beet > flax > bersim > barley > other crops. The corresponding values are: 2.30, 1.28, L.E. (1.06 for grains and 0.22 L.E. for straw), 1.03, 0.99, 0.93, 0.87 and 0.68 L.E., respectively. While, value for vegetables is 2.17 L.E.

For summer and Nile field crops, the arrangement in descending order is cotton > maize, sum. > soybean > other crops > rice > maize, Nili. The corresponding values are: 1.37, 0.80, 0.75, 0.71, 0.69 and 0.63 L.E., respectively. Values for summer, Nili vegetables and orchards are 1.1, 1.75 and 0.88 L.E., respectively.

Concerning W.U.E., values of economical evaluation for winter field crops as illustrated in Fig. (2) might be arranged in descending order as: beans > wheat > sugar beet > flax > bersim > barley > other crops. The corresponding values are 3.83, 2.39, 1.72, 1.66, 1.56, 1.45 and 1.13 L.E., respectively. While the production of consumed water i.e. W.U.E. contributes with an average value of 3.61 L.E. for winter vegetable crops.

For summer and Nili field crops, the contribution of W.U.E. in yield production can be amounted in descending order as: cotton > maize-sum. > soybean > other crops > rice > maize-Nili. While the contribution of Nili vegetables is higher than that for the summer ones. The corresponding financial values of W.U.E. are 2.29, 1.33, 1.26, 1.18, 1.15 and 1.05 L.E., respectively. For summer and Nili vegetables, contribution of W.U.E. in farmer's return income is 2.92 and 1.84 L.E., respectively. While, the yearly average of sharing W.U.E. in orchard revenue is 1.47 L.E.

These findings are slightly close to those obtained by Ibrahim *et al.* (1988) with difference in priorities of various crops in relation to the economic analysis due to the change in yield and price.

CONCLUSION AND RECOMMENDATIONS

To get an economic value for the yield per unit of applied or consumed water by different crops i.e. water utilization and use efficiencies (W.Ut.E & W.U.E) by different crops at Kafr El-Sheikh Governorate, the following steps should be activated:

1. Irrigation water must be treated as the principal factor in crop production. So, precisely determination of its is required.
2. To maximize the benefit of irrigation water, the main sector in water consumption of more than 85% from the national water budget, crop pattern should be matched with the highest return from each unit of irrigation water.

3. Several water conservation aspects should be implemented to improve the present low efficiency of irrigated rice, the highest consumed water-crop in Kafr El-Sheikh Governorate.
4. The highest yield obtained from W.Ut.E and W.U.E. for winter crops is bersim with value 10.62 and 17.70 kg/m^3, respectively. On the other hand, the highest income was obtained from beans (the least one in yield) with 2.30 and 3.83 L.E. for the two efficiencies, respectively. For summer crops, the highest yield was for maize summer and the highest revenue was for cotton.

So, it might be stated that the decision to cultivate a specific crop should be depending upon its yield and price in a specific time. Both yield and price could be changed. Therefore, the comparative advantage of crops should be reinvestigated from time to time. Keeping in mind, the fact that the Nile river is the main source of water in Egypt. Hence, the usage of its water should be treated carefully to get the maximum return from each drop.

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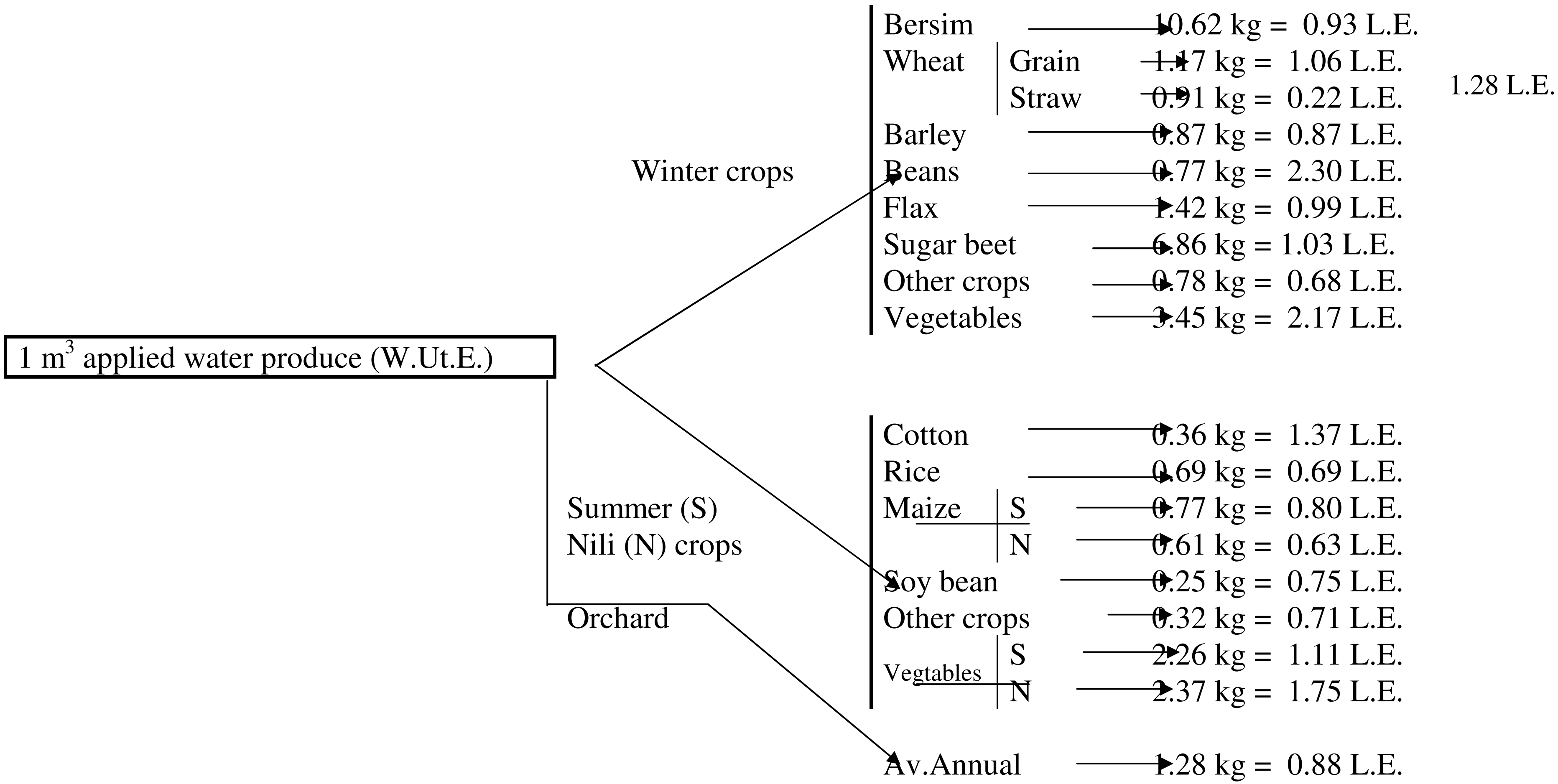

Fig. (1): Values of water utilization eff. (W.Ut.E.), kg/m^3 and L.E. for different crops.

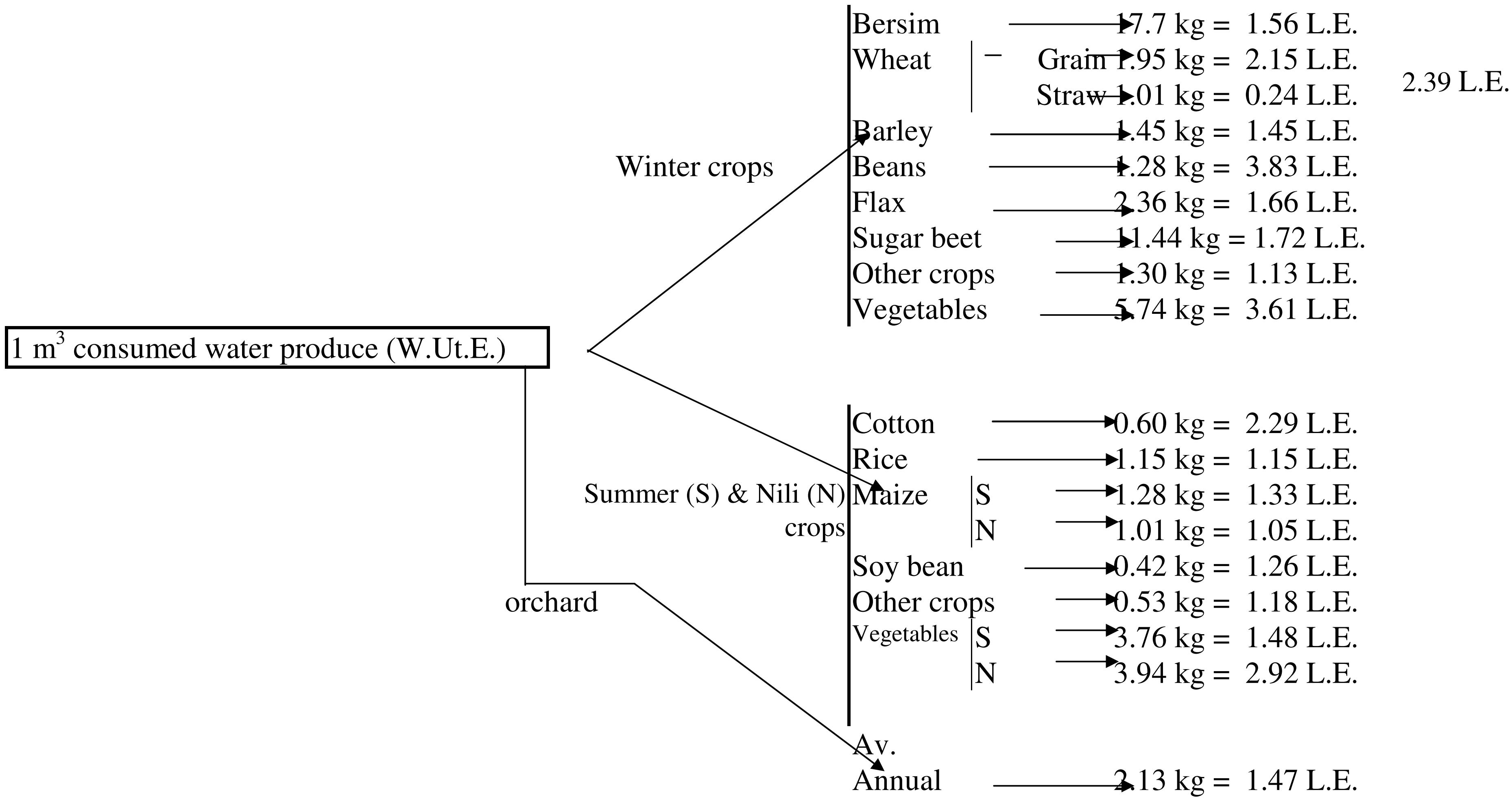

Fig. (2): Values of water use eff. (W.U.E.), kg/m^3 and L.E. for different crops.