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CROP RELATIONSHIP "YIELD - EVAPOTRANSPIRATION" FOR COMMON BEAN

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Abstract

The aim of the study is the crop relation "Yield-Evapotranspiration" (ET) for common beans, based on data obtained by full irrigation and irrigation with reduced irrigation rates. The experiment conducted in the experimental field of Agricultural University of Plovdiv with "Dobrudzhanski 7" variety in the period 2014-2016. The relationship has been studied in two directions - with regard to the summary ET and in terms of ET by phases. Thus the vegetation period of the beans is divided according to the following phases: I - growth, II - flowering, III - productive (pod development and grain filling) and IV - maturing. In both cases, existing formulas (linear, power and multi-power) were used, where the experimental data was processed by the smallest squares method. The relationship "Yield-Seasonal ET" is best represented by two-power formula: $\Delta Y = [1-(1-\Delta ET)^N]^M$. The graph is expressed graphically by the S-curve and R = 0.986 (N = 2.3 and M = 9.1). The crop relationship "Yield-ET by phases" is best expressed by the two-power formula at R = 0.921. The power of the whole vegetation period is N=1.3 and in phases is: m_1 = 0.05, m_2 = 0.79, m_3 = 0.49 and m_4 = 0.28. This means that the second sub-period is the most sensitive. The first period has very little sensitivity and the third and fourth periods are intermediate.

Key words: *irrigation, water deficit, water stress, yield, common bean.*

INTRODUCTION

The relationship between the yield and evapotranspiration is a special case of the "Yield-Water". It can be considered as a relation between total yield and seasonal ET as well as a relationship between total yield and ET established by phases, in which case parameters are obtained that characterize the sensitivity of the culture through a specific phenophases to a different degree of reduction of evapotranspiration during this same phase. To establish the relationship between yield and seasonal ET, the FAO linear formula is used worldwide (Doorenbos and Kassam, 1979). This type is also the dependence of Kraftty and Kotov (1970), representing a family of curves. Davidov (1994) creates a power and two-power equations for calculating the parameters of the same dependence, whose graphical solution is most often the corresponding convex parabola and S-curve (Kalaydjieva, 2014).

There are also several formulas for the determination of phase dependency parameters, such as Jensen (1968), Steward and Hagan (1969), Dawney (1972), FAO linear and multi-power by Davidov (1994).

By attitude to beans, the publications related to the "Yield - ET" dependence are too few and concern only the "Yield - seasonal ET" heading. Barros and Hanks (1993) and Topak et al. (2009) consider this relationship to be linear, recommending a global FAO's formula. Other authors present the relationship by a second degree equation (Hegde and Srinivas, 1990), and in order to obtain a maximum yield ET should be in the range of 268 to 299 mm. According to the results of a field experiment conducted in Suceava (Romania) there is no correlation between yield and ET (Saicu, 1987, 1988). Kalaydjieva (2014) gives detailed information about this dependence, but for French Beans. According to the author, the relation "Yield-seasonal ET" is best represented by Davidov's two-power formula at n = 1.5 and m = 2.5. The author finds that bean is most sensitive to ET during the period of beans formation and growth.

The aim of the paper is to establish the parameters of the Yield-Evapotranspiration relationship for common bean.

MATERIALS AND METHODS

The experiment was carried out during the period 2014-2016 in the experimental field of the Agricultural University of Plovdiv on soil type alluvial meadow with common bean (*Phaseolus vulgaris*) variety "Dobrudzhanski - 7". The experiment is based on the blocking method in four replicates with the size of the harvested parcels - 10 m^2. For the study of relationship "Yield - ET" are used data for relative yield and relative ET from different variants as follow: 1) without irrigation; 2) irrigation with 25% of the irrigation rate determined by full irrigated bean (25% m); 3) irrigation with 50% of the irrigation rate, determined by full irrigated bean (50% m); 4) irrigation with 75% of the irrigation rate determined by full irrigated bean (75% m); 5) full irrigation (100% m).

The irrigations of the optimal variant (variant 5) are given at 80% of FC (field capacity) pre-irrigation soil moisture in the 0-40 cm layer and the irrigation rate is calculated to wet up-to FC the entire active soil layer (0-60 cm). For this purpose, the dynamics of soil moisture was monitored during 5-7 days by weight method (Atanasov et al., 1972). Irrigation of the experimental plots is gravitationally performed on short closed furrows. Evapotranspiration is determined by the balance method according to the formula (Kirkova, 2003; Zhivkov, 2013):

$$ET = W_b - W_e + M_n + M_m \text{ (mm)} \quad (1)$$

where: ET is evapotranspiration for reporting period (mm);

W_b and W_e - water supply at beginning and end of period (mm);

M_n - sum of used precipitation (mm);

M_m - the used part of the irrigation rate (mm)

The parameters of the relationship between yield and evapotranspiration are defined in two directions - "Yield - seasonal ET" and "Yield - ET by Phase", using different formulas as follows:

Relationship "Yield - seasonal ET"

The parameters of this type of dependence are established by the data on the relative yield and the relative aggregate evapotranspiration by variants and years. For this purpose, the following formulas are used:

Linear equation /FAO/ (Doorenbos and Kassam, 1979)

$$\frac{Y}{Y_o} = 1 - K_c\left(1 - \frac{ET}{ET_o}\right) \quad (2)$$

where: Y is the yield under reduced irrigation regime;

Y_o - optimum irrigation yield;

ET - evapotranspiration in yield Y;

ET_o - evapotranspiration in Y_o yield;

Two-power equation (Davidov, 1994)

$$\frac{Y}{Y_0} = \left[1 - \left(1 - \frac{ET}{ET_0}\right)^N\right]^M \quad (3)$$

where: N - is the the power for the entire vegetation period;

M - the power for the crop

Power formula (Kalaydjieva, 2014; Kalaydzhieva et al., 2015; Petrova and Matev, 2020)

$$\frac{Y}{Y_0} = 1 - a\left(1 - \frac{ET}{ET_0}\right)^n \quad (4)$$

where: a is the coefficient of the yield.

Relationship "Yield - ET by phases"

In connection with establishing the parameters of this dependence, the bean vegetation period is conventionally divided into the following four sub-periods (phases):

- Phase one - growth, including phenophases from germination to the beginning of budding phase or on average from the second decade in May to the second of June inclusive.
- The second phase - flowering, involving the phenophases from the beginning of the budding until the end of the flowering or the average whole third decade of June and the heat of July.
- Third phase - productive, including the period of formation and growth of beans, or on average from the first to the second ten days of July inclusive.
- Fourth phase - seed pouring and ripening.

For each variant and year, the phase duration is determined according to specific phonological observations.
Experimental data was processed using the smallest squares method using the YIELD program through the following equations:

Power relationship (Davidov, 1994)

$$\frac{Y}{Y_0} = \prod_{1}^{S} \left[1 - A_i \left(1 - \frac{ET_i}{ET_{0i}} \right)^{Ni} \right] \qquad (5)$$

where: s is the number of phases;
A_i - the coefficient determining the sensitivity of the phase;
N_i - phase's power;
ET_i - the evapotranspiration for phase (i) – available.

Two-power formula (Davidov, 1994)

$$\frac{Y}{Y_0} = \prod_{1}^{S} \left[1 - \left(1 - \frac{ET_i}{ET_{0i}} \right)^{N} \right]^{Mi} \qquad (6)$$

where: M_i is power indicator by phase;
N - the power for the vegetation period.

Linear relationship /FAO/ (Doorenbos and Kassam, 1979)

$$\frac{Y}{Y_0} = \prod_{1}^{S} \left[1 - A_i \left(1 - \frac{ET_i}{ET_{0i}} \right) \right] \qquad (7)$$

Based on the final results calculated from the above formulas, graphs reflecting the test points and corresponding relationships are plotted to illustrate the degree of approximati

RESULTS AND DISCUSSIONS

Meteorological conditions

The influence of the irrigation regime on the yield and the evapotranspiration and the relation between them is determined to a great extent by the meteorological conditions of the vegetation period.
Regarding precipitation, the first experimental year is middle-wet (19.8% probability) with a drought in the third ten days of June and the first of July, coincidentally with the end of the growth period and the period of buttoning - the beginning of flowering. During the period of harvesting and pouring of the grain, the amount of rainfall ranges from 30 to 40 mm for ten days, providing for a large extent the ET of the plants. In terms of the amount of temperature, the year is average with a 46.5% probability, and with respect to the air water pressure deficit - with 96.3%.
The second experimental year (2015) is humid with a 13.2% probability with drought from the third ten days of June to the second of August (inclusive), i.e. During the reproduction period of bean the year is dry. The amount of precipitation is significant at the end of August, but they are of no practical significance for the yield. With regard to the temperature sum, the year is warm with a probability of 19.2%, and in terms of the air water pressure deficit – medium with probability of 80%. For the period May-August, the third year of the experiment (2016) is the average rainfall probability (41.5%) and the warmest of the temperature (14.1%). This year saw a comparatively uniform precipitation distribution over ten days, although they are extremely low in quantity. The sum of the air water pressure deficit is 1352.5HPa, which characterizes it as average dry with a probability of 21.3%.

Relationship "Yield - seasonal ET" by FAO's linear formula

All the initial data needed to establish the parameters of this dependence are presented in Table 1.
Figure 1 shows experimental data by year, average and total for the entire experiment period, averaged using the FAO's linear formula. The yield coefficient for the first two experimental years has very low relative values (respectively Kc = 1.07 and 1.13). This means that a minimum water output of 10-13% is sufficient to obtain a minimum yield, for which the productivity is maximal for the particular conditions the optimal variant. This is virtually impossible for this culture, so the relationship to the FAO's formula cannot be considered correct, despite the high correlation coefficient (Table 2). A little more realistic are the results of this formula, valid for 2016. The yield coefficient is Kc = 1.58, which means that under these conditions for yielding a yield other than zero, water should be consumed equal to 38-40% of ET with optimal irrigation. Here the correlation coefficient is highest (R = 0.939).

Relationship “Yield - seasonal ET”

Table 1. Output data for “Yield – seasonal ET” relationship

Variant	Yield		ET		Yield		ET	
	kg/da	Y/Y_0	mm	ET/ET_0	kg/da	Y/Y_0	mm	ET/ET_0
	2014				2016			
100 % m	239	1.00	398.9	1.000	267	1.00	339.7	1.000
75 % m	232	0.97	372.4	0.934	255	0.95	307.2	0.904
50 % m	212	0.89	322.4	0.833	228	0.85	292.4	0.861
25 % m	199	0.83	322.0	0.807	173	0.65	260.2	0.766
dry	153	0.64	299.1	0.750	126	0.47	244.7	0.720
variant	2015				average			
100 % m	252	1.00	415.8	1.000	253	1.00	384.8	1.000
75 % m	241	0.96	395.9	0.952	243	0.96	358.5	0.932
50 % m	231	0.92	351.7	0.846	224	0.87	322.2	0.837
25 % m	193	0.77	319.2	0.768	188	0.75	300.5	0.781
dry	147	0.58	289.4	0.696	142	0.56	277.7	0.722
m - irrigation rate								

The dependence on aggregated and averaged experimental data is influenced by the parameters characterizing the first two experimental years.

As a result, relatively low values of the yield coefficient (Kc = 1.27 and 1.21) are obtained, which means that at ET to 20-25% of that at optimal irrigation, a minimum yield should be expected.

Still, within the limits of the real crop yield, this linear dependence is representative.

The approximation of the mean experimental data is R = 0.933 and at all experimental points R = 0.9.

Figure 2 shows the experimental and calculated FAO linear formula yields and the relationship between them at R = 0.904.

Despite the high correlation coefficient, the graphs show very clearly the discrepancies between the experimental and calculated relative yields.

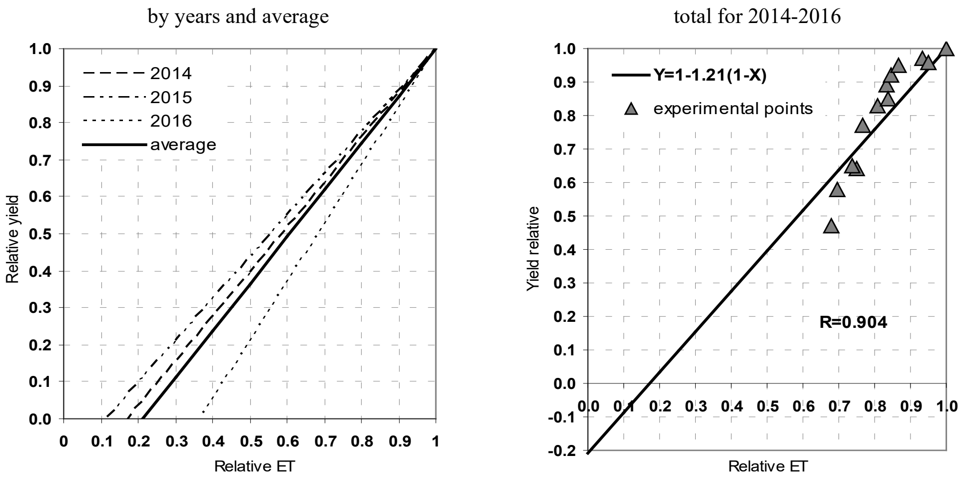
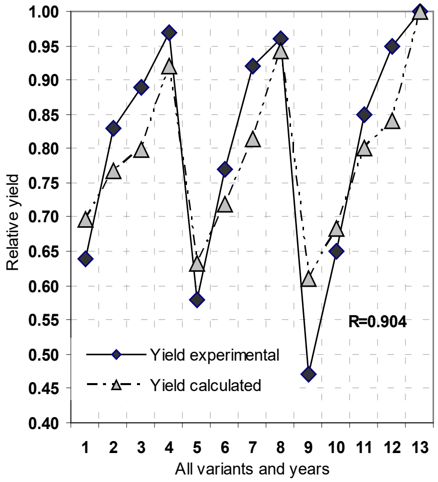


Figure 1. “Yield – seasonal ET” relationship by the FAO’s formula



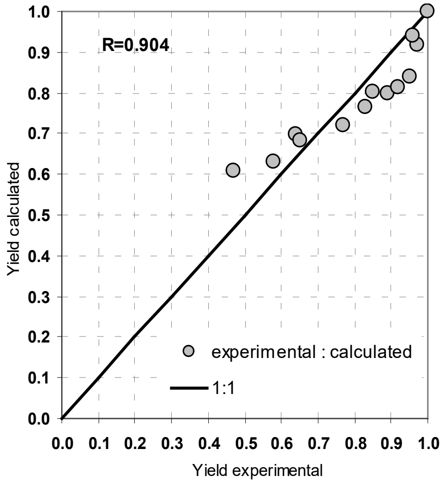


Figure 2. Relationship between experimental and calculated yield by the FAO's formula

"Yield - seasonal ET" relationship by the two-power formula

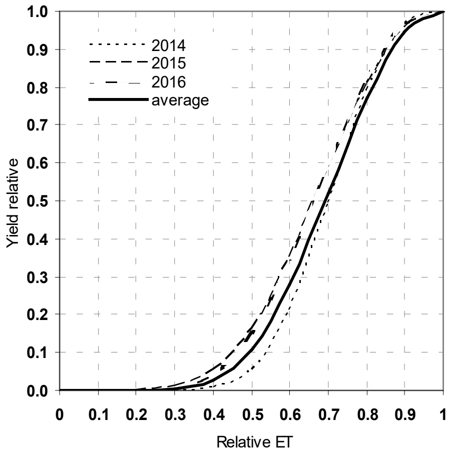
On the Figure 3, the same experimental data were applied, approximated by the two-power formula.

The results graphically represent S-curves, which very smoothly present the change of the relative yield with the change of the relative ET. As a result, the accuracy of the approximation is clearly visible on the graph. In this sense, the graphs presented in Figure 4 are also indicative.

Apart from the fact that the deviations of the calculated points from the experimental points are considerably smaller than those using linear dependence, a higher correlation coefficient (R = 0.986) is also achieved here.

All this gives reason to believe that the two-power formula surpasses FAO's linear formula in a way of interpretation and accuracy.

by years and average



total for 2014-2016 period

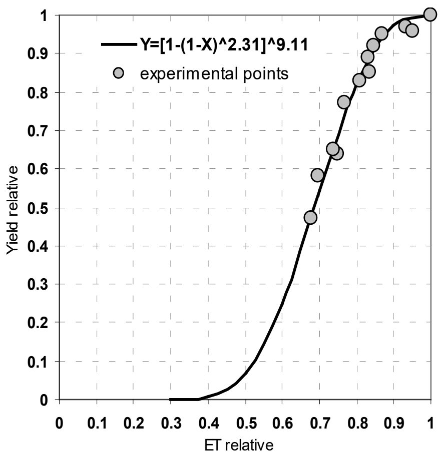


Figure 3. "Yield - total ET" relationship by the two-power formula

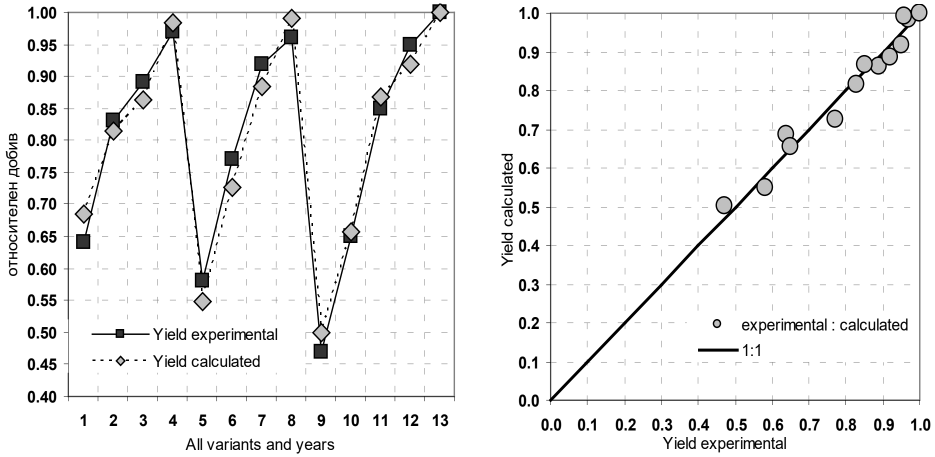


Figure 4. Relationship between experimental and calculated yield by the two-power formula

"Yield - seasonal ET" relationship by the one-power equation

This equation has a yield coefficient similar to that of the FAO linear formula, but has a variable power. This allows for an abscissa to be measured at a specific ET value at which yield can be expected while at the same time the dependency is graphically expressed by the parabola. This increases the accuracy of the approximation and at the same time follows the real trends in the change of the two indicators. In general, the FAO formula can be considered to be a special case of Davidovs's one-power formula.

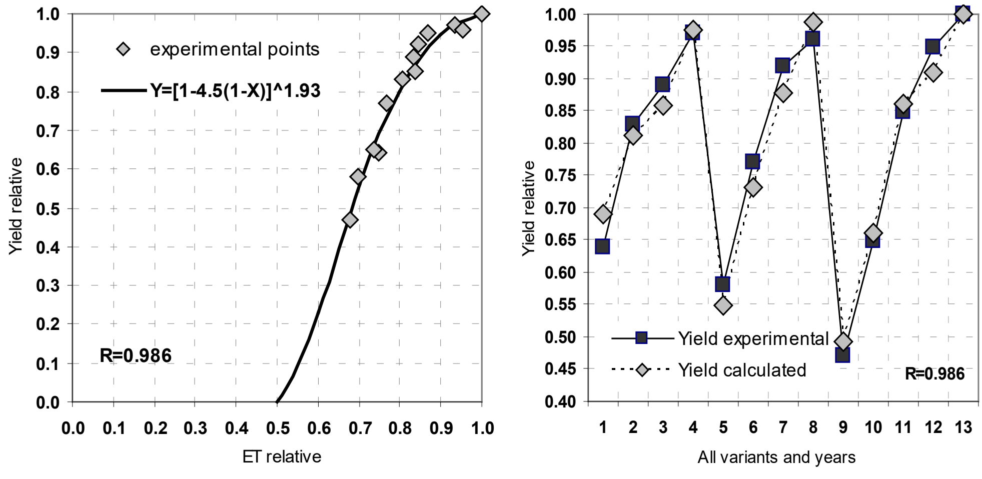


Figure 5. "Yield - total ET" relationship by the one-power formula

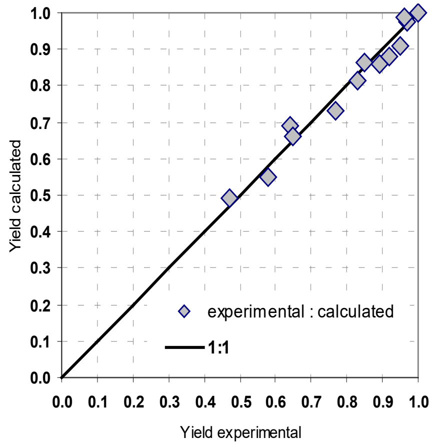


Figure 6. Relationship between experimental and calculated yields by the one-power formula

All experimental points are plotted in Figure 5. The same is done by the one-power Davidov's formula, as a result of which the parabola was drawn. The same corresponds to the following parameters: a = 4.5, n = 1.19 and R = 0.986. Depending on the dependence thus determined, a minimum yield can be expected for ET having values above 50% of those obtained with optimal irrigation. From the graph, it is clear that the experimental points are located on or adjacent to the curve, and the correlation coefficient matches that of the two-power formula. This is due to the fact that in the real yield range the two curves almost completely coincide, i.e. there is approximation of the experimental data with the same precision.

Table 2. "Yield - seasonal ET" relationship parameters

Year	Linear relationship		Two-power relationship		
	K_c	R	n	m	R
2014	1.07	0.894	2.96	17.43	0.999
2015	1.13	0.930	2.25	7.69	0.990
2016	1.58	0.939	2.39	8.94	0.999
average	1.27	0.933	2.22	9.14	0.994
total	1.21	0.904	2.31	9.11	0.986

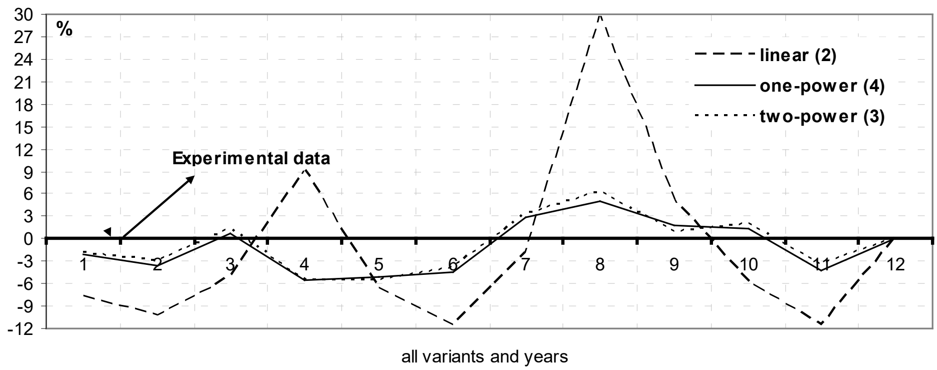


Figure 7. Relative deviation of the calculated yield in comparison to the experimental yields using the three formulas

The relationship between the experimental yields and the calculated one-power formula of Davidov is illustrated in Figure 6 at R = 0.986 and in Figure 7 the percentage deviation of the calculated yields in the three formulas used is plotted. Since the FAO's formula is globally recognized, large deviations cannot be grounds for rejection, but a much better combination of high precision and true interpretation of the biological features of culture demonstrates the formulas of Davidov (the one-power and the two-power). This is clearly visible on the graph, which categorically fills the comments made above.

Relationship "Yield-evapotranspiration" by phases (periods)

The all baseline data for ET in absolute and relative values, as well as for the yield, needed to establish the parameters of this dependence are presented in Table 3.

Table 3. Yield and evapotranspiration by phases in absolute and relative values

year	relative rate	yield		ET for different periods							
				I germination-budding		II budding-end of flowering		III formation and growth of beans		IV seed pouring and ripening	
		kg/da	relative	mm	relative	mm	relative	mm	relative	mm	relative
1	2	3	4	5	6	7	8	9	10	11	12
2014	0.00	153	0.64	75.6	1.000	83.8	0.838	76.2	0.627	63.5	0.624
	0.25	199	0.83	75.6	1.000	88.0	0.880	91.6	0.754	66.8	0.656
	0.50	212	0.89	75.6	1.000	87.5	0.875	96.2	0.792	73.0	0.717
	0.75	232	0.97	75.6	1.000	94.0	0.940	112.5	0.926	90.3	0.887
	1.00	239	1.00	75.6	1.000	100.0	1.000	121.5	1.000	101.8	1.000
2015	0.00	147	0.58	97.4	0.957	63.6	0.759	75.3	0.607	53.1	0.473
	0.25	193	0.77	99.0	0.972	73.3	0.875	89.7	0.723	57.2	0.510
	0.50	231	0.92	99.6	0.978	74.4	0.888	99.4	0.802	78.4	0.699
	0.75	241	0.96	99.8	0.980	77.8	0.928	120.4	0.971	91.8	0.818
	1.00	252	1.00	101.8	1.000	83.8	1.000	124.0	1.000	112.2	1.000
2016	0.00	126	0.47	110.6	0.927	61.9	0.630	51.0	0.569	28.4	0.696
	0.25	173	0.65	110.9	0.930	67.9	0.691	56.3	0.628	30.6	0.750
	0.50	228	0.85	113.3	0.950	70.4	0.716	56.9	0.635	36.7	0.900
	0.75	255	0.95	114.9	0.963	84.8	0.863	78.9	0.881	39.4	0.966
	1.00	267	1.00	119.3	1.000	98.3	1.000	89.6	1.000	40.8	1.000
average	0.00	142	0.56	94.5	0.961	69.8	0.742	67.5	0.601	48.3	0.598
	0.25	188	0.75	95.2	0.967	76.4	0.815	79.2	0.702	51.5	0.639
	0.50	224	0.87	96.2	0.976	77.4	0.826	84.2	0.743	62.7	0.772
	0.75	243	0.96	96.8	0.981	85.5	0.910	103.9	0.926	73.8	0.890
	1.00	253	1.00	98.9	1.000	94.0	1.000	111.7	1.000	84.9	1.000

The following results were obtained:

1) One-power formula (5) with $N = 1.1$ and a correlation coefficient $R = 0.892$.

The values of the Ai coefficient are as follows: I period - $A_1 = 0.05$, II period - $A_2 = 0.89$, III period - $A_3 = 0.16$, IV period - $A_4 = 0.32$. Figure 8 shows the experimental and calculated values of the yield, and in Figure 9 the dependence between yield and ET separately for each phase. It can be seen from the graph that both the clearer phases are described by slightly curved curves. According to the location of these curves in the coordinate system, the period of buttoning and flowering can be considered as the most sensitive. It is critical in watering in all bean cultures, including common bean. Despite the brevity of the phase (amid the high demands of plants on the water) and the still low strain of meteorological factors, beans require irrigation in almost every growing season. This makes it possible to take into account the increased sensitivity of the second period compared to the rest, as seen in Fig. Less but still sensitive are the third and fourth periods, and the first is almost not affected.

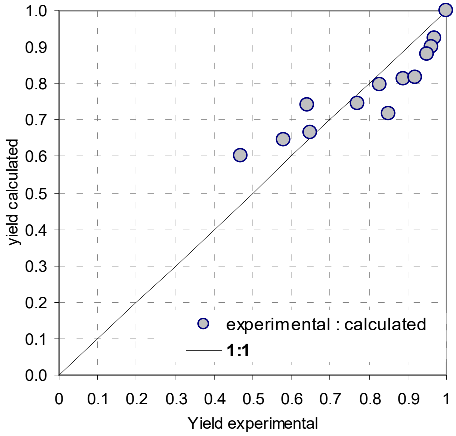


Figure 8. Relationship between experimental and calculated coefficients by formula (5)

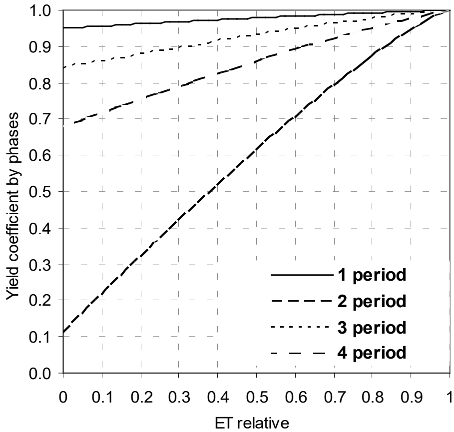


Figure 9. "Yield-evapotranspiration" by phases using formula (5)

The lack of sensitivity with regard to the first period is due to the fact that in the variants used for the study of the dependence, irrigation during this period is rarely imposed and this is most often done at the end of the period. Therefore, no significant influence of the irrigation regime on the real ET can be taken into account. In practice during this part of the vegetation the soil humidity is almost always in optimal limits and there is no way to detect the real sensitivity of the phase. The sensitivity of the third and fourth periods is mainly due to the following:

- ✓ During this part of the vegetation the yield is formed and the requirements of the plants to the water are very large;
- ✓ The temperature and the air humidity deficiency are very high, the leaf mass is very well developed, as a result of which the ET reaches maximum values.

The length of the period is relatively high, which, in the absence of precipitation, is a prerequisite for the realization of a larger number of irrigation. This leads to a greater difference in the relative ET of the individual variants within the phase.

2) Davidov's formula (6) at $N = 1.3$ and a correlation coefficient $R = 0.921$.

The power values by phases are as follows: I period - $m_1 = 0.05$, II period - $m_2 = 0.79$, III period - $m_3 = 0.49$, IV period - $m_4 = 0.28$. In addition to demonstrating high precision in the approximation of experimental data, thanks to its two powers, this formula describes a more gradual change in the yield factor when changing the ET values. Figure 10 shows the relationship between the experimental and calculated relative yield values. Here we can clearly see the greater accuracy of interpretation and the smaller deviations of the calculated from the experimental yields at $R = 0.921$. According to the graph of Figure 11, the sensitivity of the first period is again the smallest, followed by the period including the time between the end of grain filling and ripening. The results valid for this period are mainly due to the residual impact of the irrigations submitted during the previous period. The second and third periods show the highest sensitivity, with the advantage being once again on the side of the buttoning - blooming period.

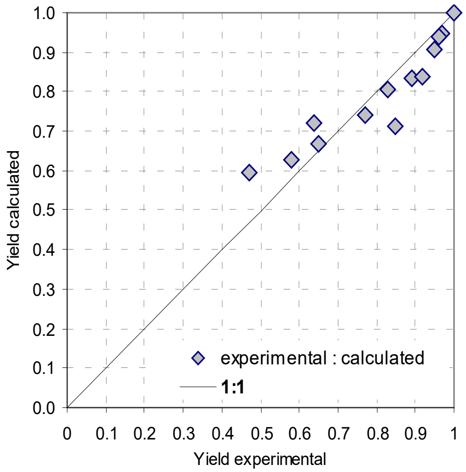


Figure 10. Relationship between experimental and calculated coefficients by formula (6)

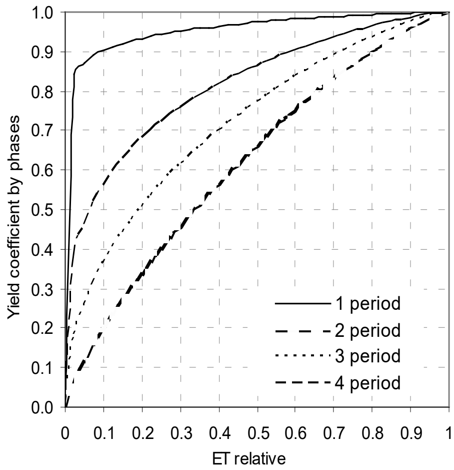


Figure 11. "Yield-evapotranspiration" by phases using formula (6)

3) FAO's formula (7) linear with correlation coefficient R = 0.878.

The values of the A_i coefficient are as follows: I period - $A_1 = 0.05$, II period - $A_2 = 0.74$, III period - $A_3 = 0.23$, IV period - $A_3 = 0.22$.

The Figure 12 shows the experimental and calculated relative yields of the formula, and in Figure13 – the relationship between the yield and the evapotranspiration is presented separately for each phase. Here again, the magnitude of the parameters A_i expresses the degree of influence of the evapotranspiration on the yield or the sensitivity of the phase. Therefore, as in the previous two cases, the second period is the most sensitive, and the first is the least sensitive. The third and fourth periods again occupy an intermediate position and practice as parameters coincide.

The data for the deviations between the experimental and calculated yields for the four formulas used are shown in Table 4. The smallest relative deviations of the calculations from the experimental yield are obtained using the two-power formula (6), with very similar results as the differences in formula (5). The linear formula (7) demonstrates less accuracy, and in some cases the discrepancy between the experimentally determined and calculated yields varies between -17 and + 30%.

They notice the more significant variations in the non-irrigated variant and the one irrigated by 50%, this being true for all years in the three formulas used without any logical explanation. For all other variations, variations vary considerably narrower.

Based on the results obtained for the dependence between the yield and phase evapotranspiration found in formulas (5), (6) and (7), the following more important findings can be made:

The relationships established by the three formulas have a high and almost equal correlation coefficient, which proves the usability of each of them;

For each of the dependencies obtained, the influence of the individual phases is determined, the same being the largest in the second phase and insignificantly in the first phase, the third and the fourth ones occupying the intermediate position;

Taking into account the results obtained in the different formulas, preference should be given to formula (6), since the smoother and highest accuracy reflects the change in the ratio between the relative yield and the relative evapotranspiration through the phases.

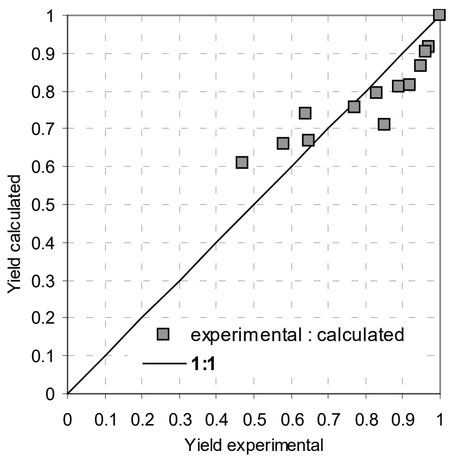


Figure 12. Relationship between experimental and calculated coefficients by formula (7)

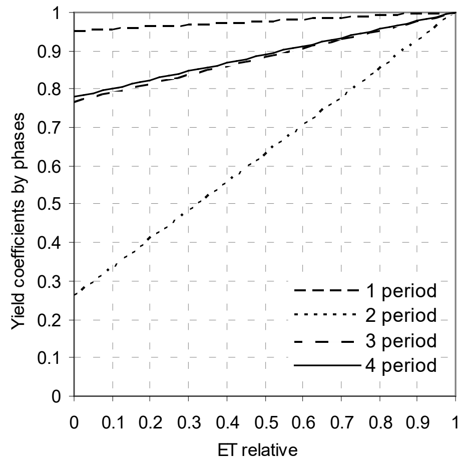


Figure13. "Yield-evapotranspiration" by phases using formula (7)

Table 4. Difference between experimental and calculated yield using different formulas

year	variant	Experimental yield		calculated yield								
				Formula (5)			Formula (6)			Formula (7)		
		kg/da	%	kg/da	%	±%	kg/da	%	±%	kg/da	%	±%
2014	dry	153	0.64	177	0.74	15.8	172	0.72	12.3	176	0.74	15.3
	25%m	199	0.83	190	0.79	-4.5	192	0.80	-3.4	190	0.80	-4.5
	50%m	212	0.89	194	0.81	-8.3	199	0.83	-6.2	194	0.81	-8.7
	75%m	232	0.97	221	0.92	-4.9	226	0.95	-2.4	219	0.92	-5.6
	100%m	239	1.00	239	1.00	0.0	239	1.00	0.0	239	1.00	0.0
2015	dry	147	0.58	163	0.65	10.7	158	0.63	7.5	167	0.66	13.3
	25%m	193	0.77	188	0.75	-2.6	187	0.74	-3.1	191	0.76	-1.0
	50%m	231	0.92	206	0.82	-10.8	211	0.84	-8.6	206	0.82	-10.9
	75%m	241	0.96	227	0.90	-5.8	237	0.94	-1.8	228	0.90	-5.6
	100%m	252	1.00	252	1.00	0.0	252	1.00	0.0	252	1.00	0.0
2016	dry	126	0.47	160	0.60	27.1	159	0.59	25.9	163	0.61	29.3
	25%m	173	0.65	178	0.66	2.6	179	0.67	3.3	178	0.67	2.8
	50%m	228	0.85	191	0.72	-16.0	190	0.71	-16.6	189	0.71	-17.1
	75%m	255	0.95	235	0.88	-8.0	242	0.91	-5.0	231	0.87	-9.2
	100%m	267	1.00	267	1.00	0.0	267	1.00	0.0	267	1.00	0.0
m - full irrigation rate												

CONCLUSIONS

The relationship "Yield - total ET" is best represented by Davidov's two-power formula. The same is expressed graphically through the S-curve, with a high correlation coefficient (R = 0.986) and value of powers n = 2.3 and m = 9.1.

The relationship Yield-evapotranspiration" by phases is the best presented by two-power formula with R = 0.921. The power's value for entire vegetation period is N = 1.3. The power values by phases are as follows: I period - m_1 = 0.05, II period - m_2 = 0.79, III period - m_3 = 0.49, IV period - m_4 = 0.28. this means that the sensitivity of the first period is the smallest, followed by the period including the time between the end of grain filling and ripening. The second and third periods show the highest sensitivity, with the advantage being on the side of the budding - flowering period.

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