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EFFECT OF GROUND WATER LEVEL ON LEGUME CROPS IN
FAYOUM GOVERNORATE :

5- CONTRIBUTION OF GROUND WATER TO
EVAPOTRANSPIRATION ASSOCIATED WITH BIOLOGICAL
NITROGEN FIXATION BY SOYBEAN

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EFFECT OF GROUND WATER LEVEL ON LEGUME CROPS IN
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ABSTRACT

Soybean (*Glycine max* (L) Mer.) variety columbus was planted in 4 plots of different ground water depths in the farm of El-Fayoum Faculty of Agriculture. The weighted averages of the ground water levels were 51.9, 70.6, 87.5 and 115.6 cm. Soil moisture depletion by the crop throughout the growth season was found 57.6, 66.2, 74.5 and 89.2 cm, respectively. The contribution from ground water was estimated to be 33.6, 25.0, 16.7 and 2.0 cm, respectively and was found to be negatively correlated to the ground water depth ($r = -0.9995$). The linear regression equation was: contribution to evapotranspiration, cm = $59.78 - (0.4973 \times \text{depth of ground water, cm})$. At the ground water depth of 70.6 cm, optimum number and dry weight of nodules, nitrogenase activity, nitrogen content, straw dry weight and yield of soybean plants were obtained. Grain yield of the 70.6 cm ground water depth plot was 118, 116 and 136% of that of the 51.9, 87.5 and 115.6 cm - ground water depth plots, respectively. At the 70.6 cm ground water depth plot, the contribution from ground water to evapotranspiration by soybean plants was 37.8% of the soil moisture depletion and was 27.4% of the consumptive use.

INTRODUCTION

Soybean crop proved potential for improving grain legume production (Hamdi, 1982). Its acreage in Egyptian agriculture was about 4000 acre during 1973 and increased to 150,000 acre during 1984.

Shallow ground water levels dominate throughout the arable land in Egypt affecting the yield of field crops (Balba et al 1975). The upward movement of ground water level is expected to affect soil moisture (Varallyay, 1981) and consequently the needs of crops for irrigation (Barakat et al 1971 and El-Gibali and Badawi 1978).

Assessment of the contribution of ground water to evapotranspiration has been studied on field crops (Barakat et al 1972, Wallender et al 1979 and Hassan 1980) while with legumes only little attention was devoted to faba bean (El-Shakweer et al 1982 b).

The present work aimed to study the contribution of the ground water to evapotranspiration by soybean and its relation with its biological nitrogen fixation at different ground water depths under field conditions.

MATERIALS AND METHODS

Four sites of the farm of El-Fayoum Faculty of Agriculture characterized by different ground water depths were chosen for this study. Soil characteristics of these sites as determined according to Black et al (1965) were : sand, from 24.4 to 24.9%; silt, from 33.7 to 34.0%; clay, from 41.2 to 41.7%; textural class, clay; field capacity, from 47.5 to 47.8%; wilting point, from 21.4 to 21.6%; organic matter, from 1.52 to 1.57%; total carbonates, from 2.04 to 2.16%; E C_e, from 1.48 to 1.50 mmhos/cm at 25°C and pH of saturated soil-water paste, from 7.9 to 8.2. The electrical conductivity of ground water in the sites was found from 0.76 to 0.82 mmhos/cm at 25°C.

At each site, 4 random replicates were prepared for the experiment. For each replicate, 3 observation wells of 10 cm diameter were dug and an area of 18 m² i.e. 7.5 x 2.4 m contained 4 rows, 60 cm apart was sown to soybean (*Glycine max* (L) Merr.) variety Columbus at 8/5/1983.

In each site, superphosphate and potassium sulphate fertilizers were added before sowing at the rate of 300 and 100 kg./acre, respectively. At sowing, the seeds were treated with effective local rhizobial inoculum (Okadin).

Irrigation took place on 8/5/1983, 1/6/1983, 10/6/1983, 21/6/1983, 1/7/1983, 11/7/1983, 23/7/1983 and 1/8/1983.

Ground water depth was measured in the observation wells by means of a graduated tape 15 times during the growth season.

To find out the contribution of the ground water to the evapotranspiration by soybean crop, the moisture depleted from the soil by the crop throughout the growth season was determined and subtracted from a theoretically calculated evapotranspiration under soybean cropped from 8/5/1983 to 26/8/1983. Calculations of the evapotranspiration was based on the modified Penman equation (FAO, 1979) :

$E T_D = W R_n + (1 - W) \cdot F(U) \cdot (e_a - e_d)$
 where :
 $E T_D$ = Potential evapotranspiration, mm/day.
 W = Temperature and altitude-depending weighted factor.
 R_n = Total net radiation.
 $F^n(U) =$ Wind - related function = $0.27 (1 + \frac{U_2}{100})$, where U_2 is the wind speed in Km/day measured at height of 2 m.
 $(e_a - e_d)$ = Vapour pressure deficit i.e. the difference between saturation vapour pressure (e_a) in mbar at mean air temperature and actual vapour pressure (e_d) in mbar.

The actual evapotranspiration ($E T_{act}$) was calculated by multiplying the potential evapotranspiration ($E T_D$) by the crop coefficient (K_c) recommended by F A O (1979).

For the determination of moisture depletion by the soybean crop, soil moisture content was determined in the soil layers above the ground water level every 30 cm-depth just before irrigation and subtracted from the normal field capacity on a volume basis. Soil sampling was carried out by means of a soil tube (Black et al 1965).

After 56 days of sowing, 20 plants were sampled from each replicate. The plant sample was carefully uprooted and the root was rinsed in tap water, then, in distilled water, excised and subjected to nitrogenase activity measurement by the acetylene reduction technique (Hardy et al, 1973). The effective nodules of the root were counted and their dry weight (68-70°C) was determined. Dry weights of shoots and roots were recorded and their nitrogen contents were determined according to Cattenie (1980).

At harvest (108 days after sowing), 20 plants were sampled from each replicate and the number and dry weight of their pods and grains were recorded. The harvested grains of the whole plants of the replicate were weighed.

Statistical analysis of the obtained data were conducted according to Steel and Torrie (1960).

RESULTS AND DISCUSSIONS

Table (1) shows the ground water level measurements during the growing season of soybean in the tested sites. It varied from 47.8 to 55.6, from 67.4 to 72.3, from 84.9 to 89.5 and from 113.6 to 116.7 cm below soil surface in the sites No's 4, 7, 8 and 9, respectively. The corresponding weighted averages of the season were 51.9, 70.6, 87.5 and 115.6 cm,

respectively.

Table (2) shows the soil moisture depletion of the tested sites throughout the growth season of soybean. Figure 1 shows that cumulative soil moisture depletion of the season was 57.9, 66.2, 74.5 and 89.2 cm in the sites No's 4, 7, 8 and 9 respectively.

The data of the theoretical consumptive use of moisture by soybean crop during its growth season from 8/5/1983 to 26/8/1983, as calculated by the General Directorate of irrigation in Fayoum according to the modified Penman Formula using Fayoum meteorological data and the recommended coefficient for soybean, were found :

	May	June	July	August
W	0.72	0.77	0.78	0.81
R, mm/day	5.5	5.6	5.8	6.0
$F^N(U)$	0.90	0.88	0.86	0.85
$(e_a - e_d)$, mbar	17.4	17.6	19.8	20.2
$K_a - e_d$	1.01	1.02	1.04	1.04
Days of growth season	22	30	31	26
$E T_{act}$ mm/month	185.4	240.9	266.5	219.6

Thus, the total actual evapotranspiration ($E T_{act}$) of the growth season of soybean was 91.2 cm i.e. 3830 m³/feddan.

Table (3) shows that the contribution of ground water to evapotranspiration by soybean plants as defined before was 33.6, 25.0, 16.7 and 2.0 cm in the sites, respectively. These values corresponded to 36.8, 27.4, 18.3 and 2.2% of the theoretical consumptive use, respectively. The contribution of ground water to evapotranspiration by soybean plants was found negatively correlated to the depth of ground water ($r = -0.995$). Figure 2 shows the simple linear regression relation between ground water depth and contribution from ground water to evapotranspiration by soybean. The linear regression equation was found : contribution to evapotranspiration, cm = 59.78 - (0.4973 x depth of ground water, cm), provided the ground water depth ranges between 47.8 and 116.7 cm. under the experimental conditions. These results confirm previous works by Bouyoucus (1953), Eagleman and Decker (1965), Vincent (1965), El-Gibali and Badawi (1978), Wallender et al (1979) and Hassan (1980).

Table (4) shows the mean values of biological nitrogen fixation parameters of soybean plant 56 days old and the

yield components at harvest as affected by ground water depth. Relative values of the tested characteristics, as seen in Figure 3, were increased with the depth of ground water up to 70.6 cm then decreased with further depth. With the 70.6 cm-ground water depth, the increases of the tested characteristics varied and ranged from 13 to 58% higher than that of the 51.9 cm-ground water depth. It could be concluded that the ground water depth of 70.6 cm was optimum for all of the tested biological nitrogen fixation and yield parameters of the soybean plant. Under this optimum ground water depth, soil moisture depleted by soybean plants was 66.2 cm (72.6% of the consumptive use) and contribution from ground water to evapotranspiration was 25.0 cm (27.4% of the consumptive use). However, optimum ground water depth for biological nitrogen fixation and yield of Berseem clover in clay loam, sandy loam and calcareous soils in lysimeters were found 130, 70 and 40 cm, respectively (El-Shakweer et al 1982a). That of faba bean legume under Fayoum field conditions was found 76.7 cm (El-Shakweer, 1982).

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Table 1 : Ground water level measurements of the tested sites during the growth season of soybean

Date	Depth of ground water level , cm			
	Site 4	Site 7	Site 8	Site 9
8/5/1983	51.2	70.4	87.1	115.1
17/5/1983	50.9	71.3	88.7	116.2
26/5/1983	53.1	70.2	87.9	115.4
3/6/1983	51.1	69.5	86.4	114.3
10/6/1983	50.3	71.5	88.6	116.5
21/6/1983	54.1	71.0	87.2	116.2
24/6/1983	52.8	70.1	86.5	114.7
1/7/1983	55.6	72.3	87.4	116.3
5/7/1983	51.8	71.8	86.3	115.5
11/7/1983	50.6	72.2	88.2	116.2
23/7/1983	53.4	71.4	89.5	116.7
5/8/1983	52.2	69.9	87.6	115.8
16/8/1983	51.6	68.5	86.7	114.2
19/8/1983	50.7	68.0	85.0	113.5
26/8/1983	47.8	67.4	84.9	113.6
Weighted average of the season	51.9	70.6	87.5	115.6

Table 2 : Soil moisture depletion during the growth season of soybean as affected by ground water depth of the tested sites

Period	Soil moisture depletion (mm) under the depth of ground water of			
	51.9 cm	70.6 cm	87.5 cm	115.6 cm
From 8/5/1983 to 19/5/1983	64.2	73.5	82.7	96.4
From 19/5/1983 to 1/6/1983	69.2	75.3	72.8	97.6
From 1/6/1983 to 10/6/1983	55.1	66.7	70.4	91.2
From 10/6/1983 to 21/6/1983	62.0	71.4	81.5	87.6
From 21/6/1983 to 1/7/1983	54.2	72.1	75.3	88.5
From 1/7/1983 to 11/7/1983	65.4	66.9	82.2	95.7
From 11/7/1983 to 23/7/1983	65.7	80.3	86.3	103.3
From 23/7/1983 to 1/8/1983	56.3	59.5	73.3	68.1
From 1/8/1983 to 26/8/1983	83.5	96.4	120.5	163.2
Total	575.6	662.1	745.0	891.6

Activity, dry matter, nitrogen contents and yield of soybean plants

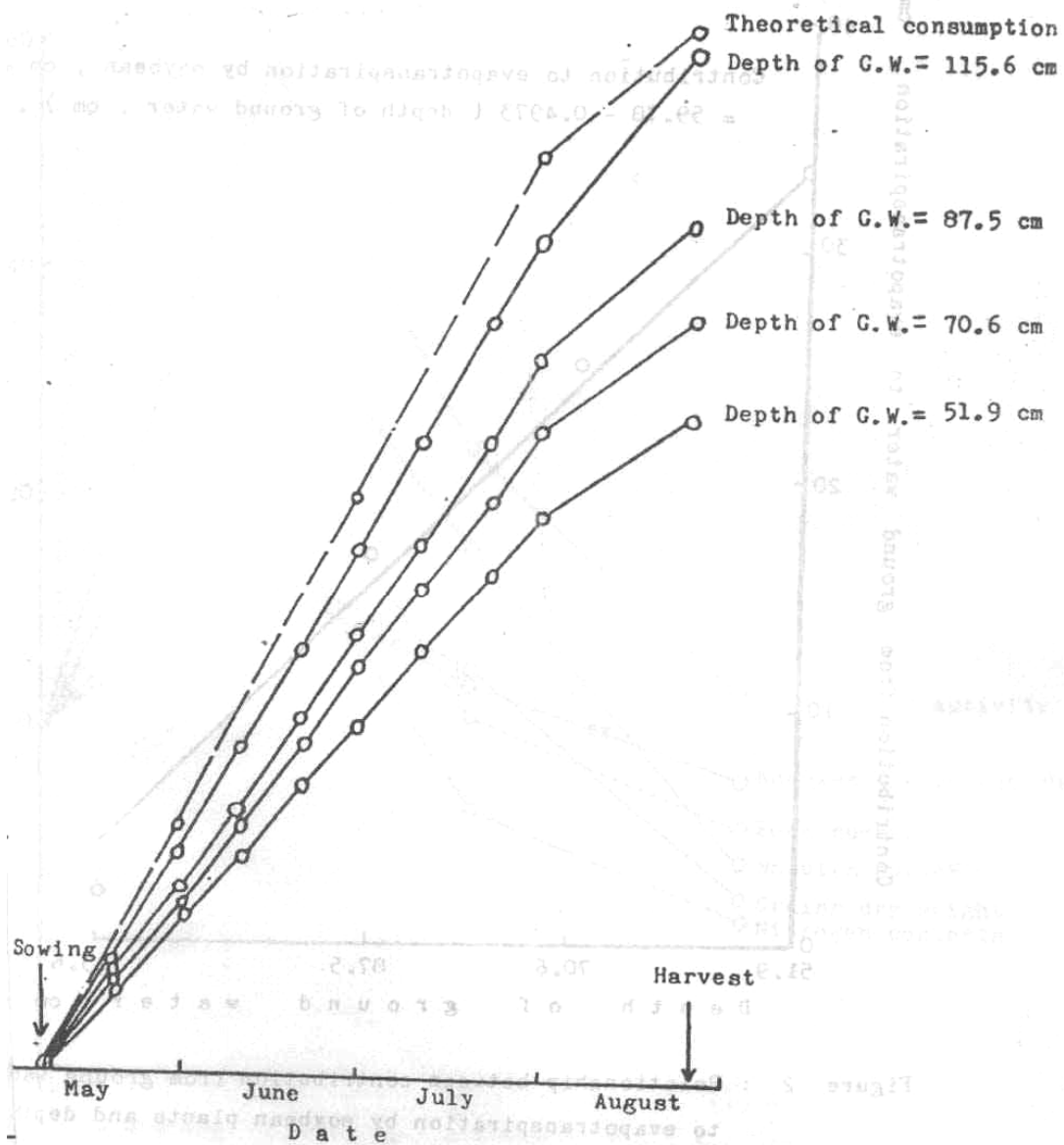
Table 3 : Soil moisture parameters under soybean cropping system (cumulative of the whole season) as affected by ground water depth.

Soil moisture parameter	Depth of ground water, cm			
	51.9	70.6	87.5	115.6
Calculated consumptive use, cm	91.2	91.2	91.2	91.2
Actual depletion:				
cm	57.6	66.2	74.5	89.2
% of consumptive use	63.2	72.6	81.7	97.8
Contribution from ground water :				
cm	33.6	25.0	16.7	2.0
% of consumptive use	36.8	27.4	18.3	2.2

Table 4 : Effect of ground water depth on nodulation , root nitrogenase activity , dry matter , nitrogen contents and yield componen of soybean plants .

Plant characteristics	Depth of ground water , cm				L S D 0.05
	51.9	70.6	87.5	115.6	
<u>At the 56 days age :</u>					
Nodules / root :					
Number	14.2	19.6	16.5	12.7	2.0
Dry weight , mg.	288	324	301	278	22
Nitrogenase activity , μ mole					
C_2H_4 / root / hr.	2.4	3.8	3.0	2.5	0.8
Dry weight of shoot + root ,					
g. / plant	21.6	28.4	23.2	20.4	2.2
Nitrogen content of shoot +					
root , mg. / plant	412	487	385	348	16
<u>At the harvest (108 days age):</u>					
Pods / plant :					
Number	42.5	54.8	43.2	39.2	1.8
Dry weight , g.	27.4	32.5	28.5	23.6	2.8
Grains yield :					
g. / plant	13.3	15.1	14.0	11.5	1.2
kg. / plot	3.46	4.10	3.54	3.02	0.18

Each value within the table is the mean of 80 plants i. e. 20 plants per replicate x 4 replicates .



: Cumulative water consumption throughout the growth season of soybean plants as affected by ground water depth .

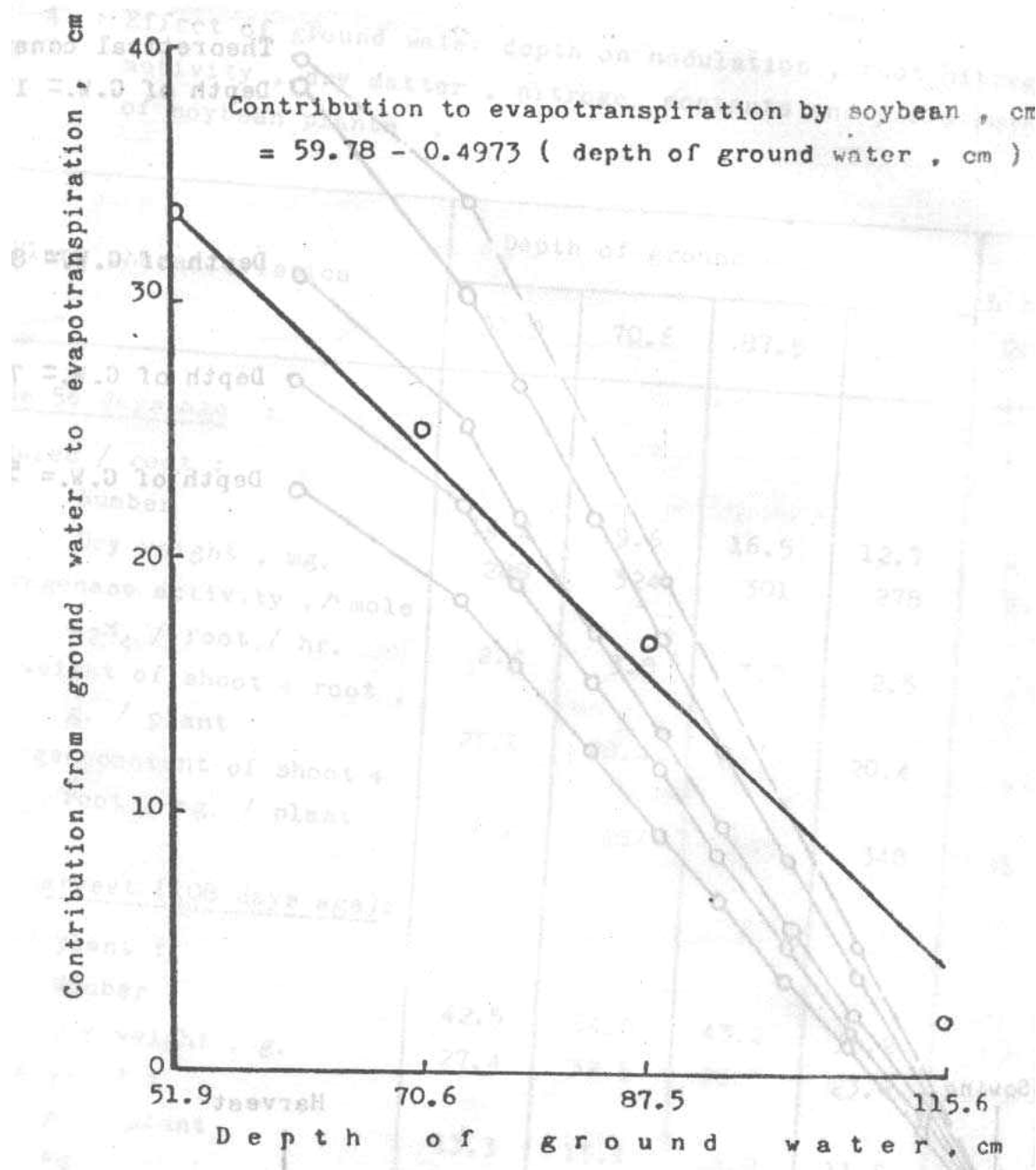
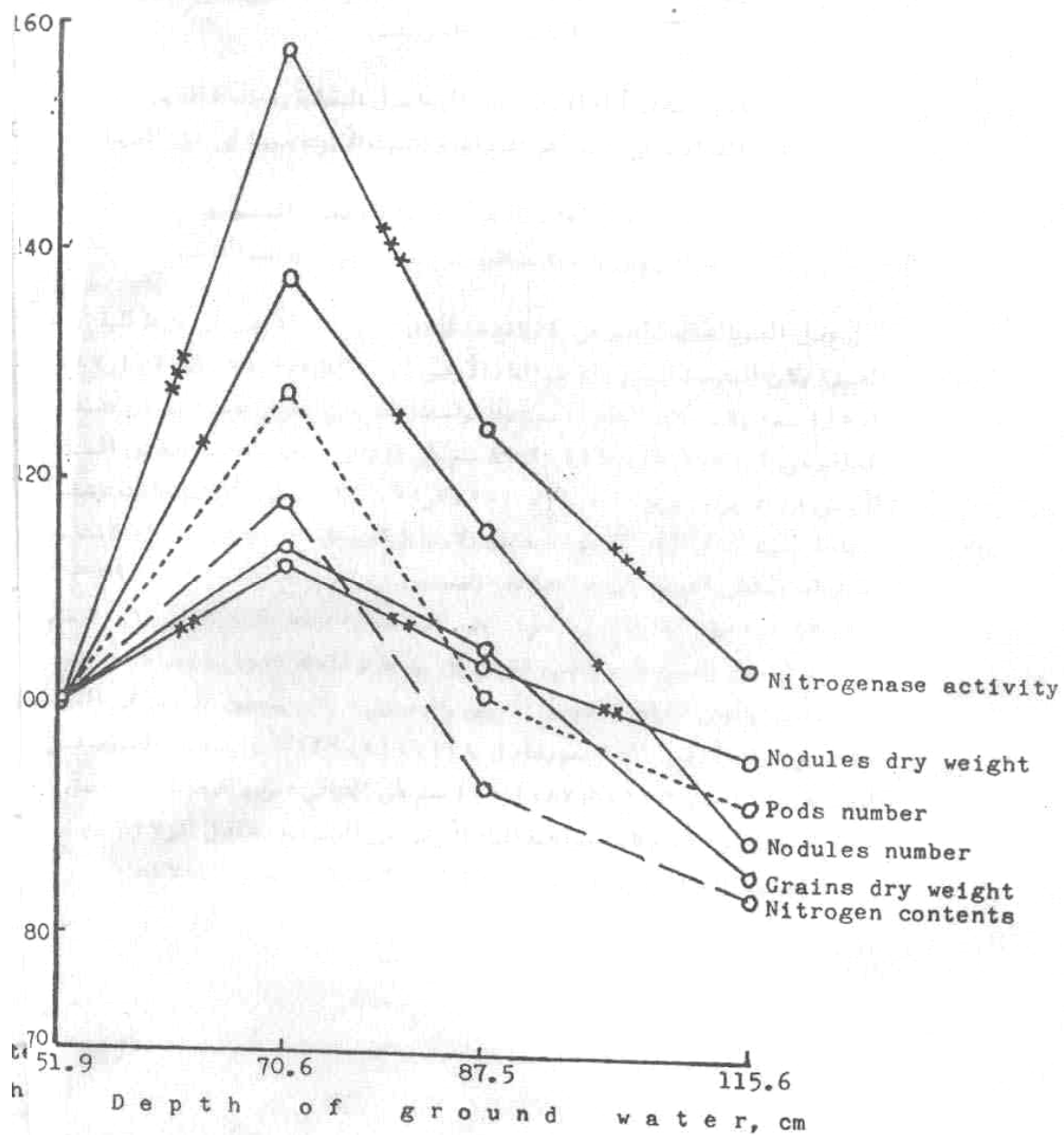


Figure 2 : Relationship between contribution from ground water to evapotranspiration by soybean plants and depth of ground water .



3 : Effect of ground water depth on relative values of the parameters of biological nitrogen fixation and yield of soybean plant .

الملخص العربى

تأثير مستوى الماء الأرضى على المحاصيل البقولية بمحافظة الفيوم
٥ - المساهمة فى البخرنتج المساهمة لتثبيت الأزوت حيويًا فى فول الصويا

محمد حماد عطية الشقوير ، ابراهيم محمد السمنودى
قسم الأراضى والمياه - كلية الزراعة بالفيوم - جامعة القاهرة

زرع فول الصويا صنف كولمبس فى ٤ مواقع تختلف فى عمق الماء الأرضى فى مزرعة كلية زراعة الفيوم . وكان المتوسط الموزون لعمق الماء الأرضى لهذه المواقع ٥١٩ر٩، ٧٠٦ر٦، ٨٧٦ر٦، ١١٥ر٦ سم . وكانت كمية الرطوبة المستنزفة بواسطة المحصول طوال موسم النمو فى هذه المواقع هى ٥٧٦ر٦، ٦٦٢ر٦، ٧٤٥ر٥، ٨٩٢ر٢ سم على التوالى . وقد رت المساهمة من الماء الأرضى فى البخرنتج فوجدت ٣٣٦ر٦، ٢٥٠ر٠، ١٦٧ر٧، ٢٠ر٠ سم على التوالى وكانت ترتبط ارتباطًا سلبيا بعمق الماء الأرضى (معامل الارتباط البسيط = - ٠٫٩٩٩٥) كما كانت معادلات الارتداد الخطى البسيط لهذه العلاقة : المساهمة فى البخرنتج (سم) = ٥٩٧٨ - (٠٫٤٩٧٣ × عمق الماء الأرضى ، سم) . وفى المعاملة ذات عمق الماء الأرضى ٧٠٦ سم كانت نباتات فول الصويا تتميز بأقصى قيم فى كل من عدد العقد الجذوية ونشاط الأنزيم النيتروجينيز والوزن الجاف والمحتوى الآزوتى والمحصول . وكان محصول الحبوب فى المعاملة ذات عمق الماء الأرضى ٧٠٦ سم يعادل ١١٨، ١١٦، ١٣٦٪ من محصول الحبوب فى المعاملات ذات عمق ٥١٩ر٩، ٨٧٥ر٥، ١١٥ر٦ سم على التوالى . وفى المعاملة ذات عمق الماء الأرضى ٧٠٦ سم كانت مساهمة الماء الأرضى فى البخرنتج تعادل ٣٧٫٨٪ من الاستنزاف من الماء الأرضى ، وتعادل ٢٧٫٤٪ من الاستهلاك المائى للنباتات .

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