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

## 3- RELATIONSHIP BETWEEN MOISTURE/AIR RATIO AND BIOLOGICAL NITROGEN FIXATION BY FABA BEAN

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## SUMMARY

For ground water levels of 26.8±1.6, 48.2±2.4, 72.1±3.0, 101.4±4.2 and 112.7±6.4 cm from the surface under field conditions; nodulation, $N_2$-ase activity of nodulated roots, growth vigour, nitrogen content of faba bean (Vicia faba L.)plants at maximum flowering and at harvest were determined. Minimum moisture content and, therefore, maximum air porosity were determined in the upper 30 cm of the soil throughout the growth season. Yield was also taken.

All tested parameters of faba bean plants, either at maximum flowering or at harvest, showed maximum values at a water table depth of 101.4±4.2 cm. This coincided with a mean minimum soil moisture content (v/v) of 28.2% and a mean maximum air porosity of 26.8%. Air/moisture ratio of the soil was 0.95.

## INTRODUCTION

Rising ground water is a problem which faces the irrigated agriculture in arid and semi arid countries. Under such conditions, moisture and air exchange in soil in volume or rate, may turn unfavourable to field crops according to their requirements. Child (1981) showed that aeration i.e. oxygen/moisture balance in soil might affect the biological nitrogen fixation by legumes. Efficiency of the symbiotic nitrogen fixation was reported also to be affected by water regime in soil (Sprent, 1976, Abdel-Ghaffar 1982 and hamdi 1982).

Several investigations have been carried out on the effect of ground water table on different field crops (Barakat et al 1971, Chaudhary et al 1975, and Hassan 1980) while legumes had received little attention (El-Shakweer 1982 and El-Shakweer et al 1982). However, in the previous work, the effect of ground water depth on the yield of the crop and some of related agronomic characters were studied. The effects of air/moistue

ratio in the root zone of the plants on the efficiency of boilogical nitrogen fixation of legumes was seldom focused. The present work was intended to study the air/moisture ratio as affected by ground water depth on the boilogical nitrogen fixation and yield of faba bean .

## MATERIALS AND METHODS

El-Fayoum Faculty of Agriculture farm (Egypt) is characterized by different ground water table levels due to elevation and drainage conditions Five sites of similar soil properties were selected in this farm to represent the variability range of ground water table. In all sites, the soil was found of clay texture (coarse sand 3.1 to 3.5%, fine sand 21.4 to 21.8%, silt 33.5 to 33.8% and clay 41.5 to 41.7%). Total porosity ranged from 55.1 to 55.5%, apparent density 1.11 g/cm$^3$, saturation percentage 62.9 to 63.5, field capacity from 47.2 to 74.9%, wilting point from 21.2 to 21.7%, infiltration rate from 0.26 to 0.30 mm/min., EC of saturated soil-water extract from 1.95 to 2.50 mmhos/cm at 25°C and pH of saturated soil-water paste from 7.9 to 8.2.These properties were determined according to Black et al (1965).

In each site, 4 random plots (6 x 7 m$^2$ each) were prepared for faba bean (Vicia faba L.)variety Giza 2-cultivation. In each plot an obsevation well was inserted to a depth of 2 m for measuring water table fluctuation during the growth season. Measurement took place 11 times i.e. just before irrigation, 2 days after irrigation and midtime between the 4 irrigations received during the growth season. The water table depth was found 26.8±1.8, 48.2±2.1, 72.1±3.2, 101.4±4.5 and 112.7±6.0 cm; each for one of the five sites. The electrical conductivity of ground water as measured in the observation wells of the sites was ranged from 0.60 to 0.68 mmhos/cm at 25°C. Inoculated seeds were sown on 25/10/1983. The crop received superphosphate (15.5% $P_2O_5$) and potassium sulphate (46.5% $k_2O$) at a rate of 150 and 100 kg/acre, respectively, but no nitrogen fertilizer was added. Yield was harvested on 29/3/1984.

Before each irrigation, soil samples to the depth 0-30 cm from each plot were taken for moisture content determination and considered the minimum in the zone of root bulk. This multiplied by apparent density would give moisture content on volume basis, which in turn by substracting from total porosity would give maximum air porosity reached in this zone.

At maximum flowering (89 days after planting) and at harvest of faba bean, 10 random plants per plot were dug out

for root nitrogenase activity measurements according to Hardy et al (1973).Nodules/plant were counted and dry weights (70°C) of nodules, root and shoot were determined.Total nitrogen content of these parts was determined (Cattenie, 1980 ).

AT harvest, pods and grains dry weights were recorded per plant.

## RESULTS AND DISCUSSION

Table (1) shows that number of pods and grain yield per plant were increased steadily and significantly with the increase of ground water depth from 26.8±1.6 to 101.4±4.2 cm then tended to decline with further increase to 112.7±6.4 cm. Number of pods and grains yield obtained at 101.4±4.2 cm depth of ground water were very close to 229 and 150%, respectively, of that obtained at the shallowest depth. It is also seen from table 1 that nodulation, nitrogenase activity of root, growth vigour and nitrogen content of plant were increased then declined similarly to the yield with increasing ground water depth. With the 101.4±4.2 cm ground water depth, the increase in nodules number and dry weight, $N_2$-ase activity dry weight of root and shoot and nitrogen content of plant at the maximum flowering stage of faba bean plant were 140. 131, 151, 223, 143 and 124% of that with the 26.8±1.6 cm ground water depth respectively. The corresponding increases at harvest were 132, 129, 155, 207, 142 and 130%.

The effect of ground water depth on symbiotic nitrogen fixation and subsequently on grain production is perhaps better understood through consideration of the variation in soil condition that may take place with the ground water depth. Perhaps the most important soil condition affected in this respect is aeration i.e. moisture/air ratio. Table (2) shows the average minimum moisture content and maximum air content during the growth season as affected by the depth of ground water. It is seen from table (2) that minimum moisture content in the upper 0-30 cm soil depth was decreased consistently and significantly as the depth of ground water increased. Air porosity took showed the opposite direction. Therefore, a plot of average air porosity/moisture during the season versus the relative values of yield components shows that nodulation, growth vigour and nitrogen content of faba bean plant either at maximum flowering or at harvest had become more meaningful and justifiable (Figures 1 and 2). Figures 1 and 2 show that at air/moisture ratio around 0.95 nodulation, nitrogenase activity, growth vigour and nitrogen fixed by the plant and yield reached maximum values and teneled to decline below or above this ratio. In other words, for

Table 1 : Nodulation , nitrogenase activity , dry weight , nitrogen content , flowers number and yield of faba bean plant as affected by ground water depth .

| | Depth of ground water table , cm | | | | | L S D |
|---|---|---|---|---|---|---|
| | 26.8 ±1.6 | 48.2 ±2.4 | 72.1 ±3.0 | 101.4 ±4.2 | 112.7 ±6.4 | 0.05 |
| | At maximum flowering | | | | | |
| Nodules / plant : | | | | | | |
| Number | 82 | 94 | 104 | 115 | 110 | 2.2 |
| Dry weight , mg. | 188 | 200 | 210 | 246 | 233 | 8.2 |
| $N_2$-ase activity, $\mu$mole $C_2H_4$/nodulated root/hr. | 14.0 | 15.9 | 18.2 | 21.1 | 16.7 | 1.3 |
| Dry weight : | | | | | | |
| Root , g. | 3.4 | 4.5 | 6.2 | 7.6 | 6.8 | 0.6 |
| Shoot , g. | 15.3 | 17.7 | 19.2 | 21.9 | 20.2 | 1.1 |
| Nitrogen content, mg/plant | 466 | 496 | 518 | 580 | 541 | 20.2 |
| Flowers number/plant | 47 | 51 | 55 | 62 | 58 | 3.2 |
| | At harvest | | | | | |
| Nodules / plant : | | | | | | |
| Number | 81 | 90 | 94 | 107 | 103 | 3.0 |
| Dry weight , mg. | 180 | 195 | 206 | 233 | 214 | 7.3 |
| $N_2$-ase activity, $\mu$mole $C_2H_4$/nodulated root/hr. | 12.8 | 14.7 | 17.4 | 19.8 | 16.6 | 1.1 |
| Dry weight : | | | | | | |
| Root , g. | 4.0 | 5.1 | 6.8 | 8.3 | 7.1 | 0.7 |
| Shoot , g. | 30.4 | 33.6 | 37.8 | 43.2 | 41.9 | 1.2 |
| Nitrogen content, mg/plant | 819 | 851 | 900 | 1062 | 964 | 24.8 |
| Pods number / plant | 4.2 | 5.5 | 7.3 | 9.6 | 8.3 | 1.0 |
| Grains , g./ plant | 10.3 | 12.2 | 13.1 | 15.4 | 14.8 | 0.9 |

Each value within the table is a mean of 40 plants(10 plants x 4 replicat

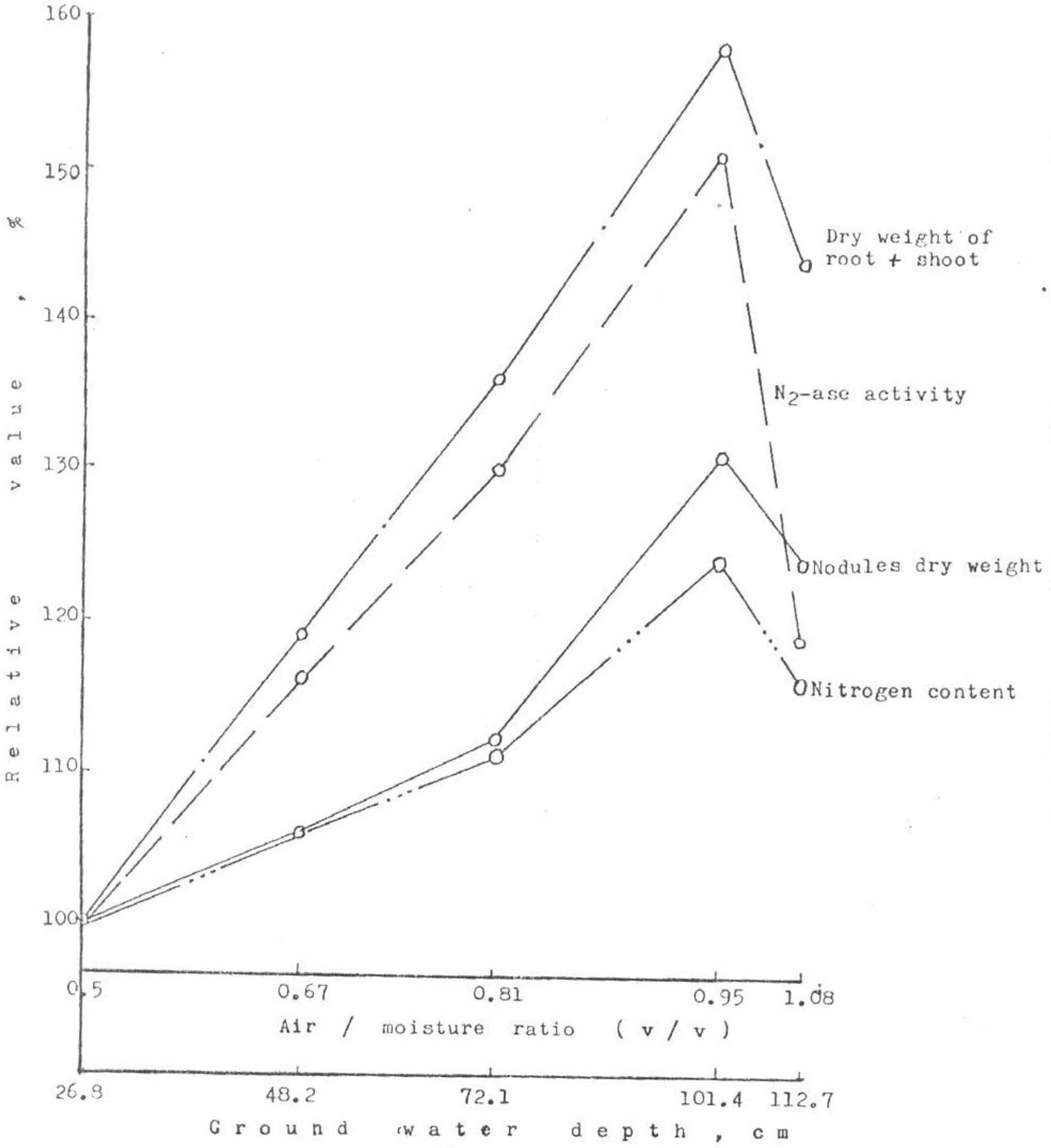
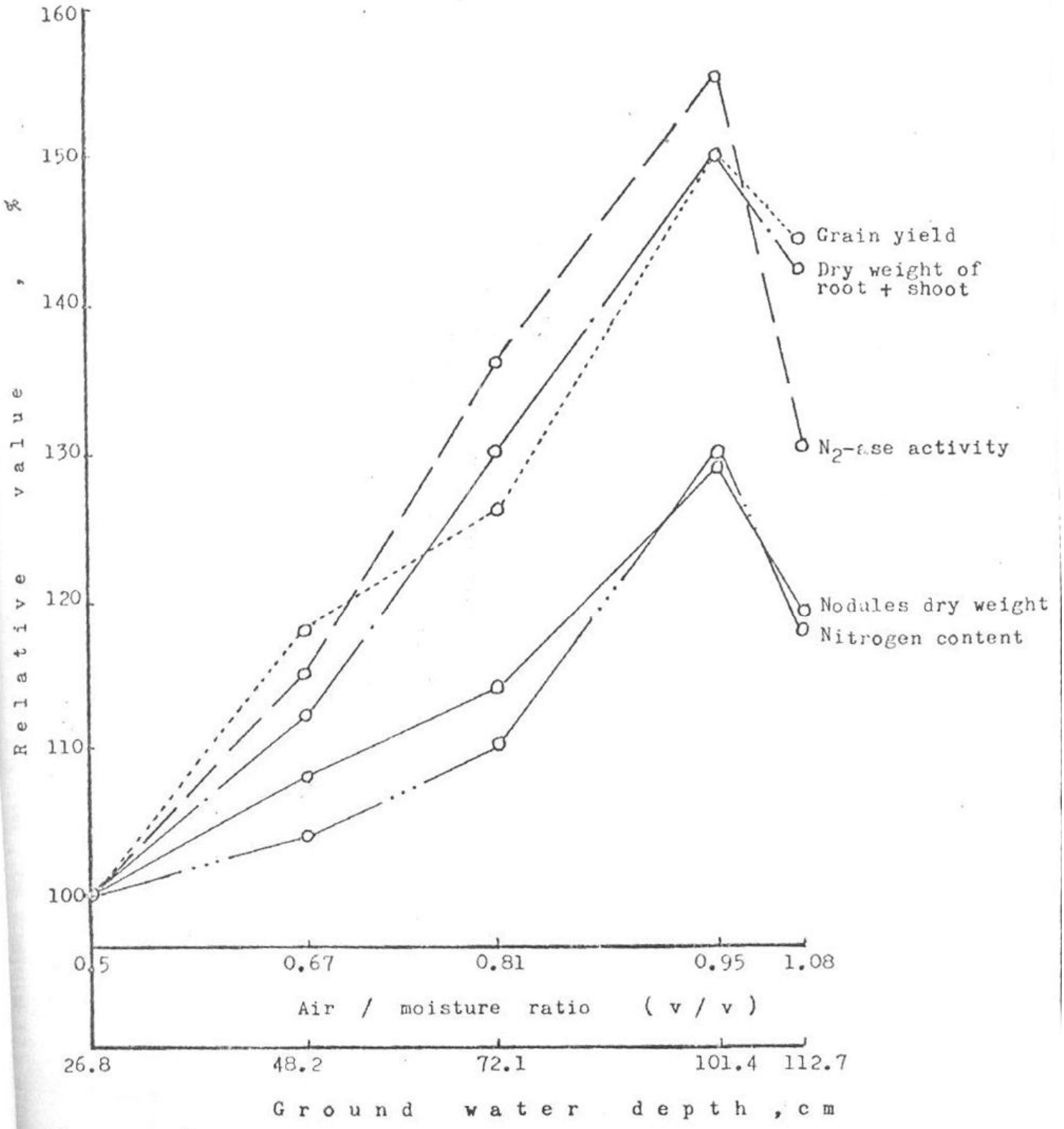



Figure 1 : Relative values of nodulation , $N_2$-ase activity , growth vigour and nitrogen content at maximum flowering age of faba bean plant as affected by ground water depth and air / moisture ratio .




gure 2 : Relative values of nodulation , nitrogenase activity , growth vigour nitrogen content and yield at the harvest of faba bean plant as affected by ground water depth and air / moisture ratio .

Table (2) **Minimum soil moisture content and maximum air porosity of the 0-30 cm soil layer during the growth season of faba bean plants as affected by ground water depth.**

| Time of Soil sampling | Depth of ground water table, cm | | | | | L S D |
|---|---|---|---|---|---|---|
| | 26.8 ±1.6 | 48.2 ±2.4 | 72.1 ±3.0 | 101.4 ±4.2 | 112.7 ±6.4 | 0.05 |
| | Minimum soil moisture content (v/v), % | | | | | |
| Before 1 st irrigation | 40.1 | 33.1 | 30.7 | 28.7 | 25.9 | 2.0 |
| Before 2 nd irrigation | 37.8 | 33.5 | 31.6 | 29.4 | 27.7 | 1.8 |
| Before 3 rd irrigation | 34.2 | 32.3 | 30.0 | 27.9 | 26.7 | 1.6 |
| Before 4 th irrigation | 34.6 | 33.1 | 29.2 | 27.2 | 26.0 | 1.8 |
| Mean for the season | 36.6 | 33.0 | 30.4 | 28.2 | 26.6 | 1.2 |
| | Maximum soil air porosity. % | | | | | |
| Before 1 st irrigation | 14.9 | 22.1 | 24.4 | 26.5 | 29.3 | 1.5 |
| Before 2 nd irrigation | 17.3 | 21.7 | 23.5 | 25.8 | 27.5 | 1.2 |
| Before 3 rd irrigation | 20.8 | 22.8 | 25.1 | 27.1 | 28.4 | 1.8 |
| Before 4 th irrigation | 20.6 | 22.0 | 25.9 | 27.9 | 29.1 | 1.6 |
| Mean for the season | 18.4 | 22.1 | 24.7 | 26.8 | 28.6 | 1.0 |

maximum growth and yield, soil moisture should be replinished when its depletion reaches half of the total voids of the soil. This condition seemed fulfilled or created by a depth of ground water of 101.4±4.2 cm during the growth season in the experimental soil.

The decline of yield of plants grown on the soil having a ground water table depth more than 101.4±4.2 indicates that irrigation water should have been incraesed to satisfy th air/moisture ratio of 0.95. This would confirm the results obtained by Sprent (1976), Child (1981) and Hamdi (9182) as they found that moisture and aeration had affected the biological nitrogen fixation process and they suggested the need for more research to identify the optimum moisture/air ratio under defferent field conditions.

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## الملخص العربي

### تأثير مستوى الماء الأرضى على المحاصيل البقولية بمحافظة الفيوم :
### ٣ ـ العلاقة بين نسبة الرطوبة الى الهواء وبين تثبيت الآزوت حيويا فى الفول البلدى

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

قدر تكوين العقد الجذرية ونشاط أنزيم النيتروجينيز وقوة النمو والمحتوى الازوتى لنباتات الفول البلدى فى مرحلتى الازهار والحصاد فى ظروف حقلية تحت مستويات ماء أرضى مقدارة ٢٦٫٨ ± ١٫٦ ، ٢٫٨٤ ± ٢٫٤ ، ١٫٧٢ ± ٠٫٣ ، ١٠١٫٤ ± ٤٫٢ ، ١١٢٫٧ ± ٦٫٤ سم تحت سطح التربة · كما قدر أقل نسبة رطوبة وأقصى مسامية هوائية فى ٣٠ سم السطحية من التربة خلال موسم النمو فى كل معاملة من مستويات الماء الأرضى · وقدر المحصول عند الحصاد ·

وتدل النتائج على أن كل مقاييس تثبيت الآزوت الحيوى التى درست على نباتات الفول البلدى سواء فى مرحلة أقصى ازهار أو مرحلة الحصاد كانت فى أعلى قيمة لها فى المعاملة التى كان عمق الماء الأرضى فيها متوسطة ١٠١٫٤ ± ٤٫٢ سم · وكان ذلك يتمشى مع أقل محتوى رطوبة أرضية متوسطة ٢٨٫٢٪ (بالحجم) وأقصى مسامية هوائية أرضية متوسطة ٢٦٫٨٪ (بالحجم) وكانت نسبة الهواء الى الرطوبة فى التربة ٩٥٫ ·

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