# Soybean Crop Production under Environmental Stress Conditions at Toshky / Egypt

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## Abstract

In the new virgin area in the extreme part of the southern Nile Valley of Egypt it is very important to establish agriculture free from pollution. The aim is to study a suitable land and water resource management plan for crop production under local climatic conditions. The study was conducted during summer 2001 and 2002; the design involves water application treatments ($I_1$: Water Requirements (WR)+20%, $I_2$: WR+10%, $I_3$: WR only, $I_4$: WR -10% and $I_5$: WR - 20%. The soil texture varies from sandy to sandy loam; with many rock fragments and gravel differing in shape, size and colour evident on the soil surface and through the whole profile. The soil taxonomy could be classified as Typic xerofluvants**,** sand loam mixed, Hyper thermic. Plant height, pods numbers, weight of plants and seed weight of soybean was highly significantly related to irrigation water applied. The highest yield was obtained with the highest amount of applied irrigation water.

## Media summary

Water management plays an important role in overcoming environmental stress. Soybean responds positively to increasing irrigation water applied.

## Keywords

New reclaimed area, Irrigation Requirement, Soybean traits and yield

## Introduction

The integrated sustainable land use of the Southern Valley regions are intended to overcome the environmental problems, increase the occupied area per person, and to decrease population intensity in the Nile Delta and Valley. The new virgin area in the southern Nile Valley of Egypt is very important for clean agriculture potentially free from pollution. The climatic condition is very hot in summer with cold winter nights, with low rainfall. Soybean, rich in protein and oil, is a very important crop for food and industrial processes. Whigham *et al.* (1978) stated that environmental variables (altitude, longitude, day length, maximum and minimum temperatures) were found to be less important than management variables such as amount of applied fertilizers and nodulation as determinants of yield. The management and sowing date play an important role in crop productivity (Ali 1993 and Shafshak *et al.* 1997). The present work aims to identify morphological soil properties and to study suitable management of land and water resources to maximize crop production under local climate conditions.

## Materials and Methods

The study was conducted on the experimental farm of The Southern Valley Agricultural Research Station - Toshky, Agricultural Research Centre. It is at the extreme southern part of the valley of Egypt about 1300 Km from Cairo. This area is about 40 Km north of the Sudanese border; at latitude 22? 25 North and longitude 31? 50 East; and 182 m above sea level (MSL). The experiment was carried out during the summer season of 2001 and 2002 with soybean as the test crop. The design involved five treatments of water amount. The treatments are: (i) water requirement + 20% ($I_1$), (ii) Water requirement + 10% ($I_2$), (iii) water requirement only ($I_3$), (iv) water requirement – 10% ($I_4$) and (v) water requirement – 20% ($I_5$). The water requirement (WR= 3674m$^3$/feddan (FD) is calculated from meteorological data in situ using Penman Monolith methods (Smith, 1991 and Ainer *etal.*1999) with a 20 percent addition for leaching

fraction; the total amount is 3647 $m^3$ for the growing period. The irrigation water is controlled by sprinkler irrigation applied daily. Chicken manure before cultivation and recommended fertilizers for soybean were added. Experimental plots were fertilized with phosphorous at a rate of 30 kg $P_2O_5$/fed (super phosphate) during seedbed preparation and 24 $K_2O$/fed (potassium sulfate) three weeks after sowing. Seeds were inoculated with the specific rhizobia and then hand planted. Nitrogen fertilizer was added as a start dose two weeks after sowing at a rate of 20 kg N/fed (Ammonium sulfate). The design includes four replicates in a randomized complete block. The size of each plot is 18$m^2$ (3m X 6m). Soybean Giza 111 was planted on 1/5/2001 and harvested on 1/8/2001 in the first season and planted on 3/5/2002 and harvested on 3/8/2002 in the second season. Most plant traits and yield were determined at harvest, the plant parameters of plant height (cm), pod number/plant, weight of plant (g/$m^2$) and seed weight (g/$m^2$) and total yield (kg/feddan) were determined. Statistical analysis was analyzed according to Snedecor and Cochran (1981). Soil samples are taken from four profiles and analyzed for soil particle size distribution, chemical analyses including, electrical conductivity, pH and calcium carbonate. Permeability was determined using international methods reported by Page (1982). Morphological features (FAO-ISRIC, 1990) and soil classification are described according to Soil Survey Staff (1994).

## Results and Discussion

*Main Meteorological Data and Soil Characteristics*

Meteorological data indicated that the maximum air temperature is 28 $^oC$ in winter (December – January) and 48 $^oC$ in summer (July – August). The average air temperature is 19 $^oC$ and 36 $^oC$, respectively. The average soil temperature is 39 $^oC$ and 26 $^oC$ in summer and winter, respectively. The relative humidity is 17% in summer and 42% in winter.

**Table (1). Morphological description of the representative soil profiles.**

| Pro. No | Depth (cm) | Color | Texture | Structure | Consistency | Gravel Stone | Other Features |
|---|---|---|---|---|---|---|---|
| 1 | 0-20 | Yellow | Sandy loam | Structureless | Loose | Gravel 10% | Calcareous Aggregates |
| | 20-45 | Brown yellow | | | Friable | | |
| | 45-60 | Yellow brown | Loamy sand | | | Break stone 25% | Gypsum & Calcareous Aggregates |
| | 57-75 | Brown red | Loamy sand | | | Break stone 10% | |
| | >75 | | | | Ped Rock | | |
| 2 | 0-15 | Yellow | Sandy | Singular | Loose | Gravel | Calcareous |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15-60 | | | aggregates | | 10% | Aggregates |
| | 60-120 | | Sandy loam | | Friable | | |
| 3 | 0-15 | Brown red | Sandy loam | Structureless | Friable | Gravel 10% | A few calcareous Aggregates |
| | 15-45 | | Loamy sand | Slightly cloddy | | | Gypsum & Calcareous Aggregates |
| | 45-65 | | | | | | |
| | >65 | | | Ped Rock | | | |
| 4 | 0-30 | Brown yellow | Sandy loam | Structure less | Friable | Gravel 10% | A few calcareous Aggregates |
| | 30-75 | | | | | | |
| | >75 | | | | | | |

Soil morphological features in the research experimental field are shown in Table (1). The main features are a sandy rock soil that is affected to some extent by weathering process. The soil surface is covered with a thin alluvial layer. It is characterized by slight undulations with the presence of many fragments of various rocks and gravels. These fragments differ in their shape, size and colour. The proportion of coarse gravel differs from 5 to 15 percent. In general, the soil color ranges from yellow to yellowish brown and sometimes tends to brownish-red. Most of soil particles are singular of loose consistency to friable. The particles get hard when dry and very soft when moist. Soil taxonomy could be classified as **Typic xerofluvants**, sand loam mixed, **Hyper thermic** (according to Soil Survey Staff, 1994) based on soil physical and chemical properties as well as morphological features. For soil salinity and reaction properties, data in Table (2) indicate that soil salinity is very low; it ranges from 0.6 to 1.2 dS/m. Soil pH values ranges between 8.7 and 8.9. The soil saturation percent (SP) is low varying between 25 and 35 percent. Soil particles distribution varied from loamy to sandy loam texture down the soil profile to bedrock. The soil profile is shallow; the depth varies from 50 cm to 100 cm to the bedrock. The total calcium carbonate varies from 9 % and 16%.

**Table (2). Main soil chemical characteristics in soil suspension and saturation extract.**

| Profile No. | Depth (cm) | pH | EC (dS/m) | SP | Profile No. | Depth (cm) | PH | EC (dS/m) | SP |
|---|---|---|---|---|---|---|---|---|---|
| | | 1:2.5 | | | | | 1:2.5 | | |
| 1 | 0-25 | 8.9 | 1.15 | 28.0 | 3 | 0-15 | 8.7 | 0.75 | 28.0 |
| | 25-50 | 8.8 | 0.68 | 35.0 | | 15-45 | 8.9 | 0.75 | 30.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50-70 | 8.9 | 0.80 | 30.0 | | 45-60 | 8.7 | 0.60 | 32.0 |
| | 70-90 | 8.9 | 0.75 | 28.0 | | | | | |
| 2 | 0-15 | 8.7 | 1.20 | 25.0 | 4 | 0-30 | 8.7 | 0.70 | 30.0 |
| | 15-60 | 8.7 | 0.85 | 30.0 | | 30-75 | 8.9 | 0.80 | 32.0 |
| | 60-120 | 8.8 | 0.65 | 30.0 | | 75-100 | 8.7 | 0.60 | 32.0 |

The above soil and weather characteristics demand good irrigation management to protect the root system from damage and to have any chance of reasonable yield. Organic matter is very low; it ranges between 0.1% and 0.5%. Low organic matter is due to the high temperatures that increase the decomposition rate and also to shortage of natural vegetation. Data indicate that the permeability rate ranges from 9.0 to 15.2 cm/hr, which is very rapid.

*Agronomic Component Characters and soybean yield*

Analysis of Variance for some agronomic components and yield of soybean as affected by various applications of irrigation water quantity treatments in the summer seasons 2001 and 2002 (Table 3) indicate that all studied plant parameters responded to the irrigation treatments.

**Table (3). Analysis of variance for some soybean agronomic components..**

| Treatments | Degree of Freedom | Plants height (cm) | Pods No/ Plant | Weight of plants ($g/m^2$) | Seeds weight ($g/m^2$) | Total yield (Kg/fd) |
|---|---|---|---|---|---|---|
| Irrigation (I) | 4 | ** | ** | ** | ** | ** |
| Season | 1 | (ns) | (ns) | (ns) | (ns) | (ns) |
| IR x Season | 4 | (ns) | (ns) | (ns) | (ns) | (ns) |

The results of the statistical analysis indicate that the plants height, pods numbers, weight of plants and seeds weight are highly significantly related to irrigation amount treatments. Neither the studied season or interaction between water irrigation amount and season show any significant responses.

**Table (5). Agronomic components and soybean yield as affected by irrigation water treatments through the two studied years (means of four replicates).**

| Treatments | Plant height (cm) | Pod No | Plant weight ($g/m^2$) | Seed weight ($g/m^2$) |
|---|---|---|---|---|

| | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 |
| $I_1$ (IR+20%) | 48.8 | 51.3 | 38.3 | 40.0 | 735 | 795 | 273 | 306 |
| $I_2$ (IR+10%) | 36.5 | 39.5 | 31.8 | 32.8 | 597 | 642 | 222 | 236 |
| $I_3$ (IR only) | 43.8 | 43.5 | 30.8 | 31.8 | 505 | 523 | 180 | 185 |
| $I_4$ (IR-10%) | 46.3 | 46.0 | 44.3 | 41.8 | 458 | 452 | 172 | 175 |
| $I_5$ (IR-20%) | 49.8 | 40.3 | 34.8 | 35.5 | 409 | 423 | 150 | 163 |
| LSD (5%) 2-T means | 5.0 | | 4.7 | | 77.1 | | 17.9 | |
| LSD (1%) 2-T means | 6.8 | | 6.3 | | 104.1 | | 34.2 | |

Data of agronomic components of soybean as affected by irrigation water amount treatments (Table 4) indicate that the averages of plants height followed the order of: $I_5 > I_1 > I_4 > I_3 > I_2$ in the first season and $I_1 > I_4 > I_3 > I_5 > I_2$ in the second season . Pods number followed the order of: $I_4 > I_1 > I_5 > I_2 > I_3$ in both seasons. Regarding plants weight, the data expressed in g/m$^2$ followed the order of: $I_1 > I_2 > I_3 > I_4 > I_5$ for both seasons.

With respect to seed weight expressed in g/m$^2$ as affected by irrigation water amount treatments, results indicate that the averages followed the order of: $I_1 > I_2 > I_3 > I_4 > I_5$ in both seasons. Data of yield shown in Table (5) and in Figure (1) as ton/hectare for seasons 2001 and 2002 indicate that the highest total yield is obtained with treatment $I_1$ (water requirement plus 20% more); the lowest yield is obtained with treatment $I_5$ (water requirement minus 20% more).

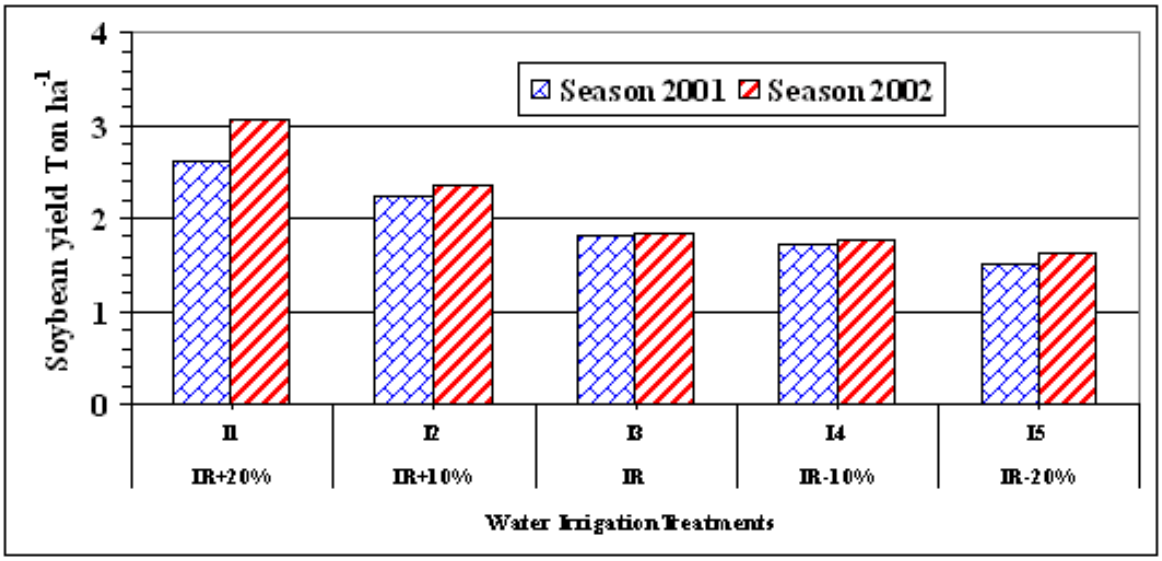

**Fig.(1). Soybean yield expressed as Ton/ha as affected with irrigation quantity treatments.**

## Conclusion

In the shallow soils and harsh climate of the previously lightly cultivated Southern Valley, irrigation gives an opportunity for substantial crop production in an uncontaminated environment.

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