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Mini Review

Agriculture Study on Sugar Beet in Egypt

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Abstract

Sugar beet cultivation in Egypt is vital for the sugar industry's main goal since its natural properties of salinity tolerance and ability to thrive in a desert climate make it the second choice for sugar production. Traditional agriculture practices have a high level of output; however, sugar beet is one of the crops that depend on yield quality rather than quantity. For sugar producers, the amount of sugar in the tuber of the sugar beet is the most essential attribute, and it is the key predictor of yield cost. Precision agriculture approaches in sugar beet production include (sowing, irrigation, fertilization, harvest, and post-harvest) and, according to some researchers, have a positive impact on cost, time, and quality. As a result, this review contains some recommendations for excellent agricultural practices based on various scientific findings as well as environmental factors in Egypt that influence crop quality and quantity.

Keywords: Precision Agriculture; Sugar Beet; Irrigation; Fertilization; Pest Management

Introduction

General

Sugar beet is a plant its roots have a high concentration of sucrose and it used commercially for sugar production. It is known as the Altissima cultivar group of the common beet (Beta vulgaris) in plant breeding. Sugar beet cultivation has spread in Egypt in Lower and Upper Egypt governorates, and since the energy for existing crops needs to grow about 200,000 feddans in order to operate at full capacity in the El Sheikh, El Dakahlia and El Fayoum and factories, more than half a million tons of sugar. The root in sugar beet contains, on average, 75% water, 20% soluble solids, about 16% sucrose, 4% non-sugar substances, which are nitrogenous substances and mineral salts, their excess hinders the crystallization of sugar, leading to a decrease in the quality of the crop, especially sodium and potassium salts. 5% fiber, which is used in the production of fodder.

The ideal choice is cultivation Beets in August, when the plant is exposed to a relatively high temperature and grows vegetative to be a root of a suitable size until the month of October, when the temperature begins to decrease the sucrose storage begins and the harvest begins in March.

Figure 1

In Egypt, the sugar beet applied in its soil for average productivity approximately 30 ton/fed [1]. In Egypt 11 million tons of sugar beets have been produced in 2018.

Project brief

There are several types of cultivars that are produced in Egypt.

Cultivar	Origin	Cultivar	Origin
Gloria	Germany	Pleno	Netherland
Toro	Germany	Farida	Netherland
Top	Germany	Demo poly	France
Monte Bianco	Germany	Deberya poly N	France
Kawemira	Germany	Ras poly	Sweden
lola	Germany	H poly	Sweden
Oscar poly	Denmark	Nejma	Sweden
Athos poly	Netherland	Beta poly teri	Hungery

Table 1

The sugar beet crop needs about 1800 - 2500 m^3 of water throughout the life of the plant, distributed over about 7-8 irrigations, which increase in light sandy lands, which may reach 15-20 irrigations. In traditional agriculture, when preparing the land for cultivation, the canal and the pit must be established, provided that the line length does not exceed 7-8 m.

Growth Stages of sugar beet

Figure 2: Common creative license.

Opportunity rationale

As Egypt is one of the countries that exports molasses that is produced from sugar beet, also the number of sugar factories in Egypt increased, hence increasing the chance of sugar beet cultivation in Egypt as the consumption rate increase inside and outside Egypt.

Environmental growth

Temperature: The optimum temperature for plant and growth 20-30 degree Celsius.

- A daily minimum temperature above 3°C.
- A daily maximum temperature below 30°C (sugar beet).
- An optimum accumulated temperature requirement of 1253°Cd (sugar beet) [2].

Sowing date: Early planting during August and mid-September, early germination, with a period ranging between 8-12 days.

Depth of cultivation: One of the main factors in the speed of germination is that the depth of seeds does not exceed 1-2 cm, especially in heavy lands, but in light lands, the depth of cultivation should not exceed 3 cm, as increasing the depth of seeds leads to a delay in germination for a period that may reach more than 40 days.

Soil quality: The germination of seeds in sandy and light lands is faster than in heavy lands.

Kind of soil	Parameter	Range	Reference
Heavy Clay soil	Salinity (EC)	3.23 and 3.16 dsm^{-1} before planting and after harvesting	[3]
Sandy Loamy	Salinity (EC)	0.58 dsm^{-1}	[4]
	PH	8.1	
calcareous soil	Salinity (EC)	1.15 - 1.2	[5]
	PH	8.4 - 8.5	
Sandy soil	Salinity (EC)	1.99 - 2.06	[6]
	PH	8.13 - 8.15	
Sandy loam soil	Salinity (EC)	3.06 and 2.77 mmhos/cm	[7]
	PH	8.1 - 8.3	
Sandy soil	Salinity (EC)	1.45 dSm^{-1}	[8]
	PH	7.9 - 8.1	
Sandy non calcareous soil	Salinity (EC)	4.6 - 5.21 dSm^{-1}	[9]
	PH	7.9- 8.1	

Table 2

Soil Nutrients uptakes by sugar beet crop to produce large yield.

Nutrients	Amount	Notes	Reference
Nitrogen	200 kg N ha^{-1}	More than 50% naturally from soil and the remaining from fertilizers its application between 4-6 weeks after sowing	[10]
Potassium	114 kg ha^{-1}		[11]

Table 3

Irrigation of agriculture: When the irrigation water is increased and the land is immersed in water for a long period without being drained, it leads to delaying germination.

Parameter	Range	Reference
Salinity (EC)	1.81 dsm^{-1}	[3]
PH	7.14	

Table 4

The Efficiency of water irrigation in desert from 6180 - 6463 m^3/ha in drip irrigation method.

According to FAO recommendation to use drip irrigation in beetroot crop [3].

Irrigation water equations:

dn = (ϴfc - ϴw)AsR

dir = $\frac{dn}{n}$ (n+1)

V = $(\frac{dir}{Ea})$. ( )A

dn is the net water required to provide the soil water deficit to reach field capacity within the root zone (mm).

ϴfc and ϴw are the soil water contents at field capacity and at measuring time, respectively (%).

As is the bulk density (g cm^{-3})

R is the root depth (mm)

dir is the net water requirement one day after soil water measurement or at the irrigation time (mm).

n is the number of days between the last irrigation date and the soil water measuring date (which was one day before the next irrigation date).

V is the volume of irrigation water (liters).

Ea is the application efficiency (for subsurface drip, surface drip and furrow irrigation this was assumed to be 95%, 90% and 80%, respectively).

A is the area of each plot (m^2) [12].

The crop evapotranspiration values were calculated according to the following equation:

ETc = ETo * Kc

ETc = Crop evapotranspiration (mm/day)

ETo = Reference evapotranspiration (mm/day)

Kc = Crop coefficient values for sugar beet crop

Equation of Applied Irrigation Water: $AIW = \frac{ETc * Kr * I}{Ea\ (1-LR)}$

AIW: Head of applied irrigation water (mm).

ETc: Crop evapotranspiration (mm/day)

Kr: Evaporation reduction coefficient, that depends on ground cover.

I: Irrigation intervals (day),

Ea: Irrigation efficiency of the drip irrigation system

LR: Leaching requirements.

Insect infestation: In many cases, germination is greatly affected by insect infestation, especially the borer, cutworm and cotton leaf worm, which may eliminate seedlings in their buds, especially in the early lugs.

The land is prepared to be plowed at least twice in a homogeneous manner when the field moisture content is 50% (cultivated land) plowing is followed by smoothing and leveling the soil, then dividing the land into lines and basins to facilitate irrigation.

Fertilization

- It is recommended to add 60 - 80 kg of nitrogen per acre
- It must be added at an early age in the life of the plant so that nitrogen fertilizer is not added when the plants reach the age

of 90 days, and nitrogen fertilizer is added in two approximately equal batches. The first batch is added immediately after thinning, and the second batch is added to the irrigation following it.

- Organic fertilizers can be added to sandy and reclaimed lands, and phosphate fertilizers are added at a rate of 100-200 kg, superphosphate 15%, and the best date for adding it is during the preparation period of the land during the plowing process so that the phosphate fertilizer can be mixed well.

Operational plan

Pests and diseases

Pests	Diseases
Mole cricket	Cercospora leaf spot (fungal disease)
Cutworm	Powdery mildew (fungal disease)
Egyptian cotton leaf worm	Damping off (fungal disease)
Flea beetle	Nematodes
Mangold fly	Hollow Heart (Nitrogen fertilization increase)
	Black heart (deficiency of boron)

Table 5

Event	Method	Equipment	No. of labors	Duration/Time	Notes	Recommendation
Soil tillage	Stubble cultivation	Tined cultivator		After harvesting the previous crop	Depth: 0.2 - 0.5m	2 passes
		Disc tiller				1 pass
	Mouldboard ploughing	Mouldboard ploughing			Depth: 20 cm or more	
	harrowing after ploughing	Rotary harrows			Depth: 5 - 15 cm	
Conservation tillage	Stubble mulch	Sweep ploughs			For large plant residues	
	Disc ploughing	disc ploughs			For small plant residue	
Pre-sowing fertilization	After soil testing			Before sowing		Phosphorus 30kg P2 O5 fed-1 in the form of calcium super phosphate (15.5% P_2O_5) [13].
Levelling	Laser levelling	Laser leveler				
Sowing seeds				During August		
First Irrigation	Surface irrigation system			After sowing seeds		Cold and abundant water flow and draining of exceed water after irrigation
Second irrigation	Surface irrigation system			After 4-6 days of sowing		To inhibit the moisture loss from seeds
Middle irrigations	Surface irrigation system			The irrigation time depend on the soil and weather condition		
Last irrigation	Surface irrigation system			4-5 days before harvest		

Sprinkler irrigation	In the case of sprinkler irrigation, especially in sandy and light lands, the need for continued availability of moisture around the seed until germination is completed, and then irrigation is carried out according to the condition of the plant and soil.					
Thinning	Hand thinning		25/acre	4-leafs stage (30 days after sowing)		
	Mechanical thinning					
Fertilization	Nitrogen			1st dose after thinning 2nd dose after 30 days of thinning		Nitrogen fertilizer was added at the 80kg N fed-1 in the form of urea (46% N) in two equal doses [13].
	Potassium			Before the 2^{nd} irrigation		Potassium 24kg K_2O fed-1 in the form of potassium sulphate (48% K_2O) before the 2nd irrigation [13].
Pest control	Mole cricket			Aug - Sep		Avoid weed condensation.
	Cutworm			Late Oct - Nov		
	Egyptian cotton leaf worm			Aug - Sep		
	Flea beetle			Dec - Feb		Avoid weed condensation.
	Mangold fly			Mar - May		
	Cercospora leaf spot (fungal disease)			Aug		
	Powdery mildew (fungal disease)			Mar – May		
	Damping off (fungal disease)					Irrigation management especially in first and second irrigation process
	Nematodes					Sugar beet have to be the 4th crop rotation Avoid cultivation peanut and sunflower.
	Hollow Heart			High moisture and nitrogen content		Spacing and nitrogen fertilizer control.
	Black heart			deficiency of boron		Irrigation, drainage, boron & nitrogen fertilizers control.
Weed control	Hand weeding with application of herbicides			After sowing or after 2 true- leaf stage it depends on the kind of weed		Visual observation and hand weeding

Harvest	Hand harvesting			The yellowish of the leaves and root protrusion from soil (180 - 210 days)		
	Mechanical harvesting					
	Storing					Normal storage duration from 24 to 48 hours maximum.
Post-harvest	Saving soil loss					Avoid harvesting in wet conditions.

Table 6

*Stubble cultivation before mouldboard ploughing should usually only be made in fields with a large number of perennial weeds or for the establishment of an autumn-sown catch crop; otherwise, the negative effects may dominate.

Soil tillage

- Primary tillage performed when soil moisture is optimum.
- Plowing depth for sugar beet varies depending on soil's clay content. Heavy soils require a depth of up to 0.5 m, whereas sandy soils require usually 0.2 - 0.4m [14].
- Repeatedly growing sugar beet on the same field causes a rapid yield drop, mainly due to increased disease inoculants. Consequently, this practice must be carefully avoided.

Pre-sowing fertilization

- Includes the necessary elements for the incoming crop, taking into account future losses through water movement, etc. Due to their limited mobility in the soil, when phosphorus, potassium and magnesium fertilization is required, they are normally applied before plowing in autumn in order to loosen the fertilizers in the processed soil layer [15].
- It is important not to give too few or too many plant nutrients, therefore the soil must first be analyzed so that the plants will not be burned, or show poor growth.

Sowing

- To reach to desired concentration of sugar we have to take in our consideration the density of the plant to plant approximately 40000 plants/acre.
- The space between each plant 20 cm.

Soil type

- Sugar beet can grow in a wide variety of soil in Egypt (saline, alkaline and calcareous soils) so it needs to monitor what the exact type that we treat with by soil analysis [13].

Planting period

- Sugar beet cultivated in Egypt from August to September and it last for 4- 6 months.

Comparison between traditional, precision and advanced agriculture techniques in cultivating sugar beet

	Traditional Agriculture	Precision Agriculture	Advanced precision Agriculture
Zoning	Drilling machine used in sowing seed to avoid the weeds or any other plant residues [16] and can used manually by cone planter [17]. The seed sowing according to previous recommendation for depth and spacing.	Identification of suitable and unsuitable conditions for sugar beet based on meteorological data history [18].	A precision study the meteorological history of the desired location and except the productivity of the crop using GIS map and gathered information about the crop critical growth points. Management Zone Delineation (MZD) there is are a various approach in precision agriculture it's important to collect a real time data like;(weather, soil, air quality, crop maturity) [19]. Zone dividing to be under more control and for easily data collection.
Soil analysis	Based on some recommendation from another farmers	Soil analysis before planting that lead to complete image about the soil and its mineral losses. Also soil texture mapping that provided by satellite [20,21].	After soil analysis and optimizing all plant needs, schedule soil analysis period and finally follow the crop with soil sensors that applied for different parameters (PH, Moisture, temperature, Insects, Weeds, pollutants) using NIR [22].

Monitoring of plant phenotype	The determination of the leaf area index of sugar beet canopies by using direct measurement techniques is very laborious [23]. The fresh weight of root is a destructive test that cannot be performed before harvest.	3 growth indicator FWL, FWT and LAI (Fresh weight of leaves – Fresh Weight of Roots - leaf Area Index) [24].	Real-time multispectral camera that based on unmanned aerial systems that follow the plant growth. Knowledge aware system that collects data from multispectral analysis and cameras and environmental sensors to reproduce a complete plant 3D module.
Diseases management	3 different applications of diseases management: 1- Preventive management 2- Curative management 3- Eradicated management	Study the crop pathogens and apply of the pesticides to avoid any infection. The visual plant disease estimation by human raters, microscopic evaluation of morphology features to identify pathogens, as well as molecular, serological, and microbiological diagnostic techniques [25]. It is able to detect Cercospora leaf spot, powdery mildew, and rust on sugar beet before the appearance of visible symptoms using Support Vector Machines and spectral vegetation indices [26].	The early stage of pathogen can be detected with thermal images [27]. Techniques: - RGB - Multispectral - Hyper spectral - Thermal (infrared thermography): detect the transpiration of the plant leaf. - Chlorophyll – fluorescence: This method has been used to study differences in the photosynthetic activity caused by biotic and abiotic stresses over the leaf area - 3D sensors - Photogrammetric solutions such as stereo cameras, 3D laser scanners, ultrasonography, or densitometry also have the potential to distinguish information about plant biomass or plant architecture. All of these techniques depend on the data collection of the disease parameters. The density of a crop stand can be an important parameter for planning targeted fungicide applications [26].
Water management	Recommended crop sequences and change irrigation method from furrow irrigation to sprinkler. Visual observation of soil moisture.	Most growers who have used watermark moisture soil sensors reduced their water use and observed slight increases in yield.	High-resolution multi-spectral imagery, in combination with ground sampling, provided enough information for the modelling approaches to accurately estimate spatially distributed surface soil moisture [28]. Real-time canopy temperature, relative humidity, solar radiation, wind speed and air temperature were required field measurements for calculating theoretical CWSI (Crop Water Stress index) for automatic irrigation [29].
Fertilization	Application of recommended brand name of fertilizers that contain NPK.	Variable rate fertilization is applied according to the zone mapping of mineral defection that need to be fertilized.	Perform soil and water analysis and during application following the plant by NDVI values [30]. Site specific fertilization: 1- Fertilizing Based on Nutrient Removal by Previous Crops. Real time fertilization: 1- Fertilizing Based on Reflectance of Soils [31].
Seeding	Manual sowing of seed without takes any consideration to soil sampling or any other recommendation.	Detection the soil moisture from soil sampling and take the recommended spaces between each seed and raw and depth.	Sensor used in during seeding for detect 2 important point sowing depth and soil moisture [31].

Table 7

* Automatic irrigation triggered only after canopy temperatures exceeded 28°C for more than 452 min accumulated in a 24 h period on an odd-numbered DOY in cotton [32].

Recommendation

- Zoning land according to GIS (Geographical Information System) and dividing zoning area to blocks for precision agriculture.
- Precision reference study of the cultivar for its resistance and productivity.
- Soil testing before cultivation (A 60 -acre field with 3 sampling areas would require 15-20 cores for each of 3 composite boxed or bagged samples).
- Real- time water and soil measurement (parameters) daily updated schedule.
- Automatic valves to control irrigation schedule.
- Monitoring of canopy temperature and soil surface temperature for early pathogen detection.
- The WSN (Wireless sensor network) can be used to test the suitability of the agricultural land to the crop cultivation, ensuring its freeness from diseases and harmful fungi, and for performing nutrient availability analysis in order to develop an appropriate fertilization scheme.

Important notes

- Crop sequence in land for high productivity Clover (short season), sugar beet then rice.
- Sugar beet, soybean then maize for water management and soil mineral saving.
- Faba bean can intercrop with sugar beet.
- When the crop is imported to the factory, a sample is taken and the percentage of sucrose, sodium, potassium, and alpha-amino nitrogen is estimated. The higher the percentage of the last three elements, the lower the percentage of sugar extraction.
- Soil physical analyses
- Particle size distribution, bulk density, and soil compaction by soil core method were determined according to [33].

Soil chemical analyses

Electric conductivity (EC), soluble cations and anions, calcium carbonate ($CaCO_3$), organic matter, pH, exchangeable Na+, macronutrients, and cation exchange capacity were determined according to United States Department of Agriculture [34].

Water samples analyses

- Three water sampling tests (pH, EC, total dissolved solids (TDS), and sodium adsorption ratio (SAR)) were carried out using the soil survey laboratory methods manual [34].
- Suitability of water for irrigation was determined according to the limitations outlined by [35].

Late harvesting impact

The late harvest (187 after emergence) obtaining the highest sugar yield when the rainfall and low temperature do not occur [36].

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