GROWTH, SEED YIELD AND ITS QUALITY OF SOYBEAN IN RELATION TO THE PREVAILING CLIMATE FACTORS DURING THE GROWING SEASON

By

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ABSTRACT

Two field experiments were conducted at the Agriculture Experiments and Research Station at Giza, Faculty of agriculture, Cairo University, Egypt during 2014 and 2015 seasons. The objectives of this study were to investigate the growth, yield, oil content and its fatty acid as well as protein content and its amino acids of soybean in relation to prevailing climate factors during the growing season. Soybean variety Giza 111 was seeded on five sowing dates (April, May, June, July and August) to obtain varied climate parameters. Delay in sowing date from April to August decreased the growing season duration by two weeks; this was related to high values of maximum temperature ($T_{max.}$), minimum temperature (T_{min}), actual sunshine hours (ASSH), accumulated growing degree days (AGDD) and accumulated photo-thermal units (APTU). Delaying sowing date after June decreased leaf area and top dry weight per plant. This was related to low values of ASSH and solar radiation energy (SRE) during the period from emergence (E) to 60-days later .Seed yield and its components were gradually decreased as seeding date was delayed, this was related to the change in diurnal temperature range (DTR), ASSH and SRE prevailed during reproductive growth stage (RGS). Seed oil content was slightly decreased as sowing was delayed from April until July, while the reduction was more obvious for August sowing date; this was related to high daily average temperature ($T_{av.}$) DTR, ASSH and APTU-prevailed during RGS. The highest value of oleic fatty acid as well as the lowest value of linoleic acid was observed in seeds of June sowing date, this was related to the high T_{av}, DTR, ASSH and APTU prevailed during RGS. High protein content (PC), high non-essential amino acids (NEAA) and low essential amino acids (EAA) were observed in the seed of June sowing date; this was positively correlated with $T_{av.}$ and $T_{min.}$ for (PC) and (NEAA) and negatively correlated with $T_{max.}$ for (EAA).

Keywords: Soybean, Sowing date, Climate parameters, Oil content, protein content, Fatty acids, Amino acids.

DEDICATION

I dedicate this work to my parents, my husband, my future son and for all who gave me support and assistance for finishing this work.

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Abbreviations used

($T_{max.}$): Maximum Temperature.

($T_{min.}$): Minimum Temperature.

($T_{av.}$): Average Temperature.

(DTR): Diurnal Temperature Range.

(SSH): Sunshine Hours.

(SRE): Solar radiation energy.

(APTU): Accumulated Photo-Thermal Units.

(AGDD): Accumulated Growing Degree Days

(**MUSFA**): Mono-Unsaturated Fatty Acids.

(PUSFA): Poly- Unsaturated Fatty Acids.

(NEAA): non-Essential Amino Acids.

(EAA): Essential Amino Acids.

(LA): Leaf Area per plant.

(TDW): Top Dry Weight.

(E- FL): Emergence to Flowering Stage.

(FL-PM): Flowering to Physiological Maturity.

(E-PM): Emergence to Physiological Maturity.

(**CPT)**: 1, 2-Diacylglycerol Choline Phospho Transferase

(LPCAT) : Lysophosphatidylcholineacyl Transferase.

(ACCase): Acetyl-CoA Carboxylase.

(FAS): Fatty Acid Synthase.

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INTRODUCTION

Soybean [*Glycine max (*L.*)* Merr.]is the most important oilseed crop in the world. It ranked thefirst with regard to harvested area (111 million ha.) and seed production (308 million tonne) (FAO, 2015). Soybean is grown in different growing zones allover the world with different climates, which may affect its performance (Major *et al*., 1975 a) and seed constituents (Wolf *et al*., 1982). United States, Brazil, Argentina and China produce more than 80% of world production of the soybeans (FAO, 2015). In Egypt, it is grown on 9.000 ha. which produce 25000 tonne only (FAO, 2015). The expected change in the global climate during this century will do negative impact on main crops, including soybean in temperate and tropical zones (IPPC, 2014). Thus, the researchers in agriculture sector should work hard in the area of adaptation options to mitigate these negative effects to face the increased food requirements of the increasing world population, in Africa and Asia in Particular. This is more necessary in the nations with the high rate of population increase such as Egypt.

In this study soybean was chosen because Egypt import more than 95% of edible oil (1.6 million tonne), 0.7 million tonne soybeans and 1.2 million tonne of soybean meal (FAO, 2015). Thus,Egypt need to increase the area of soybean and its productivity and/or avoid the yield decrease due to expected climate change, through adaptation options.This need information about the performance of soybean in relation to the different prevailing climates during the growing season underEgyptian conditions. For that, this study aimed to know some information could be used to create an adaptation options to mitigate the negative effects of the expected climate change on soybean under Egyptian conditions.Thus, the objectives of this investigation were to study the growth, development, yield and yield components as well as oil content and its fatty acidsand protein content and its amino acids in relation to some climate factors such temperature parameters, sunshine hours, solar radiation energy and agro-climate indices such as growing degree-days and photo thermal units.

REVIEW OF LITERATURE

The literature of this study will be reviewed under the following topics:

1. Soybean

The importance of soybean is derived from its oil and protein products which used in food, feed and industrial uses. Hauck *et al.* (1972) summarized 42 utilization for soybean seeds and its products. Soybean is an annual plant, its plant height, branching capacity depends on cultivar and growing conditions. Root system has a taproot and many secondary roots support several orders of small roots remained in the upper 15 cm of soil (Kaspar*et al*., 1978). In nodulated soybean varieties, the bacterial nodules could be visible about 10 days after planting and root system appeared nodulated extensively at physiological maturity (Wilcox, 1987). The period of vegetative growth stage of soybean varies among cultivars and affected by day length and temperature .There are two types of growth habit in soybean; the 1st is indeterminate type;the terminal bud continue in the vegetative growth near the end of growing season. The second type is the determinate; the growth of the terminal bud ceases and becomes an inflorescence (Guard, 1931). The flowering period is affected by seeding date and may extend from three to more than 5 weeks (Borthwick and Barker, 1938). Soybean plant produce much flowers, however 20-80% of the flowers exposed to shed for different varieties. Abscission can occur as bud, flower or pod until 7 days after flowering (Hansen and Shibles, 1978). Soybean is a self-pollinated plant, the natural crossing estimated less than 1.0%, the pollination may occur the day before flower opening (Wilcox, 1978). The pod reaches maximum length of 20 to 25 days after bloom, reaches maximum width and thickness about 30 days after bloom. At this time, seeds reach its maximum size in all dimensions, and it reaches maximum fresh weight 5 to 15 days later (Fraser*et al*., 1982).The whole soybean seed contains 36- 41% protein and 23% oil (Breene*et al*., 1988). Its protein contains the most of amino acids. Human body needs 20 amino acids for healthy growth and ten of them are essential and they found in soy protein. Soybean oil contains ≤ 10% saturated fatty acids (palmitic and stearic), 5-10 % linolenic, 40-55% linoleic and 12-35 % oleic according to the prevailing air temperature during the reproductive stage(Wolf *et al*., 1982).

2. Climate change and field crops

According to the Intergovernmental Panel on Climate Change (IPPC, 2014), if temperature increased by 2 Cº or more above the late 19th century levels, without application any adaptation options, production of the main crops will be negatively affected in temperate and tropical zones, however, some regions may be benefit. The distribution of land suitable for cultivating some field crops may shift due to climate change. In sub-Saharan Africa, the Caribbean, India and northern Australia can predicted to loss the land suitable for crop production. On the other hand, the northern United States, Canada and most of Europe will be gain. It is globally accepted that increased greenhouse gases in the atmosphere are the main causes of climate change. Collette *et al.* (2015) stated that millions of people whose food security depends on farming are face unprecedented climatic conditions. They added, time is not on our side, FAO calculates that global food production will need to increase by approximately 60 percent by middle of this century to ensure food security for an additional 3 billion people (FAO, 2012).Time is a key factor because adapting to climate change by developing suitable crops and identify the practices needed to manage them will take time. In this context, Wollenweber*et al.* (2003), in Germany, reported that plants exposed to warming periods of 35 C^o for a short period around anthesis of wheat had severe yield reduction. However, high temperature during vegetative stage did not have significant effect on growth and development. In India, Parsad*et al.* (2003) found that yield of groundnut significantly reduced when exposed to temperature of 40 C^o after flowering. Gornall*et al.*(2010) reported that pollen viability of maize was reduced when it exposed to temperature above 30C^o, they added that increase temperature above 29 C^o for corn, 30 C^o for soybean and 32 C^o for cotton negatively impacted on yield in the USA.

Climate change has many impacts on crop productivity, but the extent of these impacts is not yet certainly known and quantified at the global scale. An increase in mean temperature is expected but its effect on productivity may depend on magnitude, timing and duration of extreme temperatures (Gornall*et al.*, 2010). They added that mean sea level is also expected to rise which may reduce the agriculture land, as well as fresh water availability may become critical. However, drought may be offset in some areas due the increase in water use efficiency under expected high Co_2 concentration. Climate change may have indirect effects on crop productivity through pest and disease infestation in some areas.