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Genotypic Variability, Phenotypic correlation and Spacing Effect of some Non-Oil Producing Sunflower Genotypes for Growth and Seed Yield.

التباين الوراثي و الارتباط المظهري وآثر المسافات للصفات الخضرية وإنتاجية البذور لبعض الطرز الوراثية لمحصول زهرة الشمس غير المنتجة للزيت

By

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B.Sc. in Agriculture (Agronomy),

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A Thesis Submitted to Sudan University of Science and Technology in Partial Fulfillment of the Requirements for the Degree of M.Sc. in Agriculture (Agronomy).

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January, 2020

DEDICATION

Dedicate this Effort:

To the soul of my father, who taught me wonderful things in my life,

To my lovely mother Mariam gamma,

To my husband Khalid Mohamed,

To my lovely daughters, Jannat and Mariam

To my brothers, sisters

To my teachers, friends, colleagues and to my extended family

ACKNOWLEDGMENTS

First of all, praise to ALLAH for giving my Health and patience to complete this work. Also, I would like to express my deep gratitude and sincere thanks **Prof. Dr. Atif Elsadig Idris** for his guidance, supervision and great effort that had paid during this study.

Thanks are extended to Dr. Salih Adam Ibrahim Sabiel from Agricultural Res.Corporation, Elfasher, Res. Station, Thanks are extended to Dr. Mohamed Younis from Agricultural Research Corporation, Wad Medani, and my thanks were expressed to all staff members of Elfasher Agricultural Research Station, particularly Mr. Abdalla Adam Osman, Dr .Mohammed Ibrahim Ismail, Dr .Hiseen Abdelaziz, Mr. Abdlekhalig Younis, My deepest thanks and appreciation also go to My sincerer friends.

Also thank fly to my family members (brothers , sisters) who were happy and helped me during my research work throughout the difficult time, My thank also go to my lovely mother Maryam Guma Alnourfor her willingness to help and moral support my heart.

Felt thanks also go to my beloved husband Khalid Mohammed Guma for He patience and fruitful advice during my study time and research work. You mean everything in my life!

Above all, I Would like to praise and glorify the God for His help, guidance and protection in all circumstances to successfully complete the courses period and thesis research work. And I’m thankful to the teachers all Doctors in the Department of Agronomy, particularly Dr. Gafar Ali, and all the staff in the department, my classmates patch seven, friends and any person who helped me during this work. Last but not last, I express my sincere thanks to all beloved and respected people who helped me, but are not mentioned.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Fig. No. Title Page No.

ABSTRACT

A field experiment was conducted at the demonstration farm, of the Agricultural Research Corporation, ELFasher North Darfur, in the period from October 2018 to January 2019, to study the genetic variability, correlation between seed yield components and effect of spacing in four genotypes of non-oil seed sunflower on seed size/bigger or seed weight. The experiment was arranged in factorial experiment using a Randomized Complete Block Design (RCBD) with three replications. Twelve growth and seed yield characters were studied included plant height (cm), days to 50% flowering , stem diameter (mm), number of leaves/plant, leaf area (cm^2), head diameter (cm), number of seeds/head, hundred seed weight (g), seed yield/plant(g), seed yield(T/ha) and percentage of empty seed. The phenotypic and genotypic variances, phenotypic and genotypic coefficients of variation and phenotypic correlation for seed yield and yield components were determined. The analysis of variance revealed significant differences between genotypes for all characters under study. For phenotypic variance the results showed that highest value (5228) was scored for number of seed per head and the lowest value (0.01374) was scored for seed yield(ton/ha). On the other hand for genotypic variance, the highest value (5328.4) was scored for number of seed per head and lowest value (0.1324) was scored for seed yield (T/ha). For the phenotypic coefficients of variation, the highest value (603.049) was scored for number of seed/head and lowest value (7.777) was scored for number of leave per plant, moreover, for the genotypic coefficient of variation the highest value (591.638) was scored for number of seed/head and the lowest value (0.7714) was scored for number of leave/plant. The results showed positive and significant phenotypic correlation between seed size (100-seed weight) and seed yield per plant, negative and significant correlation between number of plant/plot, seed weight with steam diameter. Also spacing effect in seed yield and the best

number of plant per plot and seed yield was obtained at the spacing 30cm. It concluded that, a wide range of genetic variability was detected among different genotypes used in this study and will be of great interest in breeding program.

الخلاصة

أجريت الدراسة بالحقل التجريبي لمحطة البحوث الزراعية الفاشر ولاية شمال دارفور، خلال الفترة من أكتوبر 2018 حتى يناير2019 بهدف دراسة التباين والارتباط المظهري و الوراثي واثر المسافات بين أربعة أصناف من زهرة الشمس غير الزيتية (التسالي) لبعض الصفات. تمت دراسة اثنا عشر من صفات النمو و الإنتاجية .نفذت التجربة باستخدام التجربة العاملية بتصميم القطاعات العشوائية الكاملة بثلاث مكررات. تم تجميع البيانات لعدد من الصفات وهي: طول النبات (سم), الإزهار 50% , سمك الساق (سم)، عدد الأوراق في النبات، مساحة سطح الورقة (سم^2)،وقطر القرص (سم) ,عدد البذور في القرص , ووزن 100 حبة (جم), وزن البذرة في القرص (جم)،الوزن الكلي للبذرة , نسبة البذرة الفارغة %.تم تقدير كل من التباينين المظهري و الوراثي ومعامل التباينين المظهري والوراثي والارتباطات المظهرية لصفات الإنتاجية.اظهر تحليل التباين فروقات معنوية عاليه بين الأصناف لكل الصفات تحت الدراسة، كذلك وجد أن أعلى قيمة للتباين الوراثي كانت لعدد البذور في القرص (5228) واقل قيمة كانت لإنتاجية البذور للطن بالهكتار(0.01374) بينما وجد أن أعلى قيمة للتباين المظهري كانت لعدد البذور في القرص (5328.4) واقل قيمة كانت لإنتاجية البذور(طن/هكتار)(0.1324). أما بالنسبة لمعامل الاختلاف الوراثي وجد أن أعلى قيمة لعدد البذور في القرص(603.049) واقل قيمة كانت لعدد الأوراق في النبات(7.777) بينما أعلى قيمة لمعامل الاختلاف المظهري كانت لعدد البذور في القرص(591.638) واقل قيمة كانت لعدد الأوراق في النبات(0.7714). دلت النتائج على أن الارتباط المظهري لوزن البذرة كان موجب وبمعنوية عاليه مع إنتاجية البذور في النبات ، كذلك الارتباط المظهري لقطر الساق سالب مع عدد النباتات في الحوض و وزن 100حبة, أيضا اثر المسافات كان واضح في الإنتاجية وأفضل كان في عدد النباتات في الحوض وإنتاجية البذور تم الحصول عليها من المسافة 30سم. خلصت الدراسة إلى وجود مدى واسع من التباين الوراثي بين السلالات التي استخدمت في هذه الدراسة و التي يمكن استخدامها في برامج التربية.

CHAPTER ONE

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the 67species in the genus Helianthus. It is a dicotyledonous and diploid plant with 2n =2x = 34 chromosomes (Fick, 1989). There are two types of sunflower, oilseed and confectionary types (Salunkhe*et al.,* 1999). Oilseed sunflower is one of the most important oilseed crops in the world and is the preferred source of oil for domestic consumption and cooking worldwide (Hu *et al.,* 2010). Confectionary sunflower produces large seeds with low oil content and used in baking and snack applications (Lu and Hoeft, 2009). Confectionary kernels are roasted and salted or roasted and no salt added and marketed as edible chips.

Sunflower is mainly cultivated for commercial oilseed production by pressing and/or solvent extraction. Though the non-oilseed variety (confectionary sunflower, of larger size and lower oil content) is grown to a lesser extent, it has a wide market because it is used for human consumption and in the food industry for birds and other animals. Confectionary sunflower is generally classified into three categories: the larger seeds are roasted, salted and packaged for human consumption; medium size seeds are dehulled and packaged for use as snacks or in bakery food; and the smaller seeds are used as poultry feed. The seed of sunflower have high oil content (40-50%) and 30% digestible protein and can be used as a source of food for humans or as poultry feed (M.Younis. 2010). Sunflower cake can also be used as an animal feed.

Sunflower is an annual crop that is the source of one of the most important edible oil on a global scale. In season 2015/2016, sunflower area was 23.06 million hectares worldwide with a total production of 39.19 million Metric tons, and average productivity of 1.7 metric tons/ha (USDA, 2016). The major sunflower producing countries are Ukraine, Russia, European Union, Argentina and China (USDA, 2016).

In Sudan, sunflower is a promising oilseed crop in term of adaptable to a wide range of climatic conditions and is well suited for Sudanese conditions (M. Younis, 2010). It could be considered a suitable winter oil crop in irrigated conditions. Sunflower seed, which is a raw material for the oil industry, can increase the capacity of the local crushers, and the extra raw material can be exported to the Arab countries. Extensive commercial production of sunflower was initiated in Sudan in the late 1980's and the early 1990's with the introduction of hybrids such as Hysun-33 from Australia and PAN-7351 from South Africa (El Ahamdi, 2003; Nour*et al.*, 2005).

The production was established mainly in rain fed areas of the country and, to a lesser extent in irrigated conditions. Two open-pollinated sunflower varieties have been leased under the names Damazin-1 and Damazin-2, respectively (Adam and Osman, 1989). In the last two decades of sunflower failed to be expanded significantly in Sudan, which might be attributed mainly to some production constraints.

Have Sudan non-oil there are two primary types of cultivated sunflower: oilseed sunflower and non-oilseed "confectionary" sunflower (Duihua and Hoeft, 2009). Oilseed type is grown for vegetable oil and non-oilseed type which supply the bird food and confectionery market. Non-oil type should ideally be less than 30% oil content (Kaya *et al.*, 2008). It is rich in oil, protein, vitamins and mineral content (Hladni*et al.* 2010). Vegetable oil from sunflower seed is lower in saturated fats than most vegetable oils. Nutritionally, common sunflower oil ranks as one of the highest quality edible vegetable oils known (Skoric*et al.*, 2008). The two most important criteria for introducing new confectionary (high protein) hybrids into production are superior seed and protein yield (Hladni*et al.*, 2009b). Protein yield depends on seed yield and seed protein content. Seed protein content is one of the indicators of sunflower seed quality, according to Hladni*et al*. (2009c) protein content varies depending on the genotype, agro ecological conditions and the interaction of the genotype and external environmental conditions, it is around 16-28% with kernel increase, the amount of protein in the seed also increases so breeding for increased seed protein amount should be followed by the selection of genotypes with larger kernels (Hladni*et al.*, 2009b).

Sunflower produced mainly as an oil crop in Sudan. The large seed of non-oil seed or confectionery sunflower are lower in oil content and higher protein thin the seed the oil seed type.

Moreover, there are no registered hybrids or open-pollinated confectionery sunflower varieties until today in the Sudan. Therefore, the study of big size of seeds and kernel were needed under Sudanese conditions .Also, especial research and studies are needed in Darfur state for malnutrition in case of emergencies or/and to selection of new genotype suitable for large production and export purposes. Therefore the objectives of this study were:

1-produce and provide new promising local confectionery sunflower genotypes having high seed yield potential and adaptability for irrigated and rainfed conditions.

2. To estimates variability for growth and seed yield characters of some non-edible confectionery genotypes.
3. To estimate heritability, genetic coefficient of variation and genetic advance for the different character of non-edible confectionery.
4. To determine the correlation between seed yield components.
5. Effect of Spacing on seed size and yield.

CHAPTER TWO

LITERATURE REVIEW

2.1 General Background:

Sunflower (*Helianthus annuus L.*) is native to North America and grows nearly, in all parts of the United State of America (Miller, 1987). Fifty species have been identified in North America and fifteen identified in South America (Heiser, 1951). The cultivated species (*Helianthus annuus* L.) has a diploid chromosome number. The sunflower ability of its flower to turn towards where the sun is, accounts for both its common name and botanical name, Greek Helios = sun and anthos = flower (Miller, 1987). In the thirties of the 20th century, sunflower ranked the tenth among the world sources of vegetable oil, then the fourth in the fifties of the century. However today it ranks the third after soybean and rapeseed (Khidir, 1997). Abdalla and Abdelnour (2001) reported that, sunflower ranked fourth in the world oil crops after palm oil, rapeseed and soybean. The possible variation in cultivated sunflowers, independent of oil content is not well known, but this topic may become of paramount importance (Dauget, 2016).

According to the Statistical Division Ministry of Agriculture, Khartoum SDMA (2008) the cultivated area increased from 11000 fed in 2000 to 712000 fed in 2008. However production increased from 5000 metric tons in 2000 to 145000 metric tons in 2008 with fluctuated average productivity .Bank of Sudan (2003).

2.2 Adaptation:

Sunflower is adapted to a wide range of environments in the World. Temperature, rainfall, light and photoperiod, water requirements and soil type are the major components of the natural environmental factors which influence crop growth and production. Agronomic models can now take account of environmental conditions and architecture in the field to define the best environments for field trails and predict yields of hybrid combinations according to environmental conditions (Casadelabig*et al.*, 2015).

2.2.1 Light and photoperiod:

Sunflower is classified as insensitive because it flowers under a wide range of day length (short-day, neutral and long-day). Therefore photoperiod is not important in choosing its planting date or production area (Robinson, 1978). Sunflower leaves are phototropic. It was found to be an efficient user of light, so it does not become light saturated at relatively high levels of light (Hesketh and Moss, 1963).

2.2.2 Temperature:

Sunflower can be grown from Equator to 55^0 N. It is generally considered as a worm season crop (Onwueme*et al.*, 1991). High yield occurs between latititudes from 20^0 to 50^0 N and between 20^0S to 40^0 S (Weiss, 1983). Sunflower is tolerant to both and low high temperatures, this contributed to its wide adaptability (Robinson, 1978). Temperature of $8\text{-}10^0$c seems to be minimum for satisfactory establishment, while the optimum is much higher, about 24^0- 27^0c (FadlElmulla, 2003). A reduction in oil percentage of the seeds occurs at high temperature (Canvin, 1965), as temperature increased the seed protein content was increased too, but low temperature during seed development favored the production of high linolic acid and decrease in the oleic acid content. It is well known that oil seeds grown at low temperature are comparatively rich in saturated fatty acids (Canvin, 1965).

2.2.3 Rainfall:

Sunflower is commonly grown as a dry land crop**.** It is not suitable to the wet tropics and very heavy rain during the early stages of growth**.** Cool wet weather during ripening stage is not good for the crop. Weiss (2000) also reported that sunflower will produce moderate yield under rainfall as low as 300 mm, but the field relationship between rainfall and seed yield is often linear from 200 to 500 mm. The peak water demand by the crop is in the immediate post-and thesis period and that sunflower is capable restricting its water use when about 70% of the maximum available water remains in the root zone (Anderson, 1979). Sunflower ability to extract more water from deep soil layers plays an important role in its productivity under low rainfall (Weiss, 2000). Nielsen (1998) reported that, water requirement of the crop as low as 128 mm and moisture stress during productive stage can lead to reduction in seed size, number of seeds per head and seed weight.

2.2.4 Soil type:

Sunflower can grow on a wide range of soils, but it should be deep and well drained. It grows well in soils ranging from sand to clay and ranging PH from 6.5-8 (Weiss, 2000). Sunflower roots play an important role in the plant tolerance to salinity. They act as accumulators of sodium rather than as assimilators. It cannot tolerate very acidic or water logged soils (Onwueme, 1991). In Sudan, Skoric (1982) reported that central clay land is suitable for sowing sunflower as Khidir (1997) reported, which saline have up to 70% clay and PH is ranging from 8.5-9 with free calcium carbonate in the profile. In dry land conditions the depth of the soil profile and its moisture storage capacity will be important factors in determining the distribution and productivity of the crop.

2.3 Growth habit:

Sunflower is an annual erect, broad leaf plant with strong taproot and prolific lateral surface roots. Stems are usually round early in the season, and normally, un-branched. Sunflower leaves are phototropic and will follow the sun's rays with a lag of 12^{o} behind the sun's azimuth. This property has been shown to increase light interception and possibly photosynthesis. The sunflower is not a single flower (as the name implies), but is made up of 1000 to 2000 individual flowers joined at common receptacle. The flowers around the circumference are ligulate ray flowers without stamens or pistils; the remaining flowers are perfect flowers (with stamens and pistils). Anthesis (pollen shedding) begins at prefer and proceeds to the center of the head. Since many sunflower varieties have a degree of self-incompatibility pollen movement between plants by insects is important and bee colonies generally increased yields. In temperate regions, sunflower requires approximately 11 days from planting to emergence, 33 days from emergence to head visible, 27 days from head visible to first anther, 8 days from first to last another and 30 days from last anther to maturity. Cultivars difference in maturity are usually associated with changes in vegetative period before the head visible (Khidir, 1997).

2.4 Sowing dates of sunflower in Sudan:

There is an increasing interest in sunflower over the world, due to its wide adaptability and high percentage of excellent oil. The savannah areas of the Sudan mainly the central clay plains, where rains occur during the period of May-October, with a total of annual rainfall varying from 400 to 900 mm, are suitable for sunflower production. The main production problem is the inadequate soil moisture during flowering which causes poor seed setting (Skoric, 1982). In central Sudan and during the rainy season day temperature is around 34C^o and night temperature 22C^{o}Khidir (1997). Skoric (1982) considered Gedarif and Damazin the potential region I ;Kadugli and Rank as the potential region II; for rain fed production ; however , Blue Nile, White Nile, Suki and Rahad schemes are potentially favorable for sunflower growing with supplementary irrigation. Doorenbos and Pruitt (1977) reported that water requirements of crops vary substantially during the growing period mainly due to variation in crop canopy and climatic conditions. Anderson (1979) suggested three growing stages, heading, flowering and milking in sunflower as sensitive to water stress. Flowering stage is most sensitive stage to water stress causing considerable decrease in both yield and oil contents. According to Schnieter and Miller (1984), sunflower growth stages can be divided in to four physiological phases; vegetative, floral, seed filling and dry down phase. Therefore, several reports in literature indicate that better yields were achieved with irrigation applied at the most critical stage, i.e. flowering than irrigation at other growth stages (Connor, 1985; Unger, 1982).

Sunflower can be planted at a wide range of dates, as most cultivars are earlier in maturity than the length of growing season in most areas of the world with no winter (frost), sunflower has been planted at all months of the year to obtain satisfactory yields Khidir (1997). Khalifa (1981) tested three sowing dates, namely 15 July, 30 July and 15 August. He found that delayed sowing resulted in significantly lower grain yields. Overall earlier sowing was associated with higher grain yields, whereas sowing as late as 15 August, gave extremely low grain yields under rain fed conditions. This was attributed to decreasing moisture availability with delayed sowing. On the other hand, under supplementary irrigation, the effect of sowing date on grain yield was less marked. There was no significant difference between sowing on 15 July and 30 July. Sowing as late as 15 August could give good grain yields depending on environmental conditions (mild temperature during flowering period late in October enhanced by long rainy season). On the evidence available, 15th July is recommended as optimum sowing date for sunflower under rain fed conditions. However under supplementary irrigation sowing up to 30 July is recommended (Ishag, 1988; Khidir, 1997). According to Ishag (1988), in irrigated Rahad scheme high grain yield was obtained from winter sowing particularly with non-hybrids. Sowing dates affected the oil composition in summer by increasing the percentage of oleic acid and decreasing the percentage of linoleic acid and vice versa in winter sowing. In Gezira research station for winter season, six sowing dates at two weeks intervals from first October to 15 December were tested with two cultivars Rodeo (open-pollinated) and Pioneer 634 (hybrid). The result showed that higher seed yield, head yields and other better agronomic characteristics were obtained from the crop during the period, from first October to 15 November (Khidir, 1997).

2.5 Variability in sunflower:

Phenotypic variability in a population is of paramount importance for any successful breeding program. This is because of selection of desirable genotypes for a certain trait will not be effective unless considerable variation is existed in the genetic material under study. Variability analysis has been found useful for getting information about the characters that are expected to response for selection (Arshard*et al* 2013). Many workers have reported evidence for the existence of considerable amount of variability in sunflower for all characters.

2.5.1 Phenotypic and genotypic variability:

Genetic variability is essential for successful crop improvement through breeding programs. The main objectives in sunflower breeding vary with specific programs generally emphases on high seed yield and high oil contents. Any progress in a breeding program depends on the magnitude of genetic variability in the genotypes (Casgebaig, 2015). According to *Fick* (1978) sunflower possesses much genetic variability for seed yield. However, Sheriff and Appandurai (1985) studied the genetic variability in 23 sunflower genotypes. They found a wide range of variation, and the phenotypic variance was greater than genotypic variance for the traits. *Tariq et al* (1992) studied the genetic variability and correlation in fourteen sunflowers hybrids. They found that the genotypic and the phenotypic variance was high for plant height, seed yield and oil content. Gill *et al*. (1997) studied 45 genotypes of sunflower grown under four environments and fertilizer level. Their results showed significant phenotypic variability for head diameter, 100-seed weight, seed yield/ plant and number of seeds / head. Patil*et al.* (1996) stated that, the analysis of variance revealed significant genotypic differences for all the characters studied in sunflower genotypes, the range of variation was high for number of seeds / head followed by weight of the head and seed yield. Mahmmood and Mehdi (2003) indicated that, the genotypic variances were smaller than their corresponding phenotypic ones for all characters.

2.5.2 Phenotypic (PCV %) and genotypic (GCV% coefficient of variation:

The goal of the plant breeders is to develop genotypes, which are adapted over a wide range of environmental conditions. The breeders, therefore, select those genotypes, which to some extent, show some extend of variability .Chikkadevaiah*et al* (1998) reported high genotypic and phenotypic coefficient of variability for seed yield / plant, percentage of husk, head diameter and filled seeds / plant. Saravanan*et al*. (1996) reported moderate genotypic and phenotypic coefficient of variability for head diameter, plant height and 100-seedweight.

2.6 Heritability in broad sense (h^2) and genetic advance (GA):

Heritability in broad sense is a ratio between genotypic variance and phenotypic variance of a trait. High estimate of heritability for a specific trait with high genetic advance would be taken as indication for progress in selection.

Heritability as defined by Johnson *et al.* (1955) is the portion of the phenotypic variability, which is due to genetic causes. Since genetic progress increases with increase in genetic variance, the utility of the heritability estimates increases when it is used in conjunction with genetic coefficient of variation. Estimation of heritability together with the genetic coefficient of variation is usually useful in predicting the resulting effect of selection than heritability value alone. This is mainly because, heritability estimates as a ratio of genotypic to phenotypic variance, varies greatly depending on sample size, environment, character and population. The higher ratio of the genetic components in phenotypic expression of a certain trait, the higher is the heritability and selection for these traits can be performed in earlier generation. Heritability accompanied with an estimation of genetic gain is more useful than heritability alone in accurate prediction of the selection effects (Johnson *et al.,* 1955). Muhammad *et al.* (1992) reported that, the dominant and epistatic nature of inheritance was reflected by high heritability and low genetic advance estimates. Kloczowski (1975) and Shabana (1974) reported broad sense heritability estimates 40% and 80% for plant height. Kshisagar*et al.*(1995) stated that, heritability estimates for plant height and 100-seed weight were high, while that for yield was moderate. Dash et al (1996) reported that, heritability and genetic advance were high for all physiological characters. Patil*et al.* (1996) reported high heritability estimates with low genetic advance for days to 50% flowering, plant height and stem diameter Pellet (1993) indicated that, heritability and genetic advance were high for all studied characters in sunflower, except the physiological characters, which showed very low amount of genetic advance. Gill *et al.* (1997) reported high estimates heritability and genetic advance of head diameter and 100-seed weight, while for seed yield/plant and number of seeds/ head moderate values were shown.

2.7. Confectionary sunflower

According to Arnon (1972) there are two types of sunflower recognized all over the world namely, the oil seed type and non-oil seed type. The seeds are usually large with higher protein contents than the oil type, and the kernels do not fill the husk, constituting about 50% of the weight of the seed. The oil seed type is used for oil extraction. It is usually small seeded type and the kernel accounts for about 60% of the weight of the seed. The non-oil seed type is used for direct human consumption.

Non-oil seed sunflower is known as confectionery sunflower, and is usually white striped and/or comes in large-seeded varieties. They generally have a relatively heavy hull that remains loosely attached to the kernel, permitting more complete de hulling. Seed of the non-oil seed hybrids generally is larger than that of the oilseed types and has a lower oil percentage with high protein and sugar content. The kernels of confectionary type also used in bakery products in European countries. USA leads in production of confectionary sunflower followed by Argentina. The nutritional composition of confectionary sunflower constitutes 900 g kg -1 of dry matter, 235 g kg -1of dry protein, 760 g kg-1 of total digestible nutrients, 250 g kg-1 of oil, 241 g kg-1of crude fiber, 38 g kg-1 of ash, 3 g kg-1 of calcium and 6 g kg-1 of phosphorous. The varieties cultivated for confectionary purpose are known as (*Helianthus annuusmacrocarpus* L). The main aim of confectionary sunflower breeding is to develop lines with low hull content, low oil content, high yielding ability and self- fertile lines. Mutation, spontaneous or induced, is an important source for creating genetic variability. Mutations are the tools being used to study the nature and function of genes, there by producing raw materials for genetic improvement of economic crops. A desired mutation can be recovered in a homozygous stage in the M 4 or M 5 generation as compared with the F 6 or F 7 generation in the case of conventional breeding methods. Chemical mutagens were more efficient than physical ones in inducing viable and total number of mutations.

Sunflower *(Helianthus annuus L.*) is mainly producing for oil production both in Turkey and in the world. However, the use of human food of sunflower especially as confectionery also is common like the use of bird food, ornamental purposes and also using in the cakes and breads, etc.. Confectionery sunflower is growing by farmers in manly Middle and Eastern Anatolia, Southern Marmara and Agean Regions in Turkey.

Turkish people like sunflower seed as confectionery bigger sizes, white color with grey stripes consuming mostly in shell unlike in Balkan countries such as Bulgaria, Romania, Serbia, etc. preferring mostly black colors.

Confectionery sunflower is the most consuming seed among other crops such as Pumpkin, peanut, pistachio, chickpea (leblebi), hazelnut, etc. in Turkey.

Although Turkey has very higher processing capacity and export possibility of modern confectionery industry, it has not enough domestic production especially in confectionery sunflower and import confectionery seeds from other countries.

Confectionery sunflower seed in shell should ideally be at least over 80 g 1000 seed weight and less than 30 % oil content. Additionally, confectionery seeds should have a lower cadmium rate, higher protein and vitamin E (Tocopherol) content to increase in the nutritional value of seed and in shelf life.

Therefore, newly developed cultivars should have higher yield capacity, larger seeds and the desired seed quality characteristics mentioned above.

Additionally, these new hybrids should be in white color with grey stripes to sell easily in Turkish market. Vidhyavathi*et al*. (2005) indicated that simultaneous selection could be for non-oilseed or confectionery types due to that no association with between yield and seed characters, i.e. seed length, 100-seed weight and oil content (in both seeds and kernels).

On the other hand, Kaya *et al.* (2003) mentioned that plant height, head diameter, seed weight and also earliness were the main yield traits determining seed yield in oil type sunflower.

2.7.1 Economic importance confectionery:

Uses as confectionery, horticulture, silage, animal and bird feed are important and very common in the world. Although confectionery sunflower is produced many countries, it cannot be considered separately from oil type. Additionally, confectionery sunflower data both for production and consumption cannot be found in most national or international organization statistics in the world.

Confectionery sunflower production is not enough for Turkey consumption and domestic needs are supplied by importing similar type. Turkey is paying 4-5 million$. Each year for confectionery seeds importing from the US, Israel, Argentina, Hungary, Canada, etc.(Gaytancioglu, 1999). Turkey has one of the most modern and the largest capacity confectionery factories in the world. Factories are processing not only sunflower but also other confectionery crops such as pistachio, peanut, hazelnut, pumpkin etc. These processing companies are selling confectioner products in Turkey and are exporting to other European countries. Confectionery sunflower seed types depend on the consumer preference in some Countries in the world. Although the favored seed color is white with light grey stripes in Turkey, the black colored seeds are preferred by consumers in Balkan countries such as Serbia, Bulgaria, Moldova and Romania. The confectionery seeds preferred by Turkish people are usually bigger and longer and their 1000 seed weights are higher. Turkish people are one of the highest confectionery sunflower consumers in the world. Although some nations consume either in-shell or kernel, Turkish people prefer only in-shell as confectionery.

2.7.2Influence of stand density on yield and quality of non-oilseed:

Non-oil type or confectionary sunflower seed is distinguished of standard oil type by Bigger size of plants and seed, higher protein and lower oil content, better seed hull ability because of thicker hull loosely connected to the kernel, as well as by different shell color and seed shape.

The most important criteria for production of confectionary hybrids are seed yield, Protein content and 1000 seed mass. Larger size of seeds is desirable because they have higher market value.

Unfortunately, production and research of confectionary sunflower in Serbia is very low. Zubriski and Zimmerman (1974) found that seed yield of nonoil sunflower increased with increase in plant density from 28200 to 47800 plants ha-1. Robinson *et al*. (1980) found that the minimum plant density required for maximum yield of nonoil sunflower ranged from 25 000 to 62 000 plants ha-1, depending on location. They attributed the differing effects of plant density on yield among the six locations to soil, temperature and rainfall. Also optimum plant density is influenced by sunflower ability to compensate different plant densities through the number of seeds per head and seed weight. Robinson *et al.* (1980) found that nonoil and oilseed sunflower generally required the same plant densities for maximum yield, while Zubriski and Zimmerman (1974) found that plant density for maximum yield of oilseed sunflower was greater than for nonoil sunflower. In deciding on an optimum plant density for nonoil sunflower, both seed yield and size must be considered. Since seed size decreases as plant density increases, it is desirable to aim for the plant density that will produce enough large seed without severely reducing overall yield(Gubbels and Dedio, 1986).According to Barros *et al*(2004) for oil type sunflower the lowest plant density increased significantly the 1000 seed mass and seed yield was the highest with the medium plant density. Maximum seed yield and oil content at four oil sunflower hybrids were at 60000Plants ha-1 (Crnobarac*et al.*, 2007).

The aim of this study was to research hybrid specificity of confectionery sunflower to plant density and to determine if plant densities could be reduced to increase seed size without reducing seed yield.

2.7.3 Use of Non-Oil Sunflower Varieties

Recent year production of non-oil type sunflower (mainly In North Dakota and Minnesota) has been in the 220 to 315 thousand acre range with annual production of over 300 million pounds. About 40 percent of the non-oil seed goes for wild birdfeed use, another 40 percent enters hulled seed confectionery uses and the remaining 20 percent goes for in-shell confectionery uses (Taylor, 1981).The demand for non-oil sunflower seed has been growing steadily in recent years, particularity in the component for confectionary use. Sunflower seed for wild birdfeed does not require that the seed be of a non-oil variety. There is, however, strong tradition in using the distinctively marked non-oil varieties for this purpose. Clearly, the confectionery and birdfeed markets for sunflower seeds are l premium-price domestic markets which should be developed and encouraged. But, even with modest growth, these markets will continue as only a minor demand sector (10 percent of the total quantity or less) compared to the utilization of sunflower seed for crushing. Thus, if the domestic market for sunflower1s to be expanded significantly, most growth must come via the much more competitive markets for vegetable oils and high protein meal.

2.7.4 Sunflower Meal

Hulls from sunflower seed are high in fiber content and, historically, this has limited the use of sunflower meal for some feeding uses. However, newer processing procedures which at least partially strip or DE hull the seed produce a high quality protein meal of about 44 percent protein compared to a protein content of about 28 percent in meal containing the hulls. The higher protein-lower fiber content meal can be used effectively in the rations for poultry, swine and ruminants. Moreover, the hulls can be utilized as a fuel. Source In some of the newer sunflower processing plants thus giving them some economic value in their own right. Finding domestic markets for increased volumes of sunflower meal does not appear to be a problem provided they are priced competitively with other oilseed meals, particularly soybean and cotton- seed meals.

2.7.5 Oil seed and confectionery sunflower

Vegetable oils and fats are vital component of human diet because they are an important source of energy. Sunflower is one of the major oilseed crops in Turkey. According to production data, sunflower was grown 657458 ha area with 1637900 metric ton seed production, and average seed yield of 2690 kg ha-1in Turkey in 2014 (Anonymous, 2015). Because of gap for vegetable oil production in Turkey, sunflower is one of the alternative and leading oilseed crops to increase vegetable oil production. Growing sunflower as a first and second crop in Aegean Region is one of the possibility to increase the production. The Aegean Region has suitable ecological conditions for first and second crop sunflower production (Tan, 2007; Tan, 2010; Tan, 2011; Tan, 2014). Sunflower research activities has been conducted since 1979 and breeding program initiated in 1984 at Aegean Agricultural Research Institute (AARI) in Menemen, Izmir, Turkey. The mission of the Sunflower Research Project is to develop improved germplasm by conventional and biotechnical breeding techniques for both first and second crop production areas in Turkey. New germplasm, breeding lines, hybrid varieties have been developed. To improve oilseed and confectionary sunflower varieties with desired characters, genetic investigations, and germplasm development of sunflower with improved yield, oil quality, resistance to diseases such as *Plasmoparahelianthi*(Farl.) Berl de Toni., *Puccinia helianthi Schw.*, and *OrobanchecumanaWalr*. Adverse conditions are also under consideration. This studies are also incorporated with agronomic and other related researches.

2.7.6 Some morphological characteristics genotypes:

Today, sunflower is largely used to meet the demands for cooking oil. In some countries, beside oil seed cultivars, confectionary cultivars are also produced (Lofgren, 1978). The confectionary seeds are rich in nutrients and they are commonly used in confectionary production through mixing them with salt, butter and honey, used as seasoning over vegetable, fish and salads, they are also consumed as snack food in roasted or non-roasted type (Millete, 1974).Confectionary use of sunflower is quite common both in Turkey and various other parts of the world and it is most commonly consumed as snack food in several countries. Sunflower has been used for confectionary purposes for a long time and it is used in more than a hundred foodstuffs worldwide including bakery, ice-cream, chocolate, cookies and etc. (Lofgren, 1997). As it was in Turkey, confectionary sunflower production is a great income source for world farmers, but it is usually considered in world literature with oilseed sunflowers. It is nationally qualified separately as oilseed and confectionary in practice, confectionary statistics are not usually presented by international agricultural organizations (OECD, FAO, ISA and etc.). The USA, Hungry, Argentina, Spain, Israel, China, Turkey, Moldova and some Eastern European countries are the leading confectionary sunflower producers. Today, the USA has the greatest confectionary sunflower production. On the other hand, Germany, Denmark, the Netherlands, Canada, Mexico, The United Kingdom and Belgium are the leading shelled confectionary sunflower buyers and Spain, China, Turkey, Jordan, Canada, Mexico, Israel, Germany and Japan are the primary unshelled confectionary sunflower buyer countries. The seeds used in productions are mostly open-pollinating village-type populations (Tan, 2011), however, certified cultivars have recently been used. Confectionary sunflower is commonly cultivated in Central and Eastern Anatolia provinces and village populations called based on physical appearance like Alaca, Kıbrıs, Inegol and etc are used. Unit area yield levels are quite lower under dry conditions than the yield levels obtained from hybrid oilseed cultivars (Kaya, 2004). Previous researches revealed that confectionary types have low oil content, but high protein content. Low shell ratio and wide seeds are desired parameters in confectionary sunflowers (Kaya *et al*., 2008; Hladni*et al*., 2011). The primary objective of the present study was to purify confectionary sunflower cultivars with high adaptation capacities and consumer desired quality parameters. In this way, new cultivars may be developed and registered to meet the country needs and further breeding will also be possible to develop advanced cultivars. Along with these objectives, head height, head shape and self-pollination ratios were determined (1020-1021).

2.8. Phenotypic correlation:

Seed yield is a complex polygenic trait that is highly affected by environmental factors (Nadarajanand Gunasekaran, 2005). Understanding interrelationships between yield and factors affecting yield is a pre-requisite for designing an effective breeding programme (Velkov, 1980). Plant breeders commonly prefer yield components that indirectly affect seed yield (Marinkovic, 1992; KayaandAtakisi, 2003; Yasin and Singh, 2010). The use of simple correlation analysis (Putt, 1943; Ross, 1939) could not fully explain the relationships among yield and yield related traits. Path-coefficient ana-lysis (Varshney*et al.,* 1977; Ivanov*et al*., 1980; Lakshmanrao*et al*., 1985; Tyagi, 1985; Marinkovic, 1992; Sujatha and Nandini, 2002; Yasin and Singh, 2010), partition correlation coefficients of one variable to direct and indirect effects, giving a clearer picture of the indivi-dual contribution of each variable to seed yield. This study was conducted to investigate the inter-relationships of some characters with seed yield of confectionery sunflower and to determine the direct and indirect effects of studied characters on seed yield. Study on the relationships between yield and yield related traits will improve the efficiency of breeding programs by determining appropriate selection criteria.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Experiment Site:

The experiment was conducted under irrigated conditions in sandy soil a semiarid zone, at El.Fasher Research Station Farm located in (13° 37′ N 25°20′ E, 748 m above sea level) North Darfur State, Sudan, for winter season from end of October 2018 to January 2019.

3.2. Treatment:

3.2.1. Genotypes:

The materials used in the study consisted of four non-oil seed (confectionary) sunflower genotypes, obtained from the Agricultural Research Corporation, Sunflower Breeding Program, Sudan. These genotypes were; Full White (G1), Black white grey stripes (G2), White with black stripes (G3) and Grey with black stripes (G4). The genotypes G1 and G2 were selected from Turkey materials, while G3 and G4 from China materials.

3.2.2. Design and layout of the experiment:

The experiment was laid out in factorial experiment using a Randomized Complete Block Design (RCBD) with three replications and 36 plots. Each plot consisted of four rows of 3 m length, with 70 cm inter-row spacing and plant spacing 30, 40 and 50 cm intra-row spacing. The plant population per hectare for the three spacing will be as (41600, 31200 and 24456).

3.3. Land preparation:

By use traditional methods.

3.4. Sowing of seed:

Seeds of non-oil seed sunflower cultivars sown on ridges, at rate of two seeds per hole at 30cm, 40cm, 50cm spacing and covered with fine soil, planting date was 24 October 2018. The field was irrigated lightly immediately after sowing.

3.5. Cultural practices:

Optimum crop management operations were carried out as needed throughout the cropping season to maintain proper growth and development of plants.

3.5.1. Thinning and gap filling:

The seedling were thinned out from the holes at 10 days after planting keeping only one health seedling per hole, At the same time replanting of missing holes was done.

3.5.2. Irrigation:

Irrigation was applied once immediately after sowing of seeds, and then continued at 8 to 10 days interval after seedling emergence.

3.5.3. Weeding:

Manual weeding was practiced two times after three weeks from sowing and after one month from the first weeding.

3.6. Data collection:

For data collection and measurements, five plants in the middle of the inner two rows of any plot were selected and from the following growth and yield characters (except to 50%flowers) were recorded.

3.6.1. Growth characters:

This can be summarized in the following:

3.6.1.1. Days to 50% flowering:

The numbers of days from planting to the date when 50% of the heads in a plot have initiated were counted.

3.6.1.2. Plant height (cm):

It was measured from ground sunflower to the tip of the plant.

3.6.1.3. Stem diameter (cm):

It was measured at 15cm above the ground level and the arouse stem diameter, using a vernier.

3.6.1.4. Leaf area (cm^2):

Leaf area (LA) =Maximum Length ×Maximum Width × 0.75

3.6.1.5. Number of leaves per plant:

The total number of leaves on the main stem was counted on individual plant basis after maturity.

3.6.1.6. Plant population:

The number of plants was taken at harvest time and counted manually on individual plant basis.

3.6.2. Seed yield components of non-oil sunflower head were recorded as following:

3.6.2.1. Head diameter (cm): The average diameter of heads was measured using scale tape

3.6.2.2. Number of seed per head: Number of seeds per head is determined by calculating the seeds in each head in each head in the sample.

3.6.2.3. 100-seed weight (g): Average weight of triplicate random sample of 100-seeds was taken, from the bulked dried seeds of each plot.

3.6.2.4. Seed yield per plant (g) = weight of seed per head (Calculated by dividing the seed yield per plot by the corresponding number of heads per that plot).

3.6.2.5. Seed yield (T/Ha): The heads from each plot were air dried, separately threshed, cleaned, bulked and weighed. The seed yield was then calculated according to the following formula:

$$\text{Seed yield (t/ha)} = \frac{\text{Seed weight plot (kg)} \times 10000}{\text{Plot area} \times 1000}$$

3.6.2.6. Percentage of Empty seeds: it was determined by dividing the number of empty seeds per head by the total number of seeds per head multiplied by 100.

$$\%\ \text{Empty seed} = \frac{\text{Number of empty seeds}}{\text{Total number of seeds per head}} \times 100$$

3.7. Statistical analysis:

3.7.1 Analysis of variance:

Analysis of variance (ANOVA) was carried out for each character using the computer system statistic-8, for factorial experiment using a Randomized Complete Block Design to detect significant effects among the genotypes.

3.7.2. Coefficient of Variation (C V)

Coefficient of variation (CV) for each character was determined according to the following formula.

$$C.V = \frac{\sqrt{(\text{MSE})}}{(G)} \times 100$$

Where:

MSE = mean square of Error, G= Grand mean

3.7.3. Phenotypic (σ^2ph) and genotypic (σ^2g) variances.

For the separate analysis of variance, they were estimated as follows:

$$\sigma^2 g = (M_2 - M_1)/r$$

$$\sigma^2 ph = \sigma^2 g + \sigma^2 e$$

Where:

r= number of replications

σ^2e= error or environments

M_1, M2= error and genotype mean squares

3.7.4. Heritability estimate (h^2):

Broad sense heritability was estimated in each season separately, using the formula suggested by Johnson *et al*, (1955) as the follows:

From the separated ANOVA:

$$h^2 = \sigma^2 g / \sigma^2 ph$$

σ^2g = genotype variance , σ^2ph = phenotypic variance

3.7.5. Phenotypic and genotypic coefficient of variation:

They were recorded according to formula suggested by Burton and Devane (1953).

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sqrt{\sigma^2 Ph}}{\text{Grand mean}} \times 100$$

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{\sigma^2 g}}{\text{Grand mean}} \text{x } 100\%$$

3.7.6. Expected genetic advance (GA)

It was estimated by the formula of Robinson *et al*., (1949) as follows:

$$GA = \frac{\sigma^2 g}{\sigma ph} x\ k$$

Where:

k =selection differential and it was 2.06 as defined by Lush (1949) at selection intensity of 5 %.

σph = square root of phenotypic variance.

3.7.6. Phenotypic Correlation:

It was used to estimate phenotypic covariance .They was used further for computation of phenotypic correlation between different characters, using the formula suggested by Miller *et al*. (1958).

Phenotypic Correlation coefficient (r ph) = $\sigma^2 phxy \backslash \sqrt{(\sigma^2 ph\ x)(\sigma^2 phy)}$

Where:

$\sigma^2 ph\ x\ y$ = phenotypic covariance between two traits (x ,y)

$\sigma^2 phx$ = phenotypic variance for trait x, $\sigma^2 phy$ = phenotypic variance for trait y.

Table .1. The analysis of variance different characters of four genotypes of non-oil seed sunflower

Source of variation	**Degree of freedom**	**Mean square**	**Expected mean square**
Replication	(r-1)=2		
Treatment	(t-1)=1		
Error(a)	(r-1) (t-1)=2		
Genotypes	(g-1)=3	M3	$\sigma^2 e + r\sigma^2 g\ t + r\ t\sigma^2 g$
Gen x Treat	(g-1)(t-1)=3	M2	$\sigma^2 e + r\sigma^2 g\ t$
Error(b)	T(r-1)(g-1)=12	M1	$\sigma^2 e$
Total	(rtg-1)=35		

CHAPTER FOUR

RESULTS

1-Phenotypic variability

2- Interaction effects of spacing and genotypes

3- Genetic variability

a- Genotype, phenotypic variation

b- Genetic phenotypic coefficient of variance (GCV%, PCV %)

c- Heritability genetic advance

4- Main values

5- Simple (phenotypic) correlation coefficients

4.1 Growth characters

4.1.1 Plant height PH (cm)

The individual analysis of variance showed non-significant differences ($p \leq 0.05$) between genotypes, spacing and their interaction (Table, 4.1). The means of the genotypes, spacing and their interaction were shown in Tables (4.5, 4.6 and 4.7A), respectively. The grand mean was (175.26 cm) and coefficient variation (CV) was 8.8 (Table, 4.5).

4.1.2 Stem diameter SD (cm)

The analysis of variance for this character revealed that there were significant differences between genotypes, spacing and their interaction (Table4.1). The means of the genotype highest value (28.14cm) was obtained by genotypes-2, spacing and interaction shown in Tables (4.5, 4.6, and 4.7A), respectively. The grand mean for this character was (27.00cm), the coefficient of variation (CV) was 9.1 (Table, 4.5).

4.1.3 Number of leaves per plant

Number of leaves per plant showed non-significant differences (P≤0.001) between genotypes, spacing and their interaction (Table, 4.1). The means of the genotypes, spacing and their interaction were shown in Tables (4.5, 4.6 and 4.7A), respectively. The grand mean was (32.86) and coefficient variation (CV) was 8.7 (Table, 4.5).

Table4.1: Mean squares for different characters of four non-oil seed sunflower genotypes evaluated during this study

Character	**Genotype df=3**	**Plant spacing df=2**	**G x PS df=6**
Plant height	140.3ns	185.6 ns	407.0 ns
Stem diameter	14.582 *	7.729 ns	9.472 ns
Number of leaves	6.437 ns	2.681 ns	5.672 ns
Leaf area	5963 ns	3028 ns	3151 ns
50%flower	179.48 **	23.03 ns	9.18 ns
Plant population	249.30**	293.78 **	30.96 ns
Head diameter	2.793 ns	13.690 ns	5.638 ns
Number of seeds/head	51452 *	5090 ns	35768 *
100-seed weight	35.318 **	1.383 ns	1.346 ns
Seed yield/plant	931.1 ns	388.3 ns	560.3 ns
Seed yield(T/Ha)	0.11371 **	0.7319 **	0.07249 *
Empty seed %	114.777 **	56.96 ns	10.99 ns

**= highly significant at P≤ 0.01 level, *=significant, ns= non-significant

4.1.4 Leaf area (cm^2)

The analysis of variance for this character revealed that there were non-significant differences between genotypes, spacing and their interaction (Table, 4.1). The means of the genotypes, spacing and their interaction were shown in Tables (4.5, 4.6 and 4.7A), respectively. The grand mean was (281.000) and coefficient variation (CV) was 21.6 (Table, 4.5).

4.1.5. Days to 50% flowering

The analysis of variance showed high significant differences ($P< 0.05$) between genotypes, spacing and their interaction (Table4.1). The means of the genotype highest value (75.33) was obtained by genotypes-2, spacing and interaction shown in Tables (4.5, 4.6, and 4.7), respectively. The grand mean for this character was (68.89), the coefficient of variation (CV) was7.3 (Table, 4.5).

4.1.6. Plant population

The analysis of variance indicated for this character revealed that there were high significant differences between genotypes, spacing and their interaction (Table4.1). The means of the genotype highest value (36.56) was obtained by genotypes-2, spacing highest value (38.50) was obtained by spacing -1, and interaction shown in Tables (4.5, 4.6, and 4.7A), respectively. The grand mean for this character was (33.06), the coefficient of variation (CV) was 14 (Table, 4.5).

4.2 Seed yield characters

4.2.1. Head diameter (cm)

Head diameter as a character revealed non- significant difference between genotypes, spacing and their interaction (Table, 4.1). The means of the

Genotypes, spacing and their interaction were shown in Tables (4.5, 4.6 and 4.7A), respectively. The grand mean was (30.23) and coefficient variation (CV) was 7.6 (Table, 4.5).

4.2.2. Number of seed per head

Number of seeds per head showed significant differences ($P \leq 0.001$) among genotypes , spacing and their interaction (Table4.1). The means of the genotype highest value (954.89) was obtained by genotypes-4, interaction highest value (1085.3) was obtained by genotypes-4, spacing -2, and spacing shown in (Tables 4.5, 4.6, and 4.7A), respectively. The grand mean for this character was (883.58), the coefficient of variation (CV) was 13.9 (Table, 4.5).

4.2.3. Hundred Seed weight (g)

The analysis of variance for this character revealed that there were high significant differences between genotypes, spacing and their interaction (Table4.1). The means of the genotype highest value (16.81) was obtained by genotypes-1, spacing and interaction shown in (Tables 4.5, 4.6, and 4.7B) respectively. The grand mean for this character was (14.22), the coefficient of variation (CV) was 11.9 (Table, 4.5).

4.2.4. Seed yield per plant (g)

The individual analysis of variance showed non-significant differences ($p<0.001$) between genotypes, spacing and their interaction (Table, 4.1). The means of the genotypes, spacing and their interaction were shown in (Tables 4.5, 4.6 and 4.7B) respectively. The grand mean was (124.15) and coefficient variation (CV) was 14.4 (Table, 4.5).

4.2.5. Seed yield (t\ha)

The analysis of variance for this character revealed that there were high significant differences between genotypes, spacing and their interaction (Table, 4.1). The mean of genotype scored the highest value (1.07) obtained by genotype-1, spacing scored the highest value (1.20) obtained by spacing -1, interaction scored the highest value (1.5533) obtained by genotype-1 , spacing-1(Tabel,4.5, 4.6 and 4.7B) ,The grand mean was (0.9439), and coefficient of variation (CV) was 15.3 (Table, 4.5).

4.2.6. Percentage of empty seed

This character showed high significant differences ($P<0.05$) among the studied non-oil seed sunflower between genotypes, spacing and their interaction (Table4.1). The means of the genotype highest value (17.04) was obtained by genotypes-1, spacing and interaction shown in (Tables 4.5, 4.6, and 4.7B), respectively. The grand mean for this character was (13.72), the coefficient of variation (CV) was 34.5 (Table, 4.5).

4.3 Genotypic (∂^2g), Phenotypic (∂^2ph) variances and Heritability (h^2)

The results of this study revealed the highest genotypic variance (5228) was regarded by number of seed per head and the lowest estimate of genotypic variance (0.01374) was given by seed yield. On the other hand, the highest estimate of phenotypic variance (5328.4) was regarded by number of seed per head and the lowest one (0.1324) was obtained by seed yield (T/ha). The highest estimate of heritability (0.98) was obtained by number of seed per head and lowest value was (0.010) obtained by number of leaves per plant (Table, 4.2).

Table4.2: Genotypic (σ^2g), Phenotypic (σ^2ph) variances and Heritability (h^2)

Character	**(σ^2g)**	**(σ^2ph)**	**(h^2 b)**
Plant height	4.63	17.15	0.27
Stem diameter	1.70	3.725	0.46
Number of leaves	0.255	2.571	0.010
Leaf area	937.33	986.8	0.95
50%flower	56.76	60.88	0.93
Plant population	87.60	91.38	0.96
Head diameter	0.9136	2.812	0.33
Number of seeds/head	5228	5328.4	0.98
100-seed weight	11.324	12.716	0.89
Seed yield/plant	123.6	138.26	0.89
Seed yield(T/Ha)	0.01374	0.1324	0.10
Empty seed %	34.595	38.47	0.90

(σ^2g) = Genotypic, **(σ^2ph) =** Phenotypic,(**h^2 b) =**Heritability

4.4 Genotypic (GCV), Phenotypic (PCV) coefficients of variation and Expected genetic advance (GA)

Estimates of genotypic coefficient of variation (GCV) of number of seed per head regarded highest value was (591.638), number of leaves showed lowest value was (0.7714). The (PCV) estimate highest value by Number of seed per head it was (603.049), lowest value obtained by Number of leaves per plant it was (7.777). (Table 4.3).The (GA) estimate highest value by Number of seed per head it was (2.0211), lowest value obtained by number of leaves it was (-0.2043). (Table 4.3)

Table4.3: Phenotypic (PCV) and genotypic (GCV) coefficient of variation and Expected genetic advance (GA)

Character	GCV %	PCV %	GA
Plant height	2.65	9.782	0.5566
Stem diameter	6.307	13.79	0.9418
Number of leaves	0.7714	7.777	0.2043
Leaf area	333.55	351.170	1.956
Days to 50% flowering	82.400	88.373	1.9208
Plant population	264.99	276.41	1.975
Head diameter	3.022	9.3020	0.6692
Number of seeds/head	591.638	603.049	2.0211
100-seed weight	79.645	89.434	1.8345
Seed yield/plant	99.556	111.369	1.85
Seed yield(T/Ha)	1.4556	14.020	0.2138
Empty seed %	252.187	280.420	1.8525

GCV=Genotypic coefficient of variation.

PCV=Phenotypic coefficient of variation.

GA=Genetic advance.

4.5 Phenotypic correlation

The results of phenotypic correlation among different character in this study were presented in (Table 4.4). Stem diameter was positive and non-significant correlation with number of leaf per plant, leaf area, and 50%flower and seed yield ten per hector and empty seed. Whereas it was positive highly significant correlation with plant high and head diameter and number of seed per head and seed yield per plant. On other hand, negative and non-significant correlation with plant population and 100-seed weight. Plant high was positive highly significant correlation with number of seed per head, head diameter and seed yield/plant. On other hand positive non-significant correlation with leaf area, seed yield /plant and empty seed. Whereas it was negative non-significant correlation with number of leave per plant, plant population, 50%flower, and 100-seed Wight. Number of leave/plant was positive highly significant correlation with plant population, But it was negative significant correlation with 100-seed weight. Leaf area was positive significant correlation with multi head and seed yield/plant, plant population, positive non- significant with 50%flower,number of seed/head and seed yield ton/hector, moreover negative highly significant correlation with 100-seed weight, head diameter and seed yield/plant, empty seed . Days to 50% flowering was positive and non-significant with empty seed, moreover negative non- significant correlation with number of seed/head and 100-seed weight, seed yield ton/hector. Head diameter was positive highly significant correlation with seed yield per plant. Significant correlation with number of seed/head and 100-seed weight. Number of seed per head was positive highly significant correlation with seed yield /plant, moreover negative highly significant correlation with 100-seed Wight, empty seed. 100-seed Wight was positive highly significant correlation with seed yield/plant. Seed yield per plant was positive highly significant correlation with seed yield ton/hector, moreover negative non- significant correlation with empty seed.

Table 4.4: the phenotypic correlations among four non-oil seed sunflower characters

	SD	PH	NLP	LA	PP	DF	HD	NSH	SW	Sypp	SYTph
PH	0.519**										
NLP	0.174	-0.008									
LA	0.217	0.272	-0.0733								
PP	-0.014	-0.268	0.3370*	-0.0028							
FLW	0.0253	-0.212	0.0615	-0.2227	0.1415						
HD	0.425**	0.336*	-0.0197	0.2368	-0.3682*	-0.4041*					
NSH	0.560**	0.426**	0.2720	0.1897	0.1522	-0.1832	0.3952*				
SW	-0.205	-0.016	-0.3764*	0.2085	-0.5295**	-0.2562	0.3820*	-0.4397**			
Sypp	0.351*	0.388*	-0.0498	0.3929*	-0.3112*	-0.4202*	0.7484**	0.5481**	0.5026**		
SYTph	0.094	0.264	-0.0000	0.2157	0.1261	-0.2413	0.2370	0.1718	0.3288*	0.4692**	
EMtS	0.079	0.061	-0.0969	-0.0396	-0.3228*	0.0541	0.0534	-0.3411*	0.1859	-0.1771	-0.2466

PH=plant height (cm), SD=stem diameter (cm), LA= leaf area (cm^2) , NLP= number of leaves per plant, PP = plant population, DF = days of 50% flowering, HD = head diameter (cm), NS/H = number of seed per head, SW = seed weight (g), SY/P = seed yield per plant (g), SYT/h = seed yield tan per hector (T/ha), % Emt.s = percentage of Empty seed.

Table4.5: Mean of different character of four Genotype evaluated during this study

Character	G1	G2	G3	G4	mean	CV%
PH	178.56^{A}	172.71^{A}	171.08^{A}	178.70^{A}	175.26	8.8
SD	25.95^{A}	28.14^{A}	25.86^{A}	28.07^{A}	27.00	9.1
NLP	31.78^{A}	33.80^{A}	33.13^{A}	32.73^{A}	32.86	8.7
LA	298.30^{A}	265.64^{A}	253.10^{A}	306.97^{A}	281.00	21.6
DF	68^{B}	75^{A}	66^{B}	67^{B}	69	7.31
PP	25.22^{B}	36.56^{A}	35.00^{A}	35.44^{A}	33.06	14
HD	30.78^{A}	29.69^{A}	29.82^{A}	30.64^{A}	30.23	7.6
NSH	777.22^{B}	909.44^{A}	892.78^{AB}	954.89^{A}	883.58	13.9
SW	16.81^{A}	12.06^{C}	14.37^{B}	13.63^{BC}	14.22	11.9
SYP	130.70^{A}	109.08^{B}	127.03^{A}	129.80^{A}	124.15	14.4
SY	1.07^{A}	0.80^{B}	0.93^{AB}	0.97^{A}	0.94	15.3
ES	17.04^{A}	16.22^{AB}	12.22^{BC}	9.39^{C}	13.72	34.5

Means followed by the same letter for each parameter were not significantly different at (0.05%) level according to LSD-All. Pair -wise Comparison test.

PH=plant height (cm), SD=stem diameter (mm), LA= leaf area (cm^2), NLP= number of leaves per plant, PP = plant population, DF = days of 50% flowering, HD = head diameter (cm), NSH = number of seed per head, SW =100- seed weight (g), SYP = seed yield per plant (g), SY = seed yield tan per hector (T/ha), ES = percentage of Empty seed (%).

A= non-significant, A, B, C= significant, G1, G2, G3, G4= genotype

Table 4.6: Mean of different character of There spacing evaluated during this study

Spacing	**PH**	**SD**	**NLP**	**LA**	**DF**	**PP**
30 cm (S1)	173.39^{A}	26.51^{A}	33.40^{A}	272.65^{A}	70.17^{A}	38.50^{A}
40 cm (S2)	172.61^{A}	26.58^{A}	32.52^{A}	299.32^{A}	67.42^{A}	31.83^{B}
50 cm (S3)	179.78^{A}	27.93^{A}	32.67^{A}	271.03^{A}	69.08^{A}	28.83^{B}
Mean	175.26	27.00	32.86	281.00	68.89	33.06
CV%	8.8	9.1	8.7	21.6	7.31	14
Spacing	**HD**	**NSH**	**SW**	**SYP**	**SY**	**ES**
30 cm (S1)	29.02^{B}	865.67^{A}	13.87^{A}	118.92^{A}	1.20^{A}	12.20^{A}
40 cm (S2)	31.02^{A}	906.08^{A}	14.55^{A}	130.21^{A}	0.93^{B}	12.74^{A}
50 cm (S3)	30.67^{AB}	879.00^{A}	14.23^{A}	123.33^{A}	0.70^{C}	16.21^{A}
Mean	30.23	883.58	14.22	124.15	0.94	13.72
CV%	7.6	13.9	11.9	14.4	15.3	34.5

Means followed by the same letter for each parameter were not significantly different at (0.05%) level according to LSD-All. Pair -wise Comparison test.

PH=plant height (cm), SD=stem diameter (mm), LA= leaf area (cm^2) , NLP= number of leaves per plant, PP = plant population, DF = days of 50% flowering, HD = head diameter (cm), NSH = number of seed per head, SW = 100-seed weight (g), SYP = seed yield per plant (g), SY = seed yield tan per hector (T/ha), ES = percentage of Empty seed (%). A= non-significant, A, B, C= significant, 30, 40, and 50 = spacing

Table 4.7.A: Mean of different effect and varieties and spacing character of four Genotype evaluated during this study

Genotype	Spacing	PH	SD	LA	NLP
G1	**30**cm	183.11^{A}	27.827^{ABC}	321.99^{AB}	31.000^{A}
	40cm	178.67^{AB}	25.760^{BC}	293.42^{AB}	31.400^{A}
	50cm	173.89^{AB}	24.253^{C}	279.48^{AB}	32.933^{A}
G2	**30**cm	154.11^{B}	27.020^{ABC}	267.71^{AB}	33.667^{A}
	40cm	180.45^{A}	27.993^{ABC}	297.37^{AB}	33.867^{A}
	50cm	183.56^{A}	29.413^{AB}	231.85^{B}	33.867^{A}
G3	**30**cm	169.89^{AB}	25.070^{C}	231.04^{B}	35.600^{A}
	40cm	160.56^{AB}	24.523^{C}	249.37^{B}	31.600^{A}
	50cm	182.78^{A}	27.987^{ABC}	278.89^{AB}	32.200^{A}
G4	**30**cm	186.44^{A}	26.113^{ABC}	269.86^{AB}	33.333^{A}
	40cm	170.78^{AB}	28.030^{ABC}	357.13^{A}	33.200^{A}
	50cm	178.89^{AB}	30.070^{A}	293.92^{AB}	31.667^{A}
Mean		175.26	27.00	281.00	32.861
CV%		8.8	9.1	21.6	8.7
Genotype	**Spacing**	**PP**	**DF**	**HD**	**NSH**
G1	**30**cm	29.000^{CDF}	70^{ABCD}	30.800^{AB}	811.7^{BC}
	40cm	21.000^{F}	68.333^{BCD}	31.267^{AB}	815.7^{BC}
	50cm	25.667^{EF}	67.000^{BCD}	30.733^{AB}	704.3^{C}
G2	**30**cm	44.333^{A}	75.000^{AB}	27.867^{B}	844.3^{BC}
	40cm	34.333^{BCD}	73.000^{ABC}	31.267^{AB}	912.7^{AB}
	50cm	31.000^{CDE}	78^{ABCD}	29.933^{AB}	971.3^{AB}
G3	**30**cm	40.667^{AB}	67.333^{BCD}	28.867^{AB}	849.7^{BC}
	40cm	36.667^{ABC}	65.333^{CD}	28.867^{AB}	810.7^{BC}
	50cm	27.667^{DEF}	65.667^{CD}	31.733^{AB}	1018.0^{AB}
G4	**30**cm	40.000^{AB}	68.333^{BCD}	28.533^{B}	957.0^{AB}
	40cm	35.333^{ABC}	63.000^{D}	32.667^{A}	1085.3^{A}
	50cm	31.000^{CDE}	65.667 ^{CD}	30.733^{AB}	822.3
Mean		33.056	68.889	30.233	883.58
CV%		14.00	7.31	7.6	13.9

Means followed by the same letter for each parameter were not significantly different at (0.01%) level according to LSD-All. pairwise Comparison test.

PH=plant height (cm), SD=stem diameter (mm), LA= leaf area (cm^2), NLP= number of leaves per plant, PP = plant population, DF = days of 50% flowering, HD = head diameter (cm), NSH = number of seed per head, G1, G2, G3, G4= genotype& 30, 40, 50, = Spacing.

A= non-significant, B, C, D, F, = significant,

Table 4.7.B: Mean of different effect and varieties and spacing character of four Genotype evaluated during this study

Genotype	Spacing	SW	SYP	SY	ES
G1	**30**cm	16.797^{AB}	135.92^{A}	1.5533^{A}	13.690^{BCD}
	40cm	17.613^{A}	142.35^{A}	1.0167^{BCD}	15.393^{ABCD}
	50cm	16.030^{ABC}	113.84^{AB}	0.6500^{E}	22.047^{A}
G2	**30**cm	11.753^{F}	98.10^{B}	0.9333^{CD}	17.227^{AB}
	40cm	12.463^{DEF}	113.96^{AB}	0.8133^{DE}	14.677^{ABCD}
	50cm	11.957^{EF}	115.17^{AB}	0.6567^{E}	16.740^{ABC}
G3	**30**cm	13.887^{CDEF}	116.28^{AB}	1.1100^{BC}	10.160^{BCD}
	40cm	14.917^{ABCD}	120.75^{AB}	0.8633^{DE}	11.877^{BCD}
	50cm	14.310^{BCDEF}	144.05^{A}	0.8233^{DE}	14.630^{ABCD}
G4	**30**cm	13.043^{DEF}	125.38^{AB}	1.1933^{B}	7.727^{D}
	40cm	13.200^{CDEF}	143.78^{A}	1.0267^{BCD}	9.003^{CD}
	50cm	14.643^{BCDE}	120.25^{AB}	0.6867^{E}	11.440^{BCD}
Mean		14.218	124.15	0.9439	13.718
CV%		11.9	14.4	15.3	34.5

Means followed by the same letter for each parameter were not significantly different at (0.05%) level according to LSD-All. Pair-wise Comparison test.

SW = 100-seed weight (g), SYP = seed yield per plant (g), SY = seed yield tan per hector (T/ha), ES = percentage of Empty seed (%), G1, G2, G3, G4= genotype & 30, 40, 50, = Spacing.

A= non-significant, A, B, C= significant.

CHAPTER FIVE

DISCUSSION

5.1 Variation among treatments

The variability observed for growth, seed yield components could be attributed to the effect of genotypes, spacing and their interaction, but most of this variability was observed between genotypes for the characters like stem diameter, days to 50% flowering, number of plants/plot, number of seeds/head, 100-seed weight, seed yield (T/ha) and empty seed %.These results explain that the effect of genetic background is more than the effect of spacing which considered as an environmental factor. This variability between the confectionary sunflower genotypes could be of a grad value in any sunflower breeding program aiming for obtaining confectionary sunflower cultivars or hybrids characterized with high yield and good quality. The phenotypic and genotypic variability in sunflower crop was studied by many authors (Mohammed, 2009), (Ahmed, 2018).

5.2 Phenotypic (δ^2ph), genotypic (δ^2g)

The results of this study revealed variability for most of traits of the four non-oil seed sunflower genotypes under study spacing and variety. Variation can be to attributed to phenotypic as well as genotypic variability. Similar results were reached by (Mahmood and Mehadi, 2003).

5.3 Heritability (h^2), genetic coefficient of variation (GCV %)

The utility of the heritability estimates increases when it is used in conjunction with the genetic coefficient of variation. Estimation of heritability together with genetic coefficient of variations is useful in predicting the resulting effect than the heritability value alone. This is mainly because heritability estimates as a ratio of genotypic to phenotypic variance varies greatly depending on sample size, environment, character and population. Furthermore heritability estimates in broad sense would enable plant breeders to base their selection on the phenotypic performance. In this study, the wide range of genetic variability among the evaluated genotypes was detected for the studied characters. The highest estimate of GCV was shown by number of seed per heads and the lowest one was shown by multi head, High heritability estimates, were shown by number of seed /head , number of plant/plat and leaf area. Similar findings have reported by (Saravana*et al*, 1996; Kefene, 1994; Lewis, 1954 and Gill *et al*, 1997, Mirza*et al*, 1997).

5.4 Phenotypic correlations:

Knowledge of the degree of associations of different traits with seed yield could be useful in better understanding of the inheritance of these characters and sunflower seed yield, as they give information on directions and magnitude of association between different traits. In this study, highly significant positive and negative correlations were obtained. The highest positively and highly significantly (P< 0.01) phenotypic correlation was found between plant height, stem diameter, leaf area , days to 50 % flowering, number of leaves/plant ,number of plant /plot, %multi head, head diameter , number of seeds / head, seed yield /head (g),100-seed weight , weight seed yield (t/ha) and % empty seed. Emphasis should be placed on these characters for formulating reliable selection indices for development and/or releasing of high yielding non-oil seed sunflower genotypes for climatic conditions. Similar results were obtained by Yankov and Tashin (2015). The results of phenotypic correlation among different character in this study were presented .Stem diameter was positive and non-significant correlation with number of leaf per plant, leaf area, and 50%flower and multi head, seed yield per hector and empty seed. The correlation coefficient between head diameter and seed yield was significantly positive. This result is in agreement with the findings of Marinkovic (1992), Sujatha and

Nandini(2002) and Singh *et al.* (1988). The correlation coefficient between seed numbers per head and seed yield were positive and significant. Patil*et al*. (1996) reported similar results in oily sunflower types. Positive correlation was reported between seed yield and plant height (Sujatha and Nandini, 2002), stem diameter (Punia*et al*., 1994), number of leaves (Satisha, 1995), leaf width and petiole length. Ahmad *et al*. (1991) and Marinkovic (1992) reported strong and positive correlation between 100-seed weight and head diameter phenotypic correlation =non-oil type (seed size, seed weight, bigger seeds).

CHAPTER SIX

CONCLUSIONS AND RECOMMENTED

There is high potentiality of non-oilseed or confectionary sunflower genotypes under irrigated condition of El Fasher, Western Sudan.

Highly significant differences were found among the four non-oil seed sunflower genotypes under three plant population for most characters studied.

Plant spacing affected the major seed yield components: the best number of plant per plot and seed yield (T/ha) was obtained at the spacing of30cm.

The interaction between spacing and genotypes was significant for most seed yield components. However, the highest seed yield was given by the genotype (G1) combined with spacing of 30 cm (S1).

Based on the findings obtained in this study, the following conclusions could be drawn:

1. A wide range of variability was noticed for most of the tested non-oil seed sunflower genotype. This offers a good opportunity for further breeding programs.
2. The high heritability values for most of the investigated traits suggest the possible efficiency of phenotypic selection for these traits.
3. The high genetic advance as percentage of mean and genetic coefficient of variation (GCV %) for most of the traits suggested greater response for selection.
4. It can be recommended that more seasons and locations should be used to obtain more reliable results.

REFERENCES

Abdalla, A. A. and O. Abdelnour. (2001). The agricultural potential of Sudan exclusive intelligence view. *Feb23, 2001.PP.27-45.*

Adam, N. E. M. and Osman H. G. (1989). Performance of some open-pollinated sunflower varieties at the Blue Nile under rain and supplementary irrigation. Paper submitted to Variety Release Committee. Khartoum, Sudan.

Ahmad, Q., Rana MA, Siddiqui SUH (1991). Sunflower seed yield as influenced by some agronomic and seed characters. Euphytica 56: 137-142.

Ahmed., F. A. (2018). Performance of some sunflower hybrids under Rain-fed and Irrigated condition, Sudan. Ph. D. Thesis , Agriculture , Sudan University of Science and Technology Sudan.

Arnon, I. (1972). Systematic treatment of the principal crops.Crop Production in Dry Regions.Vol. 11. Leonard Hill, London.

Anderson, W. K. (1979). Water use of sunflower crop. Aust. J. Exp. Agric. Anim. Husb. 19(97):233-240.

Anonymous. 2015. Sunflower production data. http://faostat.fao.org/.

Arshard, M., Ayub Khan, M., Ullah, I., Amjad, M. (2013).Development of short duration and high yielding indegenious sunflower (*Helianthus annuus* L.) hybrids. Science Technology and Development 32 (3): 205-214.

Bank of Sudan, (2003).Annual report. The 43$_{\text{Nd}}$. *Annual report. P. O. Box. 313.Khartoum Sudan.*

Barros J,.F.C,carvalho M, basch G.(2004):Response of sunflower (*Helianthus annuus L.)* to sowing date and plant density under Mediterranean condition. European Journal of Agronomy, Vol 21, No 3, p 347-356.

Burton, G.W, Devane, E.M. (1953). Estimating heritability in tall fescue (*Fescue arundianceae L.)* From replicated clonal material. Agronomy Journal45:478-481.

Canvin, D. T. (1965).The effect of temperature on the oil content and fatty acid composition of the oil from several oil seed crops. Can. J. Bot. 43: 63-69.

Casadelabaig, P, Poublan, B. Trepos R,Picheny, V, Debacke, P. (2015), Using plant phenotypic plasticity to improve crop performance and stability regarding climatic uncertainty. A computational study on sunflower. Proc. Environ. Sci. 29:142-143.

Chikkadevaiah, Y. Chakrapani, D. P. Jagannath, and S. Ramesh, (1998). Evaluation of sunflower genotypes for confectionary purpose.Helia,21(29):131-136.

Connor, D. J. and Jones, T. R. (1985). Response of sunflower to strategies of irrigation. Morphological and physiological response to water stress. Field Crop Res.12:91-103.

Crnobaracj.,Balalici.,Dusanicn.,Jacimovicg. (2007): Efekat vremena setve i gustine us eva na prinos i kvalitet suncokreta u 2006. godini. Zbornik radova, Institut za ratarstvo i povrtarstvo, Novi Sad, Vol. 43, 1, str. 129-137

Dash,S. S. Singh, D. N:D. S. and sirvastava.(1996).Evaluation of hybrids of sunflower for quantitative traits. Journal of Applied Biology, 6: 1-2, 39-41.

Dauguet, S., F. Labalette, F. Fine, P. Carre A. Merrien, J. P. Pallaeau (2016): Genetic impact on protein content and hull ability of sunflower seeds, and on the quality of sunflower meal. OCL, 23(2) D205

Doorenbos, J and Pruitt Wo. (1977). Guideline for predicting crop water requirements (FAO irrigation and drainage paper 24).FAO, Rome English M and Raja SN.1996 perspectives on deficit irrigation. Agric. Water management, 32:1-14.

Duihu A, L., E, Hoeft (2009): Compendium of Transgenic Crop Plants, Sunflower, 10:2776.

El Ahamdi A. B. (2003). A proposal for the release of three sunflower hybrids. Paper presented to the Variety Committee. Khartoum, Sudan.

Fadl Elmula, I. E. 2003). Effect of nitrogen and plant spacing on growth and yield of sunflower (*helianthus annuus* L.). M. Sc. Thesis. Fac.Of Agric. U. of K.

FAO. (2014). Food and Agriculture Organization of the United Nations, (www Document), available at: http:// www. Fao.Org / caccesssed.08/ 2014.

Fick, G. N. (1978). Sunflower breeding and genetics.Pp279-337. In J.F.Carter (ed). Sunflower Science and Technology. Agron. Monogr. 19. ASA. CSSA, and SSSA. Madison. WI.

Fick, G.N, (1989). Sunflower. In: Oil Crops of the World (Rbbelen G, Downey R.K, Ashri, A (eds.). McGraw-Hill, New York, N.Y, pp. 301-318

Gaytancioglu, O. 1999.Cerezlik ayciceginin uretim ve dis ticaret sorunlari. Cerezlik Aycicek Cekirdegi Dis Ticaret Semineri.9 Haziran 1999.istanbul.

Gill, H. S., R. K. Sheoran, L. Kumar, and Chandra. (1997). Genetic Variability, heritability, and genetic advance for seed yield and components traits in sunflower (*Helianthusannuus* L.), An ailysis of Biology, Iudhiana, 13(2): 279-281.

Gubbels G. H. and Dedio W. (1986): Effect of plant density and soil fertility on the performance of nonoil sunflower. Can. J. Plant Sci. 66, 801-804

Heiser, C. B. (1951). The sunflower among the North American. Indians, Proc. Am. Phil. Soc. 95:432-448.

Hesketh, J. D. and Moss, D. N. (1963).Variation in the response of photosynthesis to light. Crop Sci. 3: 107-110.

Hladni, N., Jocic, S., Miklic, V., Saftic-Pankovic, D., Kraljevic-Balalic, M., (2011). Interdependence of yield and yield components of confectionary sunflower hybrids. Genetic 43(3): 583-594.

Hladni, N., (2010): Genes and Sunflower Yield. Monograph. Foundation and rejevic, Serbia Beograd, pp.116.

Hladni, N., S. Jocic ,V.Miklicn .Dusanic,D.Saftic-pankovi,.Radeka,N.lecic (2009b): The evaluation of values of new confectionery sunflower hybrids. Proc.50thOil 0I.0ndustry Conf., Herceg Novi, 57-61.

Hladni, N.,S.Jocic, V .Miklic ,V .Radic, I .Radeka, N. Lecic (2009c): Borneo - New NS sunflower confectionary type hybrid. Selection and Breeding, X.V(4):63-73.

Hu J, Seiler G, Kole C (2010). Genetics, genomics and breeding of sunflower. Routledge, U.S.A, p. 342.

Idris, A. E.(2001).Study of variability in seven genotypes of sunflower M.Sc. Thesis, Agriculture Omdurman Islamic University. Sudan.

Ishag, H. M. (1988). Sunflower a potential crop for the Sudan. Proceedings of the fourth oil crops and network workshop held at Njor, Kenya pp.82-88.

Ivanov P, Stoyanova Y, (1980). Studies on the genotypic and phenotypic variability and some correlations in sunflower (*Helianthus annuus L.*). Proc. of the 9th Inter. Conf. of Sunflower, 336-342, 8-13 June, Johnson, H. W, Robinson, H. F, Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybeans. Agronomy Journal. 47:314-318.

Kaya, Y., Evci, G., Pekcan, V., Gucer, T., Yilmaz, I. M., (2008). Yield Relationships in Confectionery Sunflower (*Helianthus annuus L.*).Annual conference of the University of Rousse. Bulgaria 31 October -01 November. 7-11.

Kaya, Y. ve I. K. Atakisi. Ayciceginde (*Helianthus annuusL.)* Farkli Verim Ogelerinde Path ve Korelasyon Analizi. Anadolu.(2003). 13: 31-45.

Kaya, Y., (2004). Confectionery Sunflower Production in Turkey. Proceeding of 16 th International Sunflower Conference. August 29-September 2. Fargo, USA 817-822.

Kefene, H. (1994). Genetic diversity of introduced sunflower varieties and their performance for oil and seed yield in Ethiopia. M. Sc. Thesis. Alemaya University of Agriculture, DirDawa, Ethiopia.166 leaves.

Khalifa, F. M. (1981). Summary of agronomic research finding on oil crop at tozi and Abu-Naama Research Stations during the period 1952/ 1953-1978/1979 Unpublishedoporation (ARC).*Wad Medani. 98 Sudan*.

Khidir,M. O. (1997). *Oil Crops in Sudan*.U. of K. Press Is ted. PP. 103-120.

Kloczowski, (1975). Studies of some features of oil sunflower and their significance in breeding sunflower plant in Poland. HodowlaRosl. Aklim.Nasienn. 19(2): 89-131.

Kshirsagar, A. R. Deshmukh, D. T. and R. S. Dudhe.(1995). Study of genetic variability in sunflower PKV.*Res. J. 19(2):175.*

Lakshmanrao NG, Shambulingappa KG, Kusumaku maxi P., (1985). Studies on Path-coefficient analysis in sunflower. Proc. Of the 11th Inter. Sunfl Conf. 733-735, 10-13 March, Mar del Plata, Argentina.

Lewis, D. (1954). Gene environment interaction and relationship between dominance, heterosis , phenotypic stability and variability. Heridity,8, 333-338.

Lofgren, J. R., (1978). Sunflower for Confectionery Food, Bird food and Pet Food. In J. F. Carter Sunflower Technology and Production ASA, SCA and SSSA Monograph, No: 19 Madison WI. P. 441-456.

Lofgren, J.R., (1997). Sunflower for Confectionery Food, Bird food and Pet Food. In A. A. Schneiter Sunflower Technology and Production ASA SCSA and SSSA Monograph No:35. Madison WI. P. 747-764.

Lu G, Hoeft E., (2009). Sunflower. Compendium of Transgenic crop plants (Kole C, Hall TC eds.), Vol 2. Wiley- Blackwell, London.

Lush, J. L. (1949).Animal breeding Plant. Third edition. The Collegiate Press, Ames, Lowa..

Mahmood, T. and S. S. Mehdi. (2003). Evaluation of S1 and S2 progenies of sunflower (*Helianthusannuus* L.) for seed yield and its components and resistance to charcoal rot (*Macrophominaphaseolina*). Asian. J. of plant Sci. 2 (11):834-840.

Marinkovic, R., (1992). Path- coefficient analysis of some yield components of sunflower (*Helianthus annuusL.).*Euphytica 60: 201-205.

Miller, J. F. (1987). Principles of cultivar development crop species. *Editor. Fehr, W. R. Macmillan Publishing Company. 2, 662-668.*

Millete, R. A., 1974. Seeds from the sunflower. Nart Dakota State Universıty Fargo Cir. He-120 pp. 3.

Mirza, S. H., M. S. Hassan and D. Nessan.(1997). Genetic diversity amongst 5099 sunflower (*Helianthus annuus*L.) genotypes.*Bangladesh J. Botany, 26, 51-54.*

Mohamed, M .Y. (2010).Development and stability of some Sudanese sunflower hybrids under irrigated conditions. Helia, 33, Nr. 52, p.p. 135-144.

Mohammed, MY, Ibrahium NE, Elzein Mohamed EA, Eleasir AHA, Siddig AE, Mohamed KH and Abdelrahim AA.(2009). A proposal for the release of new local sunflower hybrids for the Sudan conditions. A paper presented to the National Variety Release Committee. Khartoum, Sudan.

Muhammad, T., Ghulam, I., Asadulluh, T., Tarig, M.; Idress, G. and A. Tahir.(1992). Genetic Variability and correlation studies in sunflower.Sarhad, J. agric., 8(6):659-663.

Nadarajan N, Gunasekaran M., (2005). Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Pub. New Delhi, India. Pp. 27-28.

Nielsen, D. C. (1998). Comparison of three alternative oil seed crops for Central Great Plains. J. Prod. Agric. 11:336-441..

Nour, A. M., Mohamed, M. Y., and Ahmed , O. M., (2005). A proposal for the release of new sunflower hybrids for rain fed and irrigated conditions of the Sudan. A paper presented to the National Variety Release Committee. Khartoum, Sudan.

Onwueme, I. C. and T. D. Sinha. (1991). Field Crop Production in Tropical Africa Principles and Practice. Technical Center for Agricultural and Rural Co-Operation.PP(349)-(345).

Patil, B. R., Rudraradhya, Vijayakuman, C. H. M., Basapa, H. and K. Virupakshapa.(1996). Genetic variability in sunflower *.J. of oil seeds Res. 13(2):157-161.*

PuniaM , Gill., H. S., (1994). Correlation and path coefficient analysis for seed yield traits in sunflower (*HelianthusannuusL.*). Helia 17: 7-11.

Putt ED (1943). Association of seed yield and oil content with other characters in the sunflower. Sci. Agric. 23: 377 -383.

Robinson, H. F.; Comstock, R.And Harvey, P. H. (1949). Estimation of heritability and degree of dominance in corn. Agronomy Journal41: 353-359.

Robinson, R. G. (1978). Production and Culture. Sunflower Science and Technology. American Society of Agronomy. Pp. 89-132.

Robinson, R. G., Ford J. H., Lueschen W. E., Rabas D. L., Smith L. J., Warnes D. D. and Wiersma J. V. (1980): Response of sunflower to plant population. Agron. I. 72: 869-87l.

Ross A. M, (1939). Some morphological characters of(*Helianthus annuusL.*) And their relationship to the yield of seed and oil. Seien. Agricul. 19: 372-379.

Salunkhe, D.K, Chavan J.K, adsule R.N, Kadam S.S (1999).World oil seeds: Chemistry, Technology, and Utilization. Van Nostrand Reinhold, New York.

Saravanan, K. Gopalan, M. and N. Senthil.(1996). Heritability and genetic advance in sunflower. Gujorat- Agric University Research, Journal, 22(1):101-102.

Satisha , (1995). Evaluation of sunflower (*Helianthus annuusL.*)germplasm for yield and yield components. M.Sc.(Agri) Thesis, Univ. Agri. Sci. Bangalor, pp. 93.

SDMA, Statistical Division Ministry of Agriculture, Khartoum. (2008).

Shabana, R. (1974). Genetic variability of sunflower varieties and inbred lines. Pp. 263-269. Int Proc. 6th Int. Sunflower Conf., Bucharest. Romania. 22-24 July 1974. Int. Sunflower Asoc., Paris. France.

Sheriff, N. M. and Appadurai, (1985).Genetic variability in some quantitative traits of sunflower. *Madras Agric*. J. 72 (9) 539-540.

Singh, M., Singh, H., Raj Kumar, Tank DS, Singh VP, Singh T, Singh SM (1988). Correlation and path coefficient analysis of some morphological and seed yield characters in sunflower. Crop Res. 16: 93-96.

Skoric, D. (1982). The potential of sunflower in Sudan. Arab Organization for Agricultural Development, Khartoum, Sudan. Pp. 1-25.

Skoric, D., S. Jocic, N. Lecic, Z. Sakac (2008): Genetic possibilities for altering sunflower oil quality to obtain novel oils. Can. J,. Physiol. Pharmac. 86(4):215-221.

Sujatha H. L, Nandini (2002). Correlation and path analysis in sunflower.Helia 25: 109-118.

Tan, A. S. 2007. Ayciceei Tarımi. p.41-83. TYUAP/TAYEK Ege -Marmara Dilimi Tarla Bitkileri Toplantisi. 2-4 Ekim 2007.Ege Tar. ara. Enst. Menemen, Izmir.

Tan, A. S. 2011. Cerezlik Aycicegi Tarımı. p.22- 47. 2011 Yili Tarla Bitkileri Grubu Bolge Bilgi Alısveriş Toplantısı Bildirileri Ege Tarimsal Arastirma EnstitusuYayinlari.Yayın No: 145. Menemen, Izmir.

Tan, A. S. 2014. Bazi Yaglık Hibrit Aycicegi cesitlerinin Menemen Ekolojik Kosullarında Performansları Anadolu 24 (1): 1-20.

Tan, A. S. and A. Tan. 2010. Sunflower (Helianthus annuus L.) Landraces of Turkey, Their Collections Conservation and Morphmetric Characterization. 8th European Sunflower Biotechnology Conference. SUNBIO 2010.1-3 March 2010, Antalya, Turkey.Helia 53: 55-62

Tariq, M., G. Idress, and A. Tahir. (1992). Genetic variability and correlation studies in sunflower. Sarhad Journal of Agriculture, 8(6): 659-663.

Taylor, (1981). “Uses of Non-oil”, Paper presented at 1981 Sunflower Forum, Fargo, North Dakota, January 27.

Tyagi, AP., (1985). Association and path analysis of yield components and oil percentage in sunflower (*Helianthus annuus L.*).Proc. of 11th Inter. Sunfl. Conf. 807: 10-13 March, Mar del Plata, Argentina .

Unger,P. W. (1982). Time and frequency of irrigation effects on sunflower production and water use.USDA Conservation and Production Research Laboratory. Soil Sci. Soc. Am. J. 46: 1072-1076.

U.S.D.A(2016).United States Department of Agriculture.

Varshney SK, Singh B., (1977). Correlation and path-coefficient analysis in sunflower (*Helianthus annuus L.*).Pantnagar J. Res. 2: 147-149.

Velkov, VN., (1980). Relationship between yield and some characters in sunflower. Genetic 13: 329-338.

Vidhyavathi, R., Mahalakshmi, P., Manivannan, N., Murulidharan, V. Correlation and path analysis in sunflower (*Helianthusannuus L.*). Agricultural Sci. Digest, 2005. 25: 1.6-10.

Weiss E. A. (2000). Oil seed Crops, 2nd ed. Blackwell Sci. Ltd, Victoria, Austalia. Welsh J. R. 1981. Fundamentals of plant genetics and breeding. John Wiely Sons, Inc.

Yankov B, Tahsin N; Genetic variability and correlation studies in some drought-resistan sunflower (*Helianthus annuus* L.) genotypes Journal of Central European Agricultur, (2015).

Yasin, AB., Singh S., (2010). Correlation and path coefficient analyses in sunflower. J. Plant Breeding and Sci. 2: 129-133.

Zubriski, J C and Zimmerman, D C (1974).Effect of nitrogen, phosphorus and plant density on sunflower. American Society of Agronomy, 66: 798-80.

APPENDICES

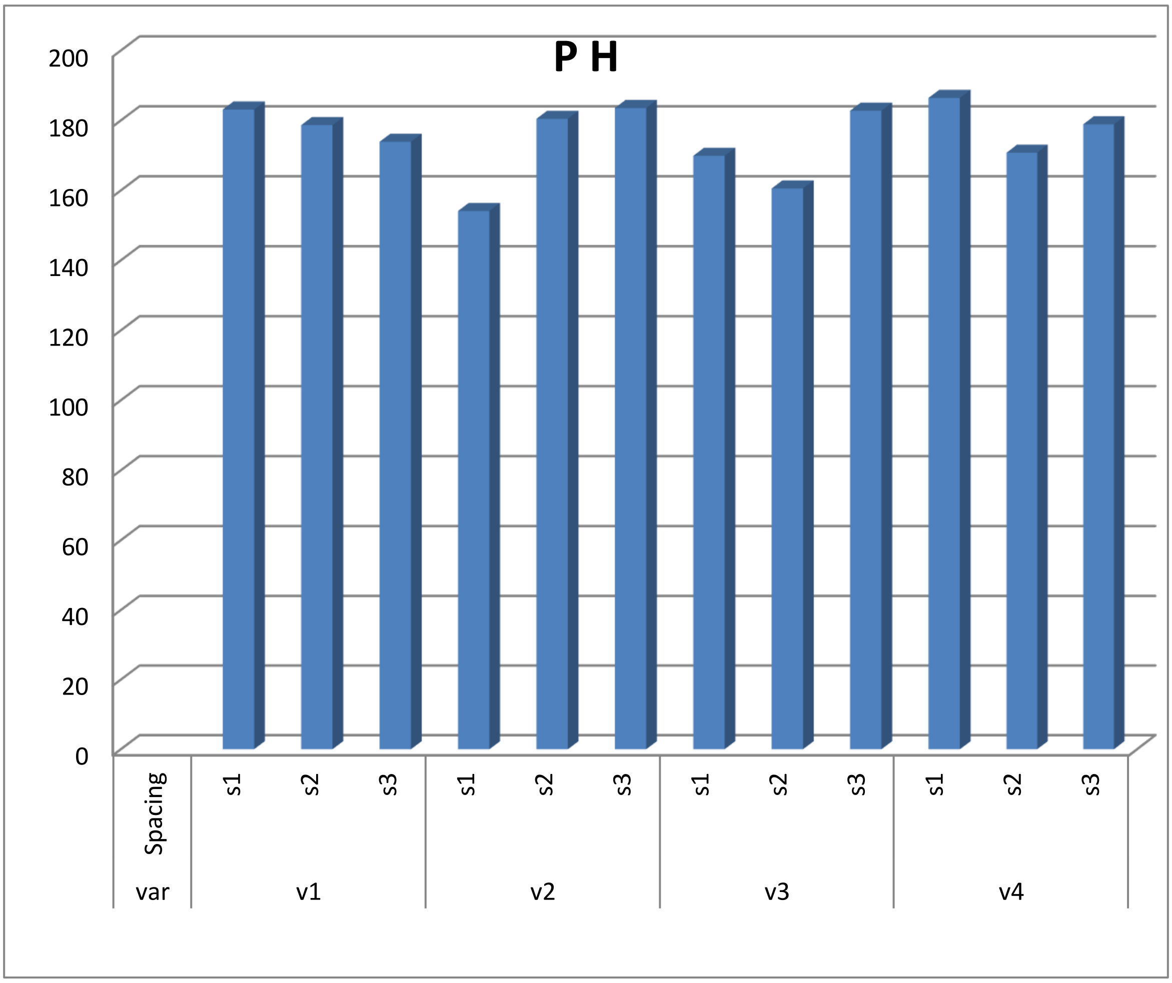

Fig.1: Mean of plant height (cm) of four non-oil seed sunflower genotype at three spacing effect.

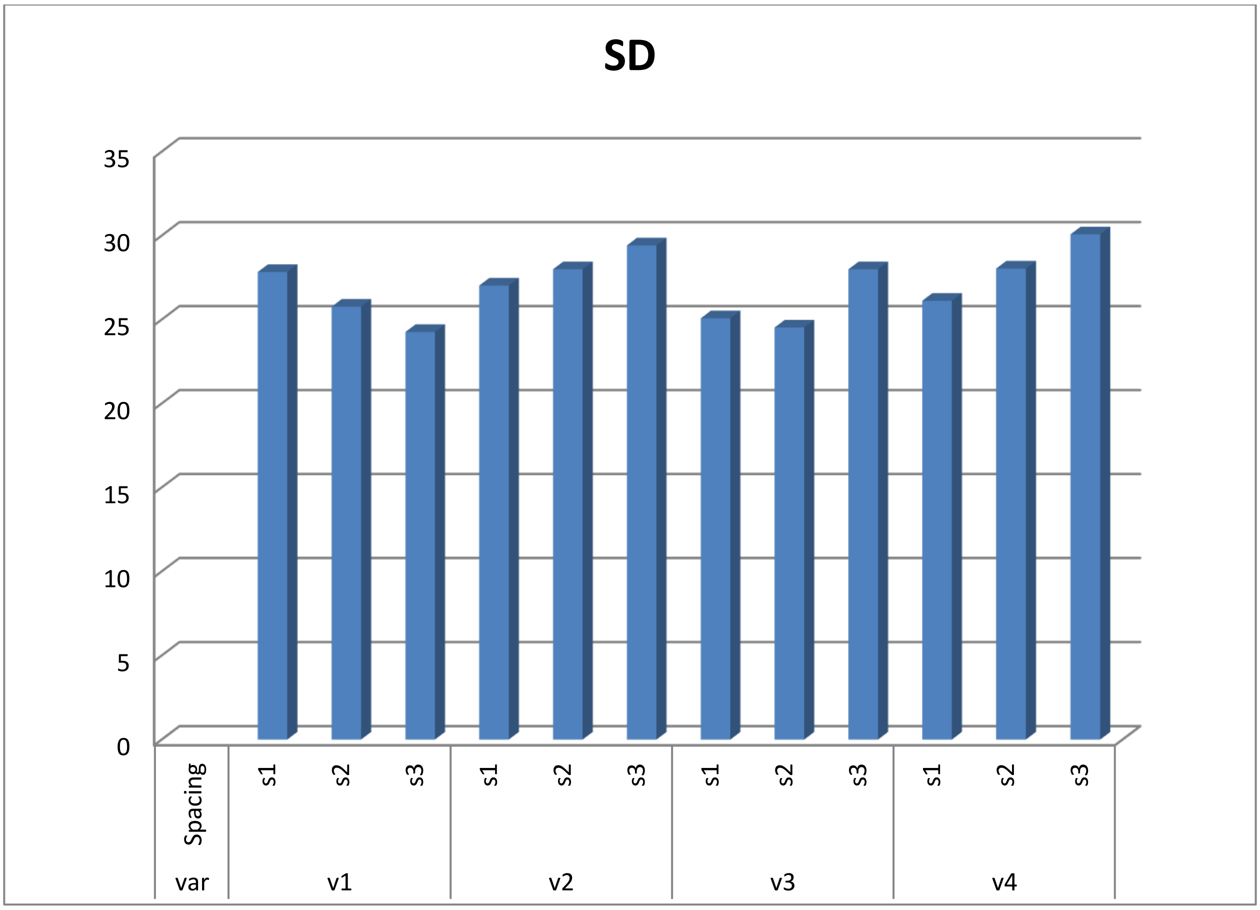

Fig.2: Mean of stem diameter (cm) of four non-oil seed sunflower genotypes under three spacing effect.

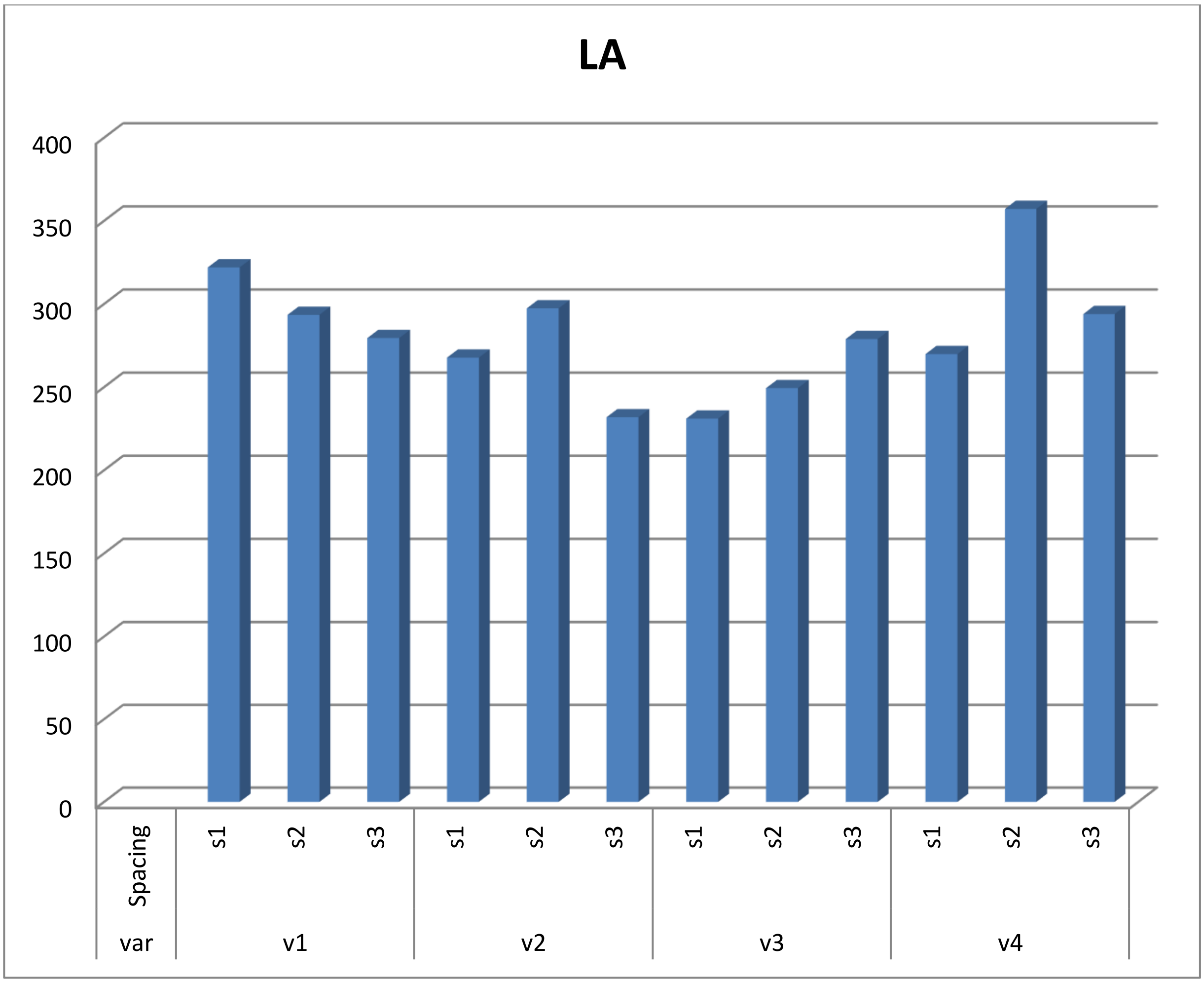

Fig.3: Mean of leaf area of four non-oil seed sunflower genotypes at three spacing effect.

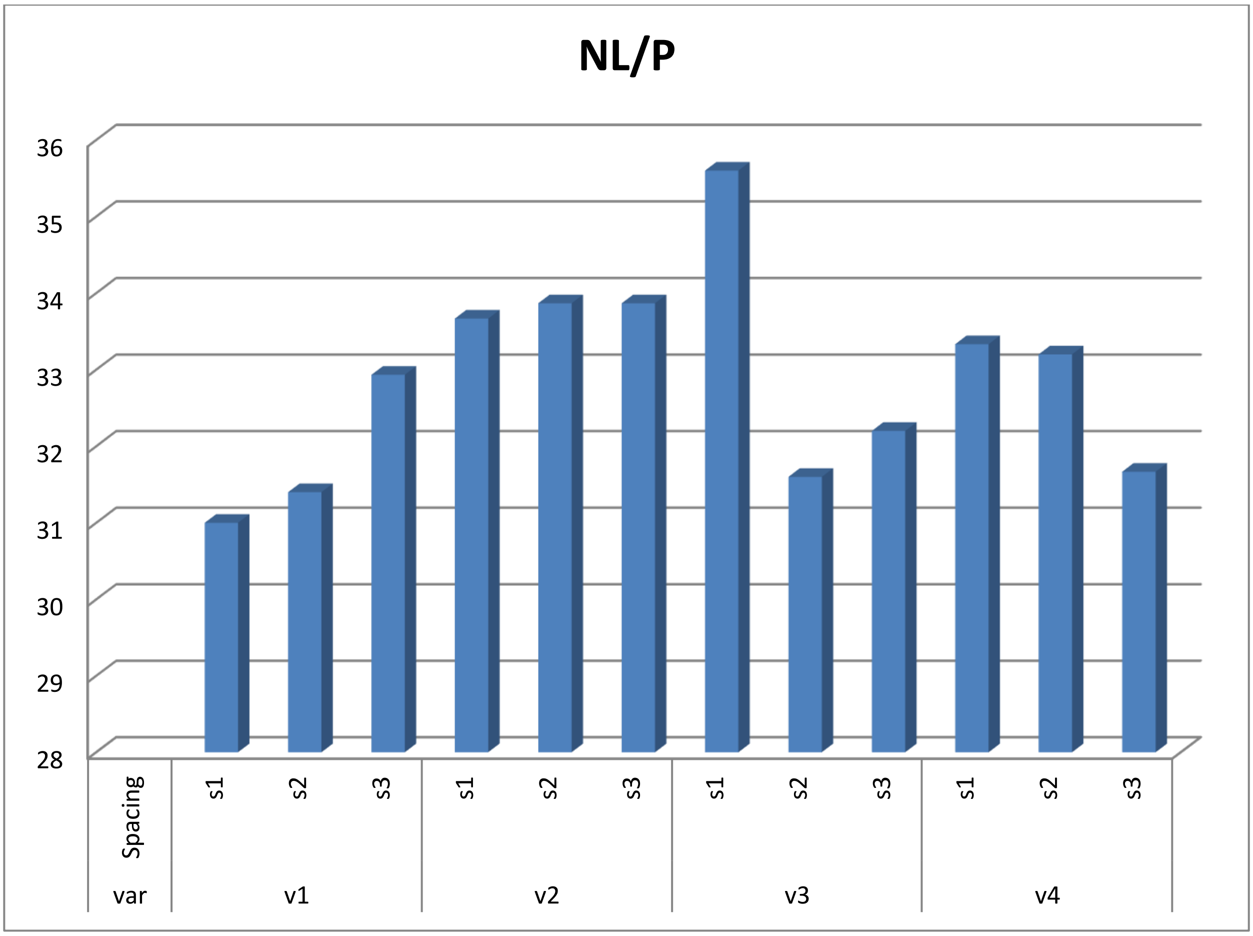

Fig.4: Mean of number of leaves/ plant of four non-oil seed sunflower genotypes under three spacing effect.

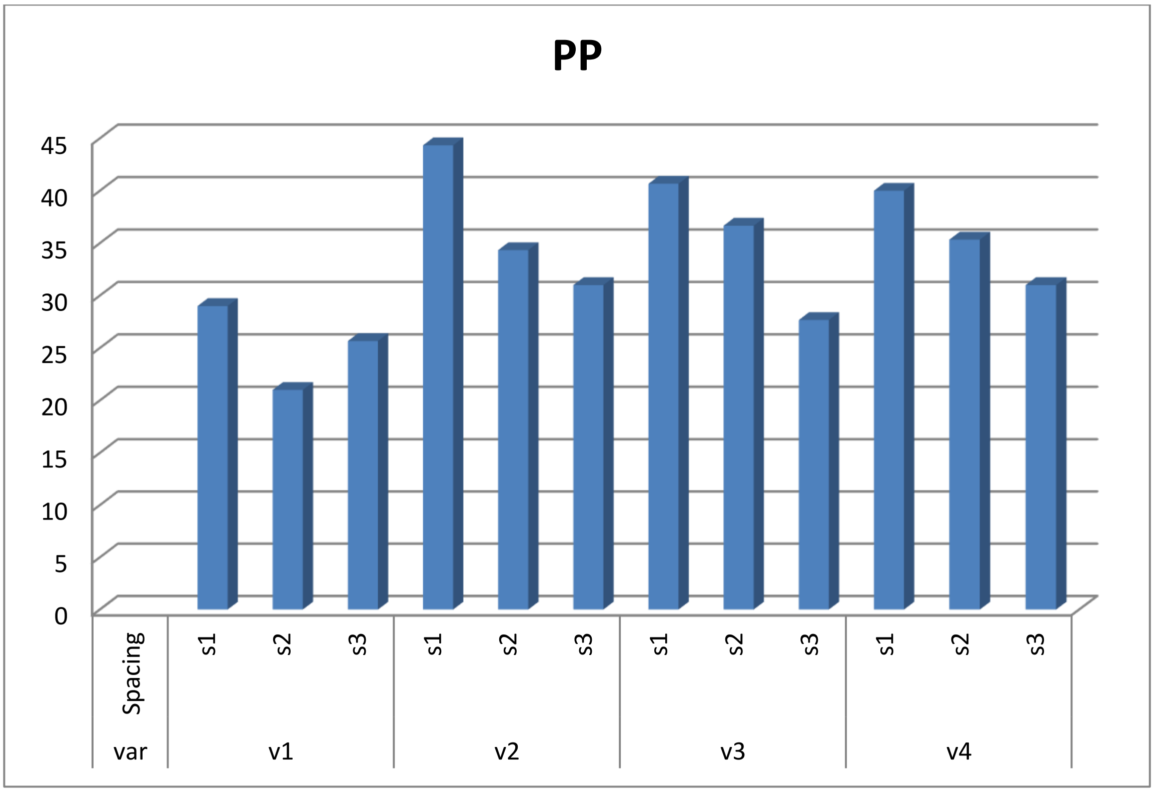

Fig.5: Mean of plan population of for non-oil seed sunflower genotypes at three spacing effect.

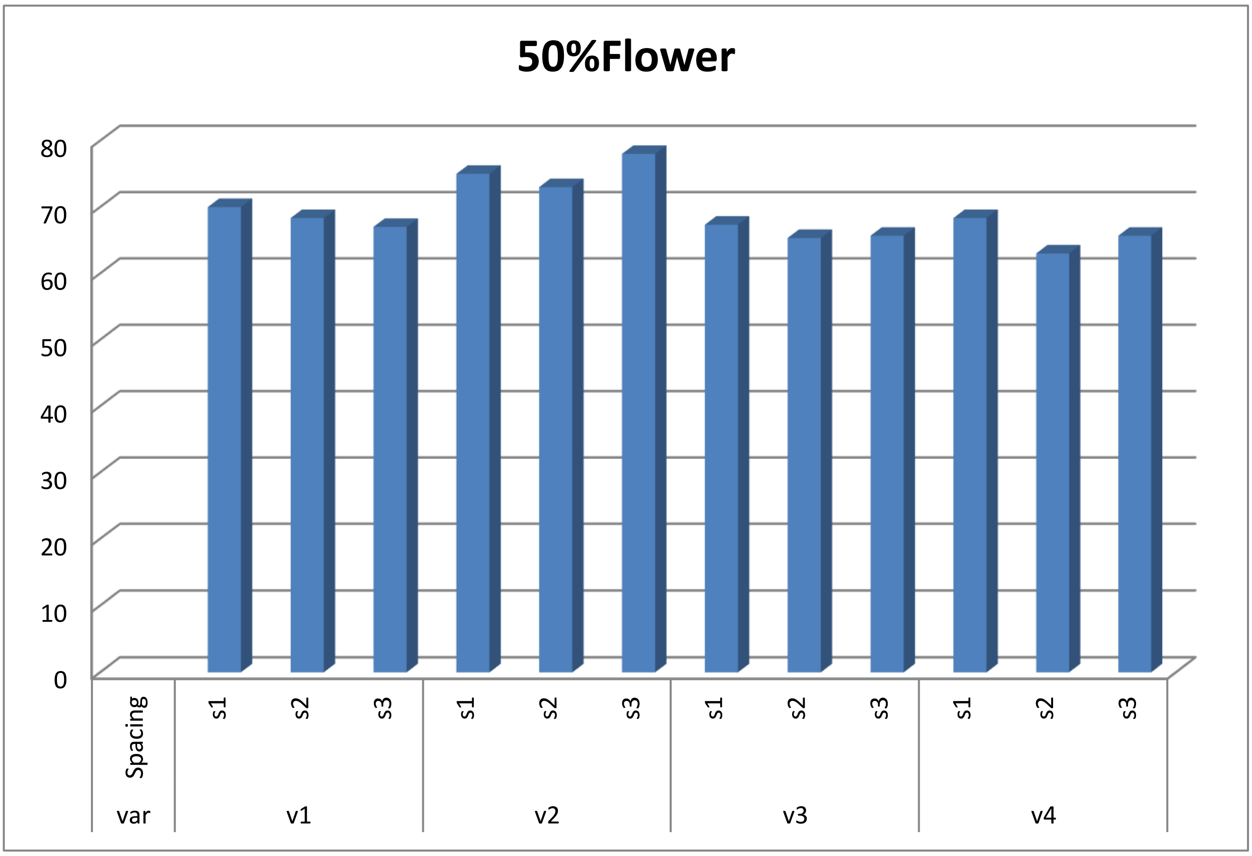

Fig.6: Mean of 50% flower of four non-oil seed sunflower genotypes under three spacing effect.

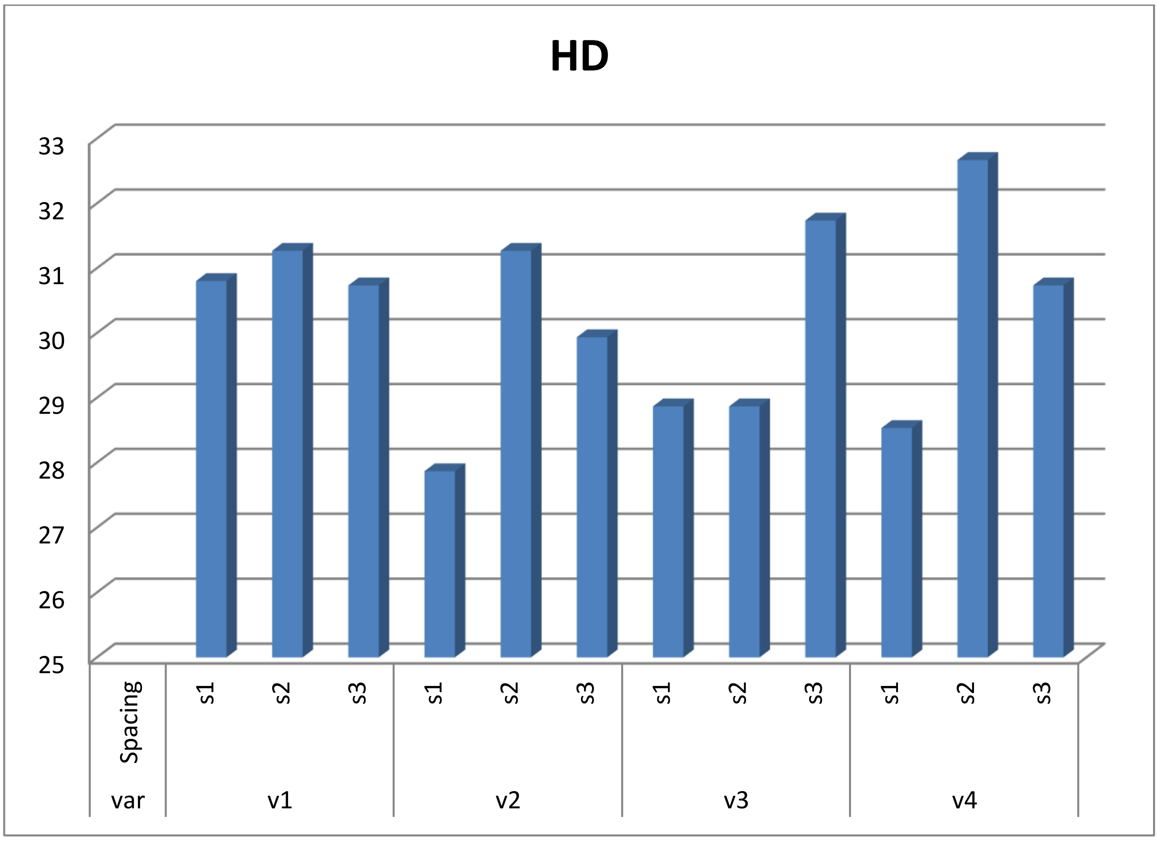

Fig.7: Mean of head diameter of four non-oil seed sunflower genotypes at three spacing effect.

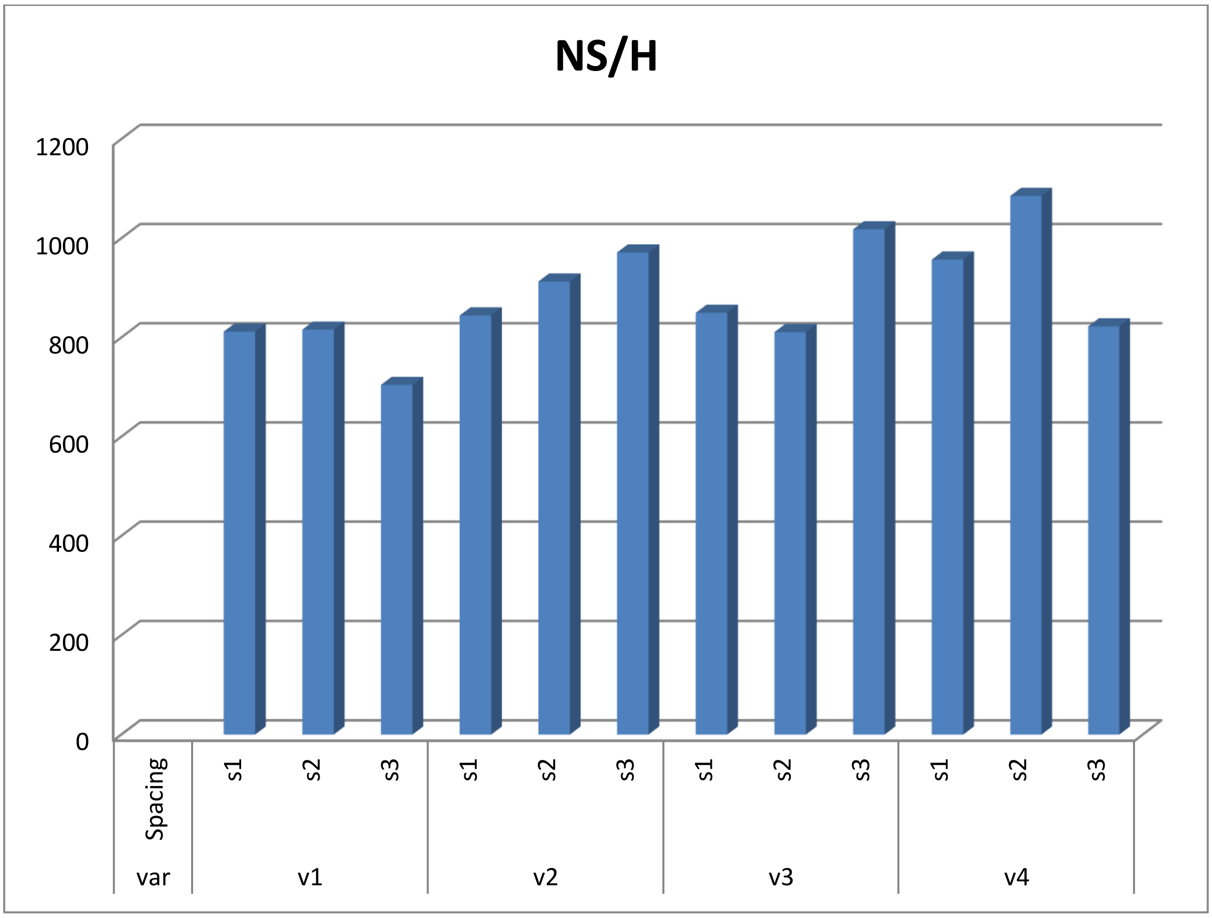

Fig.8: Mean of number of seed /head of four non-oil seed sunflower genotypes under three spacing effect.

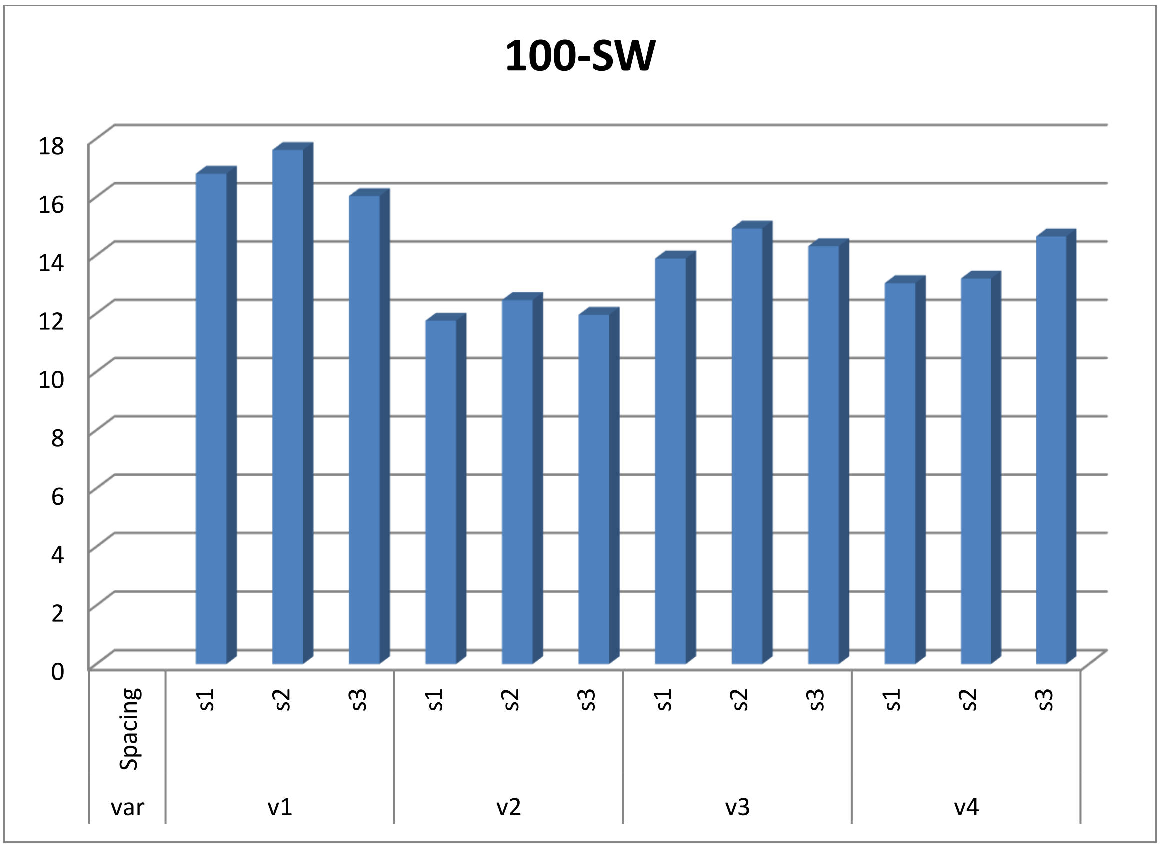

Fig.9: Mean of 100- seed weight of four non-oil seed sunflower genotypes at three spacing effect.

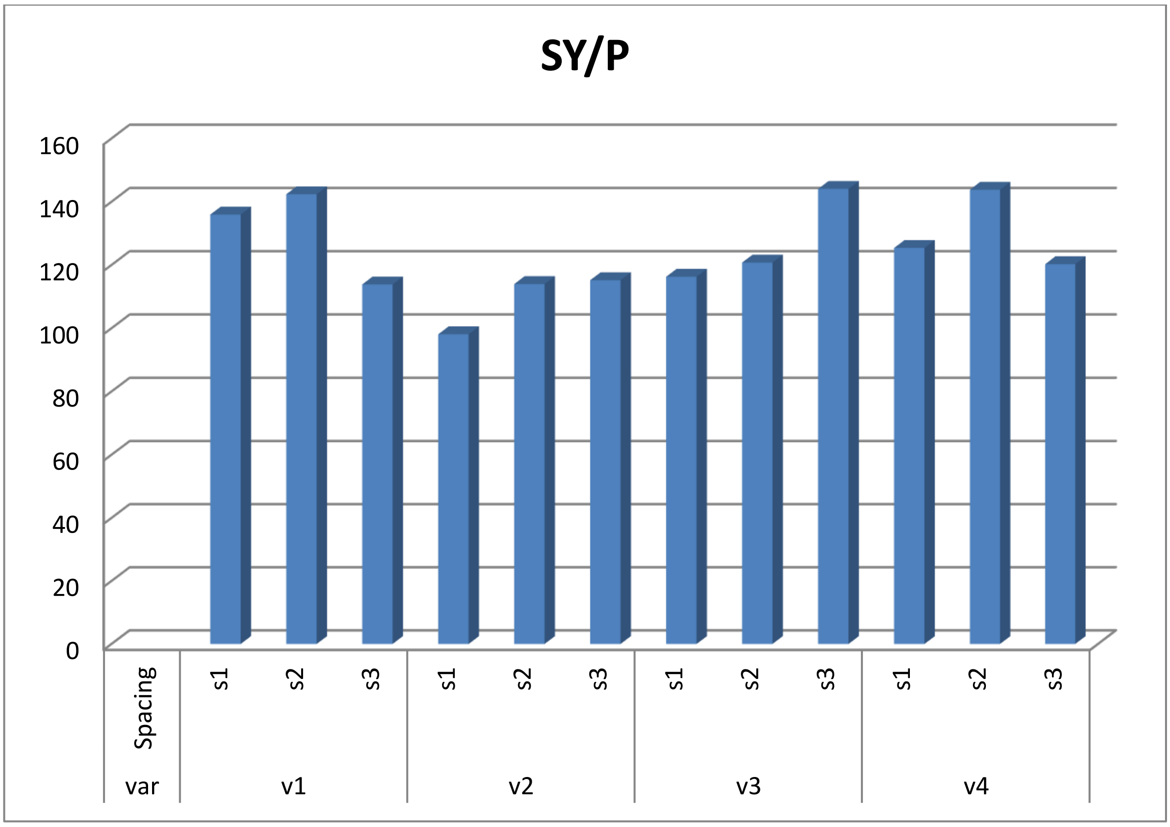

Fig.5: Mean of seed yield/plant of four non-oil seed sunflower genotypes under three spacing effect.

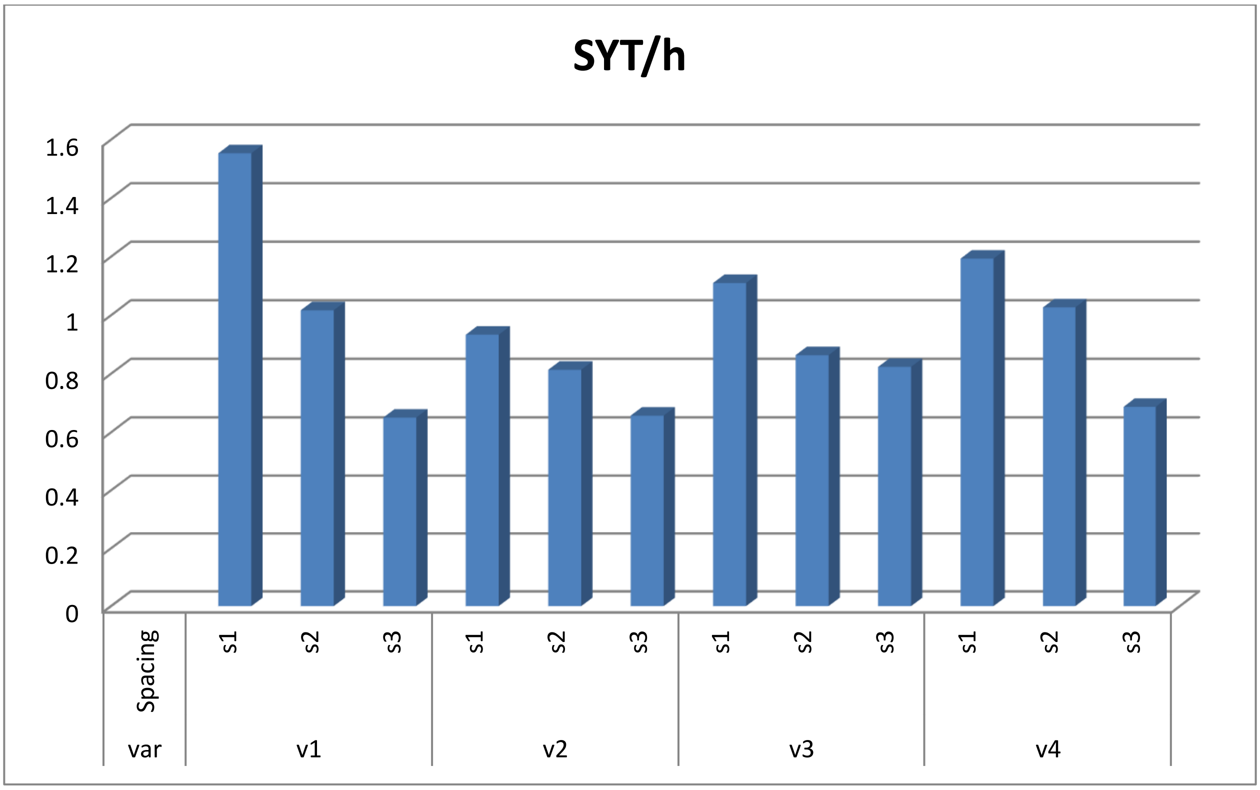

Fig.6: Mean of seed yield (T/ha) of four different non-oil seed sunflower genotypes at three spacing effect.

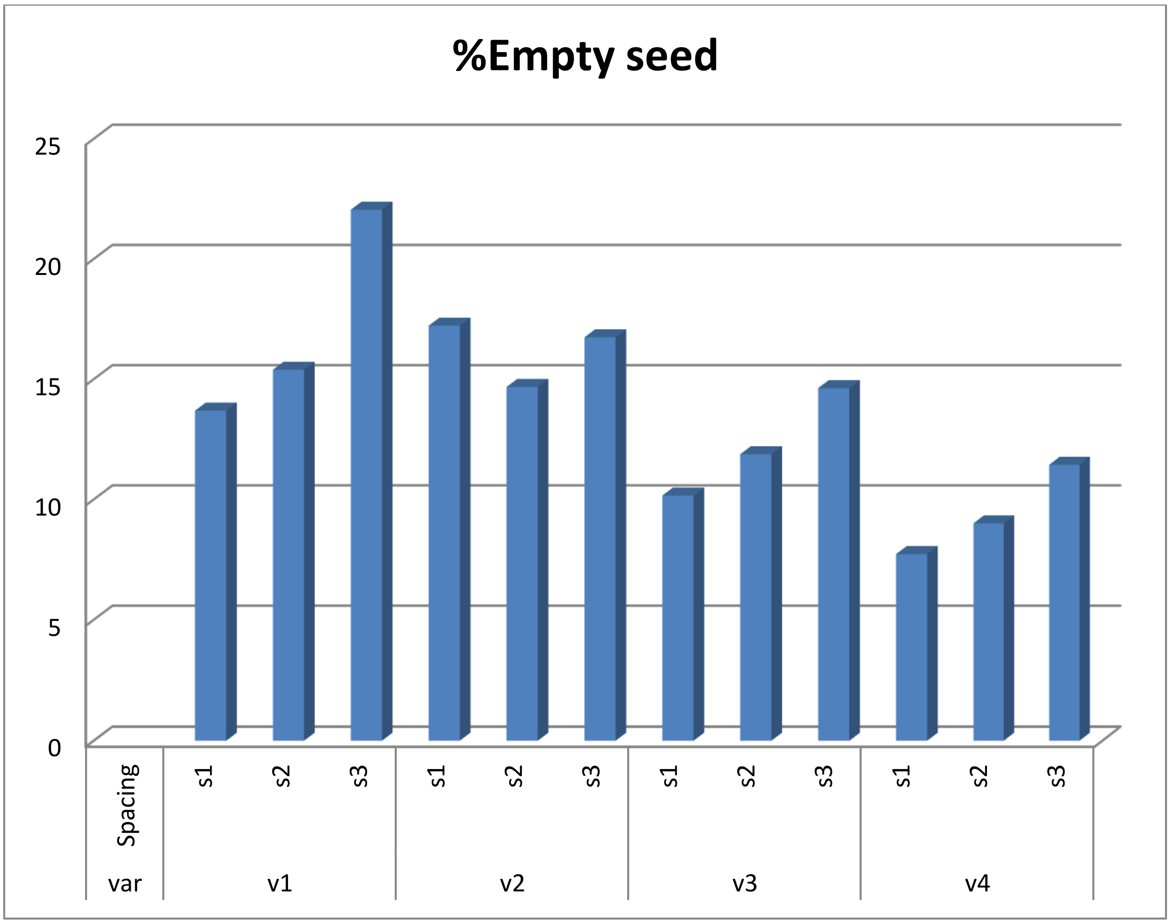

Fig.12: Mean of % Empty seed of four non-oil seed sunflower genotypes under three spacing effect.