Sudan University of Science and Technology

College of Graduate Studies

Effect of Inter Plant Spacing and Weeding on Growth and Yield of Two Varieties of Sunflower (*Helianthus annuus L.)*

تأثير مسافات الزراعة بين النباتات والعزيق علي نمو وإنتاجية صنفين من محصول زهرة الشمس

AThesis Submitted to In Partial Fulfillment of the Requirements for the Degree of M.Sc in Agriculture (Agronomy)

By

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الآية

قال تعالي:(مثل الذين ينفقون اموالهم في سبيل الله كمثل حبه انبتت سبع سنابل في كل سنبله مائه حبه والله يضعف لمن يشاء والله واسع عليم)

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DEDICATION

To my dear father and lovely mother who have supported me to continue my education, to my brothers, sisters and to all my friends.

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Abstract

An experiment was conducted at the college of Agricultural studies farm at Shambat during the winter season 2017 - 2018. The objectives of the experiment were to study the effect of inter plant spacing, weeding and varieties on growth and yield of two sunflower varieties.The treatments were, inter plant spacing (15cm, 30cm), two varieties (Behooth,sirena) and weeding(Hand weeding, un weeding), Split- split Block Design with four replicates was use. Results showed that there were no significant differences on plant height(cm) and head diameter(cm) in all varieties as affected by weeding and inter plant spacing treatments, and significant effect on number of leave in the inter plant spacing, Result showed highly significant effect on leaf area (cm^2) in weeding treatment, but no significant effect in inter plant spacing Results showed that in number of seed(g)had highly significant effect on inter plant spacing and significant effect in weeding treatments Result also showed that seed weight(g)had highly significant effect on weeding treatment and significant effect on inter plant spacing and varieties, Result showed that yield(t/ha)had significant effect on weeding treatment and no significant effect on inter plant spacing.

Result showed that the inter plant spacing 30cm is better than 15cm, Hand weeding is more effective than un weeding, and variety Behooth yielded better than Sirena.

المستخلص

اجريت تجربة حقلية في مزرعة كلية الدراسات الزراعية بشمبات خلالموسم (2018-2017) لدراسة اثر المسافات بين النباتات والعزيق علي نمو وانتاجية صنفين من محصول زهره الشمس. تم استخدام تصميم القطاعات المنشقه-المنشقه باربعة مكررات ، والمعاملات التي استخدمت هي المسافه بين النباتات(15و30سم) و معامله العزيق (ازاله وعدم ازاله) والاصناف سيرين و بحوث .

اظهرت النتائج ان طول النبات(سم) وقطر القرص(سم) لم يتاثرو معنويا ، بمعامله المسافه في كلا الصنفين والعزيق بينما اظهرت النتائج زياده معنوية في عدد الاوراق بمعاملة المسافات اظهرت النتائج زياده معنويه في مساحة الاوراق (سم^2) بمعامله العزيق ولم تؤثر في معامله المسافات في كلا الصنفين واظهرت النتائج زياده معنويه في عدد البذور(غ) ، بمعامله العزيق والمسافه في كلا الاصنفين ، اظهرت النتائج زياده معنويه في وزن المائه بذره (غ)بمعامله العزيق ولم تؤثر في معامله المسافه في كلا الصنفين . اظهرت النتائج زياده معنويه في الانتاجيه (طن\ه-)في معامله العزيق ولم تؤثر في معامله المسافه ، عموما كانت المسافه 30سم افضل من المسافه 15سم ،العزيق اليدوي افضل من عدم العزيق وان الصنف بحوث افضل من الصنف سيرين في الانتاجيه.

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CHAPTER ONE

INTRODUCTION

Sunflower (*Helianthus annuus L*.) is 0riginated in North America. It is one of the most important crops in the world grown as edible oil, after soybean, rapeseed and peanut. Sunflower seed was third largest source of vegetable oil .is annual plant that growths to a length of up to about 3meters long, the large and beautiful flowers are capital type with diameter of 35cm. the seed are very nutritious containing 24%proteins, 47%oil, 20% hydrocarbons, 8% phosphorous and 9%potassium Khidir(1997).sunflower belongs to family composite has a high potential for grain yield and oil accumulation in the seed. is one of the four most important oilcropsglobally.theproducingcountriesare:Argentina,Russia,France,Ukraine,Spain, India,USA,China,Turkey,Rominia and Hungarian(FAO,2010). The total sowing area production and yield in (2012/2013) and (2013/2014) were 23,839.000 and 24,626,000 ha producing 36.062,000 tons and 42,867.000 tons respectively In Sudan, sunflower is getting increasing important as a source of vegetable oil. Official policy recently proposed putting more than one million hectares of rained land under this crop. Climatically condition and properties of the soil in Sudan are suitable for commercial production. Sunflower can be grown under rain-fed condition such as Gedarif and Demazin Blue Nile, white Nile, Suki and Rahad scheme are potentially favorable for Sunflower growing with Supplementary irrigation(Skoric,1982).In Sudan, Sunflower demonstrated at first time in Demonstration farm of Elgazera Station during 1932 until 1949. Experiments resulted that it can do well (growing by farmers in Wad Alnow, Gazera) it tried as summer at 1951/1952 and crop failed due to low fertilization Khidir, 1997.

Sunflower is grown as important oil crop after sesame, groundnut and maize. It usually cultivated in rotation with maize or sorghum to benefit from the dense mulch produced by these crops to protect the soil from the impact of rain drops and reduces the infiltration rate. Sunflower can be used for many purposes, mainly for oil extraction, bird feed, human food and cake of high quality protein source for livestock. Flour made from sunflower seeds is a good source of vitamins and mineral and seed hulls could be used for fuel. The dried stems can be returned to the soil as fertilizer, the inner part of the stem is used in paper production. The Sunflower has an ornamental value in domestic garden, and it is attractive to bees which make a good honey plant, sunflower has many medicinal uses. There are many prevailing obstacles facing sunflower production in Sudan; these include: running expensive and maintenance of machinery, bird damage, high percentage of empty seeds, water limitation at the late season and weed infestation.

Objectives of the study were:

1-To determine the effect of inter plant spacing on growth and yield of two sunflower varieties.

2-To determine the effect of weeding and un weeding on growth and yield of two sunflower varieties.

3- To determined the most productive variety.

CHAPTER TWO

LITERURE REVIEW

2.1General 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 South America. The cultivated species (*Helianthus annuus L.*) has a diploid chromosome number. The Sunflower have ability of its flower to turn towards where the sun is account for both its common name and botanical name Greek Helios sun and others flower(Miller,1987).In the thirties of the 20thcentury, 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 Abdel Nour, (2001) reported that Sunflower ranked fourth in the world oil crops after palm oil, rapeseed and soybean. The first commercial production of Sunflower as an oil crop was started in Canada in 1934 and USA in 1947 and the farmer U.S.S.R was the world leading producer in the 1960s Metakalefe and Elkin, 1980).The first hybrid produced and made available for the commercial production in the United States in 1972 and by 1976, hybrids were grown on over 80% of the Sunflower production area (Miller, 1987).

2.2 Economical Importance:

Sunflower which is a rich source of good quality edible oil and has a nice fit in our cropping pattern, is visualized as the most potential crop to narrow the gap between the total requirement and the domestic production of edible oil in the century. This could help in saving the

huge amount of foreign exchange that is being incurred on importing edible oil annually FAO, (2010). Sunflower oil has excellent nutritional propertiesand seeds contain high oil content ranging from 35-48% with some types yielding up to 50%,20-27% protein, and high percentage of polyunsaturated fatty acid (72.5%), which control cholesterol in blood Amirian et al,(2013), Non-dehulled or partly dehulled sunflower meal has substituted successfully for soybean meal in diets for ruminant animal as well as swine and poultry feeding (Skoric,1982), Hulled sunflower would be good alternative protein source to replace soybean in Europe and hulls are now an economic fuel (Dauget, 2015), Sunflower can also used as silage crop. The nutrition quality of sunflower silage is often higher than corn but lower than alfalfa (Ishag,1988), Sunflower oil contains a high proporation of unsaturated fatty acid than other vegetable oil, there for it is useful as a row material for biodiesel production Amirian,2013). Sunflower oil is also used in certain paints varnishes and plastics because of the good semi drying properties without color modification associated with oils high in linolenic acid(Ishag,1988).

2.3Growth habit:

Sunflower is an annual erect, broad leaf plant with strong tap root and prolific lateral surface roots, Stem is usually round early in the season, normally un branched, sunflower leaves are phototropic and will follow the sun rays, this property has been shown to increase light interception and possibly photosynthesis. The sunflower is not a single flower but is made up of 1000-2000 individual flower jointed at common receptacle.

The flowers around circumference are ligulae ray flowers.The remaining flowers are perfect flowers (stamens and pistils).Anthers (pollen shedding) begins at prefer and proceeds to the center of the head. Pollen movement between plants by insect is important and bee colonies generally increased yield. In temperate regions sunflower requires approximately 11 days from planting to emergence, 33days from emergence to head visible, 27 days from head visible to first anther, 8 days from first to last anther and 30 days from last anther to maturity Khidir, (1997).

2.4Adaptation:

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

2.5Effect of Spacing on Vegetative Growth:

Plant population as reported by (vijayalakshmi, 1975). influenced growth characteristic of sunflower such as plant height and number of leaves that increased with wider spacing between plants. (Karami, 1980) found that plant height decreased with increase in row spacing. In contrast to that, (Massey, 1971) reported that spacing between plants did not affect plant height or number of leaves/plant

.On the other hand ,(Khalifa,1984) investigated the effects of spacing on sunflower in the central of Sudan under rain –fed condition and under supplementary irrigation . He found that under irrigation condition plant height was no affected by row spacing, but under rain-fed condition a significant increase in plant height with wider row spacing was attained in one season only.

2.6 Effect of spacing on yield and yield component:

Ali Baghadi (2014) using plant spacing of 75, 65, 50 and 35cm observed that the result showed effect on yield and yield component of native sunflower and other result showed that space 90-100cm is only really suitable for yield. Number of seed/head and average seed weight are affected by the number of head/ha, cultivars, weather, soil and sunflower pests. Increasing plant population from (15 to 40 cm. Spacing between plants) increased head diameter were obtained by(Karami, 1980). He reported that head diameter increased with wider spacing between plants, but decreased with more plant/hill. Also, (Massey, 1971), using plant spacing of 15, 30 and 45 cm. observed that head diameter increased with each 15 cm. (khalifa, 1984) found that head diameter was increased by both wider inter –row and intra –row spacing. Increasing plant spacing of 15, 30 and 45 cm .as observed by(Massey,1971) resulted in increased seed weight of /head.(Karami1980) and (Ster*et al*. 1986) stated that 1000-seed weight increased by wider spacing between plants and decreased by increasing plant density or more plant/hill, while(Karami ,1980) and(khalifa ,1984) found that 1000-seed weight was significantly increased by wider row spacing.

2.7Effect of Weeding on Vegetative Growth:

Weeding had effect on number of leave per plant since leaves number is genetically controlled and it is hardly affected by weeding(Beshara,1999) He found that the number of leaves affected by herbicide treatment and hand weeded check as compared to the control (un weeded), Weeding did not affect plant height

this may be explained in the light of the fact that species of weeds recorded might not sufficient to cause any effect on plant height, this conformity with finding (Ibrahim, *et al*.,1988).

2.8 Effect of Weeding on Yield and Yield Component:

Yield component, number of seed per head and 100-seed weight had no effect, that contrast to the finding by (Beshara, 1999), However (Beshara,1999) found an increase of seed yield when high herbicide were applied. Hand weeding treatment cause increase of the final yield component to the control. Fageriry, (1984) reported that the highest seed yield of sunflower (6.383t/ha) was achieved by hand weeding treatment. Sunflower weeds are considered serious problem because compete for water, nutrients, light and space .that reduce crop growth and yield. Losses in million dollars are recorded all over the world due to reduction in crop yield caused by many weeds species. The reduction in sunflower yield due to weed competition range from 18 to 36% (singh and giri.2001) Weed management is important component of successful sunflower production. Sunflower is usually planted at low densities and grows slowly during the first several weeks (szentey, 1994), therefore, maintaining a weed-free sunflower crop for the first 3 to 4 weeks will minimize weed competition yields. Sunflower seedling is poor competitors to weed at early stage of development. Research studies carried out in Minnesota by Robinson *et al*., 1967) showed that sunflower could be compete with weeds but failed to develop vegetative ground cover sufficiently early in the season to prevent establishment of weed. It was also reported that maximum yield production could be obtained by keeping sunflower weed free for a period of 4-6 weeks from sowing Johnson, 1971), He Suggested that hoeing optimum timing for weed removal in sunflower could be achieved with three hoeing:(a) when rows later are visible and before appearance of second leaf, (b) or two weeks later and (c) when plant reached 30-40 cm height. keeping the plot free of weeds up to 60 days is required to have

better sunflower growth.(Gimenze and Rios ,1987), in Urguay reported that the critical period for weed competition with sunflower was 30 days after emergence. Covarelli, 1996) reported that the sunflower seed yield reduction due to weed competition was 10-40%, 30% and 17-44% respectively, In Abu Naama in Sudan, Fageiry ,1984) reported that unrestricted weed competition resulted in sunflower seed yield losses ranged from 22-100%.

2.9**Varieties in Sudan:**

The extensive commercial production was initiated in the Sudan in the late 1980s and the early 1990s with the introduction of hybrids such as Hysun-33 from Australia and pan-735 from South Africa (ElAhmadi, 2003,).A variety testing program was initiated by Agricultural Research Corporation (ARC) in 1989 and resulted in the release of two open- pollinated cultivars, Rodeo and Bolareo that were renamed Damzin-1 and Damzin-2. In addition three hybrid ,Hysun-33, Jwamkhi and Pan-7392 have been released by Arab Sudanese seed Company (ASSCO) and (ARC), two hybrid Salih and Shambat from university of Khartoum, H,2004.However in the last three years there was a release of local and introduced hybrid such as; Bohooth-1, Bohooth-2 and Bohooth-3 (2009), Pan-7049, Pan-7033 and Aguara-4 (2011), Opera and Sirena (2012), NugoldDowana and Nugold Darya (2013).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Experiment Site:

The experiment was conducted to investigating the effect of inter plant spacing and weeding in two varieties of sunflower. The experiment was carried out in winter(2018),at farm of the College of Agricultural Studies, Sudan University of Science and Technology ,Shambat, Khartoum North(Latitude 10:40 N Longitude 32:32 E and 380 meter above sea level).The climate of the site has been described by(ELzilal,1996)as semi arid and tropical with low humidity, the soil is heavy alkaline(pH8.2)

3.2. Land Preparation and Experimental design:

The land was prepared by disc plough, disc harrowed, leveled and ridged north – south, The spaces between rides 70cm The experimental design was Split-Split Block Design with four replicates. Each replicate was divided into eight plots. The main Plot was for Weeding and sub plot Variety and The sub-sub plot was Spacing size was 2*3 meters with four ridges. Sowing was done on 26 November (2018).Irrigation was applied 7-10 days. The treatments consist weeding (weeded (w1) and unwedded (w2), interplant spacing S1 (15cm) and S2 (30cm) and verities (Behooth and Serina V2) Weeds were controlled by hand weeding started after seedling stage weeding is free weeding.

3.3 Data collection: five plants were selected randomly from the two inner ridges of each plot and tagged to collect the following data. Sample of vegetative growth was taken after two months whereas yield and yield components were taken at harvest.

3.3.1Plant height (cm): Was measured at height from the soil surface to the point where the head attached to the stem, after flowering 100% reading was recorded.

3.3.2. Number of leaves / plant: It was determined by counting all the leaves of the sample.

3.3.3. Leaf area (cm^2): it was measured (cm).

3.3.4 Number of seed / head: it was determined by counting the seeds in each head of the sample.

3.3.5. Head diameter (cm): Head diameter was measured in terms of (cm)**.**

3.3.6.100-seed weight (g): it was estimated by taking 4 random samples each made of 100 seeds, taken from the bulk of seeds of the 5 plants in the random sample and then average.

3.3.7.Yield(t/ha)

seedyieldtonperhectareswascalculatedaccordingtothefollowingformula**:**

Seed yield (t/ha) = seed weight "kg"/plot*10000(m2)/ plot area (m2)*1000

Statistical analysis:-

The collected data were subjected to statistical analysis using Mstaat8; means were separated by using L.S.D.

CHAPTER FOUR

RESULTS

4.1 Mean of Vegetative growth:

4.1.1 Mean plant height (cm): Results showed that there were no significant different between inter plant spacing (15cm-30cm), varieties (Behooth and Sirena), weeding (Hand weeding and un weeding) and interaction between them. Appendix (1)

The highest mean of plant height was recorded in the inter plant spacing S1 (131.7cm) while the lowest mean was recorded in S2 (123.7cm) while the highest mean of plant highest in varieties was recorded V1 (129.4cm) while the lowest V2 (125.5cm) and the highest mean of plant highest in weeding was recorded in W1 (127.9cm) while the lowest was inW2 (126.8cm) Table 1.

4.1.2: Mean Number of Leaves per plant: Results showed that there were significant different between inter plant spacing (15cm-30cm), and no significant difference between varieties (Behooth and Sierna) and weeding (Hand weeding and un weeding). Appendix (2)

The highest mean of number of leaves per plant was recorded in the inter plant spacing S1 (32.3) while the lowest mean was recorded in S2 (31.3) The highest mean of number of leaves per plant highest in varieties was recorded V1 (31.9) while the lowest V2 (31.6) .The highest mean of number of leaves per plant highest in weeding was recorded in W1 (32.2) while the lowest W2 (31.5) Table 1.

4.1.3: Mean of Leaf area (^{cm2}): Results showed that there were no significant difference between inter plant spacing (15-30 ^{cm2}), varieties (Behooth and Sirena), and high significant difference between weeding (Hand weeding and un weeding). Appendix (3)

The highest mean of Leaf area was recorded in the inter plant spacing S1 (436.3 ^{cm2}) while the lowest mean was recorded in S2 (422.5 ^{cm2}) while the highest mean of Leaf area in varieties was recorded V1 (443.8 ^{cm2}) while the lowest V2 (414.9 ^{cm2}) and the highest mean of Leaf area in weeding was recorded in W1 (32.2 ^{cm2}) while the lowest W2 (31.5 ^{cm2}) Table 1.

Effect of inter plant spacing affected vegetative growth plant height, number of leaves and leaf area increased with wider spacing between plants reported by Vijayalakshmi.1975,while (Karami,1980)found that plant height decreased with increased in row spacing, (Massey.1917) and (Khlifa,1984)reported that spacing between plants did not effect on plant height or number of leaves per plant, Because the widely space suffer less from completion, but in this research found that Number of leaves significant increase with wider spacing similar results reported by(Vijayalakshmi,1975).

4.2 Mean of Yield and Yield Components:

4.2.1: Mean of number of seed per head: Results showed that were highly significant difference between inter plant spacing (15cm-30cm), varieties (Behooth and Sirena), and significant difference between weeding (Hand weeding and un weeding). Appendix (4)

The highest mean of number of seed per head was recorded in the inter plant spacing S2 (1176.1 t/ha) while the lowest mean was recorded in S1 (995.5 t/ha) while the highest mean of number of seed per head in varieties was recorded V1 (1149.2 t/ha) while the lowest V2 (1022.5 t/ha) and the highest mean of plant highest in weeding was recorded in W1 (1113.6 t/ha) while the lowest W2 (1058.8 t/ha) Table 2.

4.2.2: Mean of Head diameter (cm): Results showed that were no significant different between inter plant spacing (15cm-30cm), varieties (Behooth and Sirena), weeding (Hand weeding and un weeding) and interaction between them. Appendix (5)

The highest mean of Head diameter was recorded in the inter plant spacing S2 (14.8 cm) while the lowest mean was recorded in S1 (14.6 cm) while the highest mean of plant highest in varieties was recorded V1 (14.8 cm) while the lowest V2 (14.60 cm) and the highest mean of Head diameter in weeding was recorded in W1 (15.3cm) while the lowest W2 (14.10) Table 2.

Mean of 100-Seed Weight (g): Results should That There were highly significant difference between weeding (Hand weeding and un weeding), inter plant spacing (15-30cm) and Varitese (Behooth and Sirena).Appendix (2)

The highest mean of 100-Seed weight was recorded in the inter plant spacing S2 (94.8g) while the lowest mean was recorded in S1 (91.1g) while the highest mean of plant highest in varieties was recorded V2 (95.7 g) while the lowest V2 (90.1 g) and the highest mean of plant highest in weeding was recorded in W1 (100.1 g) while the lowest W2 (85.7g) Table 2.

4.2.4: Mean of Yield (t/ha): Results showed that were no significant different between inter plant spacing (15cm-30cm), varieties (Behooth and Sirena), significant different between weeding (Hand weeding and un weeding) and no significant different between interaction. Appendix (7)

The highest mean of Yield t/ha was recorded in the inter plant spacing S2 (108.2 t/ha) while the lowest mean was recorded in S1 (100.3 t/ha) The highest mean of Yield t/ha in varieties was recorded V2 (111.6 t/ha) while the lowest V1 (97.6 t/ha) and the highest mean of Yield t/ha in weeding was recorded in W1 (113.8 t/ha) while the lowest W2 (95.4 t/ha) Table 2.

).Effect of inter plant spacing on yield component Number of seed per Head diameter and 100-seed weight had significant affected similar results obtained by(Karami 1980 and Massey.1971),Because widely space suffer less from closer.

Effect of weeding on yield component had no affected by weeding reported by(Beshara,1999) because that the weeding had not be sufficient to cause any significant effect.but similar results reported by (Fagiry,1984) found that significant effect in the final of yield by using hand weeding.

Table (1) Effect of plant spacing, varieties and weeding on vegetative growth in Sunflower:

Treatment	Plant height(cm)	Number of leaves per plans	Leaf area (^{cm2})
S1	123a	31.3a	422.5a
S2	131.7a	32.3b	436.3a
V1	129.4a	31.9a	443.8a
V2	125.5a	31.6a	414.9a
W1	127.9a	32.2a	479.1a
W2	126.8a	31.5a	379.6b
CV	16.6	14.2	15.9

Abbreviation:

S1: inter plant spacing (15cm)

S2: inter plant spacing (30cm)

V1: Variety (Sirena)

V2: Variety (Behooth)

W1: Weeding (Hand weeding)

W2: Weeding (un weeding)

*same letters are not significant

Table (2) Effect of plant spacing, varieties and weeding on yield components in Sunflower:

Treatments	Number of seed(g)	Head diameter(cm)	100-seesd weight(g)	Yield(t/ha)
S1	99.5b	14.6a	91.8a	100.2a
S2	1176.1a	14.8a	94.8a	108.1a
V1	1149.2a	14.8a	90.1a	97.6a
V2	1022.5b	14.6a	95.7a	111.6a
W1	113.6a	15.4a	100.1a	113.8a
W2	105.8b	14.2a	85.7b	95.4b
CV	7.8	12.7	14.4	27.5

Abbreviation as Table (1)

*same letters are not significant

Discussion

The increase of plant height, number of leaves and leaf area of sunflower as affected by wider plant spacing may due to the increase of area available of plants to take water, nutrient and light for photosynthesis which increases plant height of Sunflower as affected by weeding may due to absence of completion between plants and weeds. The increase of yield and yield components of Sunflower as affected by wider plant spacing and Weeding treatment indicate by the ability of plant to absorb and utilize efficiently the nutrient, water and light in addition to absence of weed completion.

Conclusion

That wider inter plant spacing is better than closer,

Weeding of the sunflower is important to increase yield and un weeding decreased the yield and to produce higher yield of the sunflower it could be grown variety (Behooth).

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Appendix

Appendix (1) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of plant height (cm) in Sunflower:

Source	df	MS
Rep	3	629.4
W	1	8.6ns
Error (r*w)	3	10.1
S	1	602.0ns
W*S	1	189.1ns
Error (r*w*s)	6	457.1
V	1	121.6ns
W*V	1	161.1ns
S*V	1	237.6ns
W*S*V	1	38.2ns
Error (r*v*s*w)	12	446.8
Total	31	

ns: No significant different at p≥05

Appendix (2) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of Number of Leaves per plants in Sunflower:

Source	df	MS
Rep	3	6.4
W	1	4.8ns
Error (r*w)	3	1.9
S	1	8.4*
W*S	1	21.7**
Error (r*w*s)	6	0.8
V	1	0.7ns
W*V	1	31.6*
S*V	1	0.2ns
W*S*V	1	30.2ns
Error (r*v*s*w)	12	46.8
Total	31	

*significant different at p≥ (05)

**high significant different at p≥ (05)

ns: no significant difference

Appendix (3) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of Leaf area index (cm) in Sunflower:

Source	df	MS
Rep	3	1975.4
W	1	79162.2**
Error (r*w)	3	1707.1
S	1	1504.3ns
W*S	1	1548.5ns
Error (r*w*s)	6	1867.8
V	1	665.2ns
W*V	1	1183.4ns
S*V	1	84.5ns
W*S*V	1	882.0ns
Error (r*v*s*w)	12	4701.6
Total	31	

**high significant different at p≥ (05)

ns: no significant difference

Appendix (4) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of Number of seeds per head in Sunflower:

Source	df	MS
Rep	3	2672
W	1	2459*
Error (r*w)	3	838
S	1	2610**
W*S	1	616ns
Error (r*w*s)	6	4641
V	1	12839**
W*V	1	381ns
S*V	1	366ns
W*S*V	1	1044ns
Error (r*v*s*w)	12	7220
Total	31	

*significant different at p≥ (05)

**high significant different at p≥ (05)

ns: No significant difference

Appendix (5) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of Head diameter (cm) in Sunflower:

Source	Df	MS
Rep	3	0.70
W	1	11.16ns
Error (r*w)	3	3.21
S	1	0.42ns
W*S	1	0.94ns
Error (r*w*s)	6	5.83
V	1	0.19ns
W*V	1	8.92ns
S*V	1	0.11ns
W*S*V	1	0.47ns
Error (r*v*s*w)	12	3.51
Total	31	

ns:No significant different at p≥05

Appendix (6) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of 100-seed weight (g) in Sunflower:

Source	df	MS
Rep	3	344.7
W	1	1660.3**
Error (r*w)	3	44.2
S	1	113.6ns
W*S	1	6.5ns
Error (r*w*s)	6	163.8
V	1	253.6ns
W*V	1	825.2ns
S*V	1	11.4*
W*S*V	1	178.8ns
Error (r*v*s*w)	12	146.8
Total	31	

*significant different at p≥ (05)

**high significant different at p≥ (05)

Ns: no significance difference

Appendix (7) ANOVA Table for Analysis Variance of Effect of inter plant spacing, Varieties and Weeding of Yield (t/ha) in Sunflower:

Source	df	MS
Rep	3	1780.3
W	1	2732.4*
Error (r*w)	3	102.6
S	1	616.8ns
W*S	1	43.0ns
Error (r*w*s)	6	545.8
V	1	1552.6ns
W*V	1	225.2ns
S*V	1	291.1ns
W*S*V	1	121.2ns
Error (r*v*s*w)	12	827.6
Total	31	

*significant different at p≥ (05)

Ns: No significant difference