Sudan University of Science and Technology

College of Graduate Studies

Effect of Bio-fertilizer and Seasonality on Growth, Yield and Quality of Two Sunflower (*Helianthus annuus* L.) Hybrids at Shambat, Sudan

تاثير السماد الحيوي على نمو وإنتاجية وجودة هجينين من محصول زهرة الشمس في شمبات السودان

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

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October 2016

DEDICATION

To my father, to my mother

to my husband, sons and daughter

ACKNOWLEDGEMENTS

First of all, Praise to ***Allah*** for giving me strength and health to complete this work successfully.

I am deeply indebted to my major supervisor **Dr. Atif Elsadig Idies** for his helpful guidance, honorable advice, supervision and understanding even on a personal level throughout the course of this work.

Thanks are due to **Dr. Abdelwahab Abdalla** (University of Khartoum) and **Dr. Badreldin Abdelgadir Ahmed** (University of Kassala) for their valuable assistances. Thanks are extended to the Dean of scientific Research, Sudan University of science and Technology for financing plant of this research. Thanks also to **Mr. Abdalla Bokhari, Moroug** Company for providing me with the liquid Bio fertilizer (EM) used in this study.

Special appreciation to **Prof. Mahmoud FadlalMula, Dr. Eltayeb Suleiman** and all staff members and colleagues in Agronomy Department, Faculty of Agriculture, University of Khartoum.

My deepest gratitude is extended to my parents, sons, daughters, husband, sisters and brothers specially for their patience, encouraging and supporting during all these years of my research and I can never compensate their unlimited love and kindness.

I wish to acknowledge with thanks the enthusiasm and encouragement of my colleagues, all staff members of College of Agricultural Studies, Sudan University of Science and Technology.

Thanks to everybody helped me in one way or another and not mentioned above.

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ABSTRACT

A field experiment and quality was conducted on a silty loam soil located at Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, Sudan, during two growing summer and winter seasons of 2011/2012 to study the effect of bio-fertilizers on growth, yield of two hybrids of sunflower. The effect of bio-fertilizers on the soil were also determined. The bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75 and 25.00 L/Ha) corresponding to F1, F2, F3,F4 and F5 treatments while the two sunflower hybrids are hysun-33 (V1) and Shambat (V2). The results showed that, means of growth parameters (plant height, leaf area index and stem diameter), were higher in hysun-33 than Shambat while reverse trend was observed in case of number of seeds per head and oil content. Also, stem diameter, LAI, number of seeds per head, seeds oil content were highly influenced by bio-fertilizer application and interaction treatments. The highest, LA and stem diameter were recorded in F3× V1 treatment, while the highest seeds oil content was achieved by F4×V1 treatment. Application of F3 dose of bio- fertilizer showed major influencing factor in the most of yield attributes in summer season. Moreover, the bio-fertilizer (F4 and F5) treatments increased most of the soil properties characters (Ca, N%, ESC, pH and soil traits) particularly with Shambat hybrid. In conclusion, under conditions of this investigation, application of bio-fertilizer at rate of 18.75L/ha to Shambat hybrid sunflower could be recommended for increasing seed yield and oil % in

sunflower plant. The does of liquid bio fertilizer were added with every watering intervals, which conducted ten times per season. The experiment was arranged in split-plot based on a randomized complete block design with four replications. The main plots were allotted for the two sunflower hybrids, Hysun33 (V1) and Shambat (V2). While the subplots for bio-fertilizer treatments.

مستلخص الأطروحة

أجريت تجربة حقلية لموسمين متتابعين (صيفي2011 وشتوي 2012/2011) على تربة سلتية بالمزرعة التجريبية لكلية الدراسات الزراعية - جامعة السودان للعلوم والتكنولوجيا، شمبات. الهدف من الدراسة معرفة تأثير اضافة السماد الحيوي وصنفين من هجين زهرة الشمس على نمو وانتاجية نباتات زهرة الشمس. تمت اضافة السماد الحيوي (ميكروبات دقيقة نشطة) بمعدلات صفر،6.25،12.50،18.75 و25.0 لتر للهكتار بينما كانت الهجن المستخدمة في الدراسة هي شمبات وهاي صن 33. جرعات السماد تمت اضافتها مع كل فترة ري والتي نفذت عشرة مرات في كل موسم. تم تنظيم التجربة بنظام القطع المنشقة وعلى تصميم القطاعات الكاملة العشوائية باربع مكررات. القطع الرئيسة كانت لهجن زهرة الشمس وتحت القطع وضعت لجرعات السماد الحيوي.

أوضحت النتائج ان صفات النمو(طول النبات، معامل المساحة الورقية وقطر الساق) أعطت قيم عالية لهجين هاي صن 33 مما في هجين شمبات بينما انعكس هدا النمط في حالة عدد البذور أيضاً تأثرت كل من الصفات التالية (المساحة الورقية وقطر الساق وعدد بالقرص ومحتوى الزيت. البذور بالقرص ومحتوى الزيت) باضافة السماد الحيوي ومعاملات التاداخل، حيث كانت أكبر مساحة ورقية وقطر للساق تم تسجيلها عند اضافة 12.50 لتر للهكتار من السماد الحيوي لهجين هاي صن 33 بينما امكن الحصول على أعلى نسبة من الزيت عند مستوى الإضافة 18.75 لتر للهكتار لنفس الصنف. ولقد تبين أن الجرعة 3012.50 لتر للهكتار من السماد الحيوي كانت عاملا

مؤثراً علي معظم مؤشرات الانتاجية في الموسم الصيفي. أوضحت النتائج أن مستويات الاضافة العليا (18.75 و25.0لتر للهكتار) زادت معظم قياسات صفات التربة (نسبة الكالسيوم، النتروجين، السعة الادمصاصية والاس الهيدروجيني) خاصة لهجين شمبات.

وخلاصة القول، أنه تحت ظروف هذه الدراسة، فإن اضافة السماد الحيوي بمعدل 18.75لتر للهكتار لصنف شمبات يمكن ان يوصي باستخدامها لزيادة انتاجية البدور والزيت لهجن زهرة الشمس في منطقة شمبات.

CHAPTER ONE
INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an annual oil crop member of the family *Compositae*. It is said to be of American origin (Heiser, 1976; Khidir, 2007). Sunflower is a valuable plant both from economic and ornamental point of view. It is believed that it has been evolved from sub-species as a mutation with less extensive branching than that exhibited by the wild form (Heiser, 1976). The cultivated sunflower is a tall, erect and unbranched, coarse annual, with a distinctive large golden head (Arnon and Aslam, 1991). Sunflower is one of the most Important (Tabriz, 2012).

Sunflower is considered to be a good source of both oil and proteins. Oil content of sunflower ranges from 39-49%. Sunflower oil is generally considered a premium oil because of its light color, high level of unsaturated fatty acids and lack of linolenic acid, bland flavor and high smoke points. The primary fatty acids in the oil are oleic and linoleic (typically 90%

unsaturated fatty acids), with the remainder consisting of palmitic and stearic saturated fatty acids. Due to its edible oil content it is very important food supplement. Protein percentage of sunflower meal ranges from 28% for non-dehulled seeds to 42% for completely dehulled seeds (Putnam *et al*., 1990). Sunflower is considered to be the most suitable for margarine production, for hydrogenation and as cooking oil. The industrial uses of sunflower are the production of soaps, paints, varnishes and candles. The resulting meal is a rich source of protein utilized in the livestock and poultry feeds after oil extraction.

Sunflower was probably first introduced to Europe through Spain, and spread through Europe as curiosity until it reached Russia where it was readily adapted. Selection for high oil in Russia began in 1860 and was largely responsible for increasing oil content from 28%to almost 50%the high .oil lines from Russia were reintroduced into the U.S. after world war, which re kindled interest in the crop however, it was the discovery of the male sterile and restore gene system that mode hybrids feasible and increased commercial interest in the crop and it can grow on different types of soil but its performance is batter in soils best for the growth of maize and wheat among the cash crops (Khidir, 2007). Sunflower ranks 4th in oil seed crops all aria the world (FAO, 2000). Russia Argentina and USA are leading producer countries. Also, it is relatively proved as a good oil seed crop. It is a potential source of high quality edible oil, ranges second next to soybean as an oil crop in the world (FAO, 1985). The total sowing area, production and yield in 2012/013 and 2013/014 were 23,839,000 and 24,626,000ha producing 36,062,000 and 42,867,000 (FAS-USDA, 2014).

The first trial for growing sunflower in Sudan was 1932 at the Gezira Research Station. More trials were conducted in 1946 which are the actual Possibility of growing the crop in Sudan (Khidir, 2007). The real commercial production of sunflower in Sudan was started in the early Eighties by the private sector (sheikh Mustafa Elam in Agricultural Company) in season 1987/88 on area of 36.6 thousands hectares at Damzseen, Blue Nile State. The crop was also introduced to Rahad, Suki, and White Nile Schemes (Khidir, 1997).

According to the ministry of Agriculture of Sudan, the total area under sunflower in season 2003/2004 was 6300 ha out of this area 3360 ha were irrigated and 2940 ha were under rain fed .the total production was 385 thousand metric ton. The productivity was 952.4Kg\ha under irrigation and 238 kg/ha under rainfed (Osman and Ahmed, 2005). The major problems facing sunflower production in the Sudan as follows:

1- Presence of empty seed.
2- From partition from areas production to areas of industry and export.
3- Lack of space port forage, cultural machinery.
4- Bird damage.
5- Other problems.

Biofertilizer is defined as a substance, contains living microorganisms, which colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrient and/or growth stimulus to the target crop, when applied to seed, plant surfaces, or soil (Vessey, 2003). Bio-fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solutions and

agricultural production (Yosefi *et al*., 2011). The efficiency of EM (Effective recommended microorganisms) as a bio-fertilizer is attributed to its role in accelerating the mineralization processes of organic matter and helping the release of nutrients resulting in, enhancing the utility values of soil organic matter contents and cation exchange capacity (Yadav, 1999). Therefore, biofertilizers are gaining importance as they are ecofriendly, non hazardous and nontoxic products (Sharma *et al*., 2007). To overcome the adverse effects of chemical fertilizers the best available option lies in the complimentary use of biofertilizers as a mean of increasing yield by biological nitrogen fixation and other microbial activities (Mubassara *et al*., 2008). Nowadays multistrain biofertilizers i.e. gathered groups of soil microorganisms, having a definite beneficial well role in supporting plant growth in developing sustainable soil fertility and in bio-controlling soil born diseases (Mekki and Ahmad, 2005). On the other hand, significant differences among sunflower genotypes in yield and its components were frequently detected by many investigators (Killi, 1997; Zubillaga *et al.*, 2002; Khidir, 2007).

In recent years, biofertilizers have emerged as a promising component of integrating nutrient supply system in agriculture. Our whole system of agriculture depends in many important ways, on microbial activities and there appears to be a tremendous potential for making use of microorganisms in increasing crop production

In Sudan, few studies have been conducted on the effects of bio-fertilizer compared to control on sunflower hybrids. One of the most important means to achieve the goals of organic agriculture is to extent the application of biological fertilizers. Considering the above facts, the present study was

undertaken to assess the effect of different doses (levels) of bio-fertilizer on some growth, seed yield and quality of two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons and to determine the optimum combination suitable for improving crop production at Shambat area.

CHAPTER TWO
REVIEW OF LITERATURE

2.1 Sunflower classification

Sunflower (*Helianthus annus* L.) is one of the 67 species belongs to the genus Helianthus. It is a member of the family *Asteraceae* (*compsiteae*). There are many perennials among the sixty seven presently recognized species in this genus ,about seventeen species can be considered commercial cultivars grown for seed (Weiss,1983).

2.2 Growth habit

Sunflower is an annual, erect, broadleaf plant with a strong taproot and prolific lateral spread of surface roots. Stem is usually round early in the season angular and woody later in the season, and normally unbranched. Sunflower leaves are phototropic and will follow the sun rays with a lag of 120^{o} behind the sun azimuth. This property has been shown to increase light interception and possibly photosynthesis (Putnam *et al.*, 1990). In temperate regions, sunflower requires approximately 11days from planting to emergence, 44 days to head visible, 27 days from head visible to first anther, 8 days from first anther to last another and 30 days from last anther to maturity. Cultivars differ in maturity and usually associated with changes in vegetative period before the head emergence (Putnam *et al*., 1990).

2.3 Adaption of Sunflower

2.3.1 Temperature

Sunflower is a crop of temperate origin (Carter, 1978). It is tolerant to both low and high temperate (Robinson, 1978). It is germinates and grows

successfully across a wide range of environments including hot tropics like Sudan (Khalifa, 1981: 1984). Weiss (1983) reported that range of 8-34^{o}C is tolerated without significant yield reduction. However, the greater part of world production occurs in latitudes 20^{o} to 50^{o}N and 20^{o} to 40^{o} S (Alcan, 1971; Weiss, 1983).

2.3.2 Light and photoperiod

Sunflower is classified as photoperiod insensitive, it flowers under awide rang of day lengths and photoperiod does not act as a limiting factor in choosing its planting date or production area (Robinson, 1978). Sunflower was found to be an efficient user of light. It does not become light saturated at relatively high levels of light (Hesketh and Moss, 1963). However, sunflower leaves are phototropic (Robinson, 1978). Also, Mahmoud (1987) reported that sunflower grows and produces well under the prevailing day lengths.

2.3.3 Water requirement

Sunflower is not considered highly tolerant, but often produces satisfactory results compared to other crops. Its extensively branched taproot, penetrating to 195 cm, aids the plant during water stress (Putnam *et al.,* 1990). Weiss (1983) concluded that sunflower will produce moderate yield under rainfall as low as300 mm, but in the field the relationship between rainfall and seed yield is often almost linear from 200-500mm, with one t/ha achieved around 300-350 mm. Lazim (1985) found that seed yield of sunflower was most sensitive to water stress at flowering, it reduced head weight, number of seeds per head, 1000-seed weight and seeds yield. In Sudan, Khidir (1997) reported that central rain lands is suitable for sowing Sunflower because the rainfall ranges between 600 mm and 800 mm. Elnaggar and Allam (1991)

reported that best plant growth and seed yield of sunflower were obtained when irrigation was applied every 14 days compared to 7 days or 12 days of irrigation intervals. Elsadig (1987) indicated that the scarcity of rainfall and its uneven distribution cause a big reduction in yield due to the presence of empty seeds.

2.3.4 Soil

Sunflower grows well in a wide range of soil types from sands to clay (Robinson, 1978), with a PH ranged of 6.5-8.0 (Weiss, 1983). Ragbag (1979) reported that sunflower roots play an important role in the plant tolerance to salinity, which may act as accumulators of sodium rather than as barriers to its assimilation, and classified as low in salt tolerance. In Sudan, Skoric (1982) reported that the central rain lands, where most of sunflower is produced, is saline, have up to 70% clay of pH 8.5-9.0 with free $CaCO_3$ in the profile. Good soil drainage is required for sunflower production, but this crop does not differ substantially from other field crops in flood tolerance (Putnam *et al.,* 1990).

2.4 Factors affecting sunflower growth and yield

2.4.1 Effects of cultivars on sunflower

There are many hybrids of Sunflower grown in the world. They are diverse in plant height, oil percentage, days to pollination and harvesting. In this respect, Khidir **(**1997) reported that the hybrids grown successfully under Sudan conditions were: Hysun 33, Sunbred 281, Seed-tec 1560 m and Seed-tec 1224. Also, Khalifa (1981) found significant differences in grain yield of some sunflower cultivars depending on the system of farming and cultural practices. Moreover, Varanceanu and Stoeneseu (1978) stated that, most

hybrids tested displayed high productivity, good uniformity, superior plant and seed characteristics.

Arnon (1987) conducted a field trial at Sumsum, East of Sudan, comprising 31 sunflower hybrids of different origins under rainfed conditions, revealed that significant differences in days to flowering and maturity, plant height, head diameter, seed size and yield, with some hybrids being superior in all studied characters. Khanna (1972) in his study of seed set, indicated that sunflower hybrids were significantly different from each other with regard to the percentage of seed set, plant height, stem diameter, head diameter, days to flowering and days to maturity, meanwhile, Ample (1980) found significant variation in grain yield and seed weight in sunflower cultivars.
In trail conducted by AAA I D (1986) at Agadi, Damazin State, Sudan to compare hybrids to open-pollinated hybrids, revealed that the open-pollinated gave very low yield and high percentage of empty seeds, but no significant differences in days to flowering and to maturity were recorded. However, Adam and Osman (1990) noticed that both hybrid and open-pollinated hybrids produce empty seed in the range of 30-35% per head under normal conditions and empty seeds percentage could increased to more than 70% under adverse condition.

2.4.2 Effects of bio-fertilizers on sunflower

2.4.2.1 Plant height

Soleimazadeh *et al*. (2010) reported that using of bio fertilizer at high level significantly increased plant height of Sunflower. In this regard, they attributed these increase to the enhanced uptake of nitrogen. Also, Akabari *et al*. (2011); Kieran *et al.* (2014) reported similar conclusions.

2.4.2.2 Stem diameter

Petra *et al*. (2013) reported that, addition of bio-fertilizer to sunflower plant increased stem diameter.

2.4.2.3 Leaf number and leaf area index (LAI)

Application of bio-fertilizer to sunflower plants increased number of leaves and LAI this may be due to increase in nitrogen up taken by plant because bacteria directly affected the growth of the plants (Akbari *et al.*, 2011).

2.4.2.4 Head diameter

Soleiaman *et al.* (2010) stated that addition of bio fertilizer increased sunflower head diameter compared to control treatment. Moreover, Patra *et al*. (2013) reported that using of bio-fertilizer resulted in wider head diameter.

2.4.2.5 Yield (ton/ha)

Soleiaman *et al*. (2010) reported that increasing bio fertilizer increased seed yield of sunflower. Similarly Prama Nik and Beara (2013) stated that, addition of bio fertilizer resulted in higher seed yield of sunflower and they attributed these higher seed yield to increase in plant height, LA, filled seeds, 100-seed weight as well as stem diameter. Sunflower yield significantly differ due to growing of different hybrids particularly when treated with high bio fertilizer level (Dhanasekar and Dhandapani, 2012).

2.4.2.6 100-seed weight

Dhanasekar and Dhandapari (2012) and Kiran *et al.* (2014) reported that application of bio-fertilizer significantly increased 100-seed weight of sunflower hybrids. Also, Patra *et al.* (2013) concluded that, using of bio-fertilizer increased 100-seed weight compared to control treatment.

2.4.2.7 Number of empty seeds

Addition of bio-fertilizer increased filled seeds of sunflower (Pramanik and Bera, 2013). Similar report concluded by (Patra *et al*., 2013).

2.4.2.8 Number of seeds/head

Soleimani *et al*. (2010) attributed the increase in number of seeds /head to that, bio fertilizer increased plant growth and therefore make significant increase in number of seed per head.

2.4.2.9 Effect of bio-fertilizer on soil pH

Addition of bio-fertilizer significantly enhanced soil pH (Kiran *et al.*, 2014).

2.4.2.10 Effect of bio-fertilizer on seed oil%

Soleiaman *et al.* (2010) showed that application of bio fertilizer to sunflower resulted in higher seed oil content. However, the concomitant enhance met of growth parameters would then improve crop productivity (Ghosh and Mohiuddin, 2000; Pramanik and Bera, 2013).

2.4.2.11 Effect of bio-fertilizer on fatty acids%

Ghosh and Mahiuddin (2000) reported that fatly acids of sunflower slightly increased with application of bio fertilizer. Also, Ahmed and El-Araby (2012) concluded that, fatty acids were increased with using of bio fertilizer in sunflower.

CHPTER THREE
MATERIALS AND METHODS

3.1 General

The experiment was conducted in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat located at longitude 32°35′E and latitude 15°31′N, the climate of this area is semi-arid and with low relative humidity, the annual rainfall is about 151.8 mm (Ahmed, 2002).The soil of the site is described by AbedEihafiz (2001) as loam clay is characterized by deep cracking, moderately alkaline clays, and low permeability.

3.2 Experimental treatments and layout

The two field experiments were conducted at the Experimental Farm, Sudan University of Science and Technology, College of Agricultural Studies, Shambat (Lat. 15°40′N, Long. 32°32′E and at of 380 meters above sea level) during two successive summer and winter seasons (in the period from July 2011 to November 2011 for the summer season and in the period from November 2011 to February 2012 for the winter season). The experiments were designed to study the effect liquid bio-fertilizer (Effective Micro-organisms {EM}) on the performance of two sunflower hybrids for growth, yield, yield components and some soil traits. The experiment was arranged in split-plot based on a randomized complete block design with four replications. The main plots were allotted for the two sunflower hybrids, Hysun33 (V1) and Shambat (V2). While the subplots for bio-fertilizer treatments. The liquid bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75 and 25.00 L/Ha) corresponding to F1, F2, F3,F4 and F5 treatments. The doses of

liquid bio fertilizer were added with every watering interval which conducted ten times per season.

3-3 Source of seeds

Two sunflower hybrids (hysun33 and Shambat) were used in this study and the seeds for the two hybrids were obtained from Pacific Seeds Company at Khartoum and from Department of Agronomy, Faculty of Agriculture, University of Khartoum.

3.4 Preparation and cultural practices

The land of the experiment was prepared by disc plowing, harrowing and riding at 70 cm apart. The plot size was 5x4 meters consisting of five ridges of 0.7 m apart. Each hybrid was planted in ridges, 5 meter-long, 70 cm between ridges and 20 cm between holes. Seeds rate was three seeds/hole, the seeds were sown manually and then thinned to two plants/hole three weeks after sowing. The five liquid bio-fertilizer (EM) levels were added to the experiment at sowing date and together with watering intervals which was conducted every 10-12 days. Weeding was done manually whenever needed

3.5 Data collection

The growth, yield and soil characters were measured as following:

3.5.1 Growth characters

In each subplot randomly selected five plants were tagged to be used for the following measurements at 30, 45, 60 days from sowing date.

3.5.1.1 Plant height (cm)

Plant height was measured in each subplot from above of the soil surface to the tip of the plant using meter-tape.

3.5.1.2 Number of leaves/ plant

Leaves in the tagged plants in each sub-plot were counted to determine the average number of leaves per plant.

3.5.1.3 Stem diameter (cm)

Measured at a height at level 1/2of stem height, the stem diameter was measured as the average thickness of the main stems of five randomly selected plants as each plot using venire caliper.

3.5.1.4 Leaf area (cm^2) and leaf area index (l.A.I)

Using Watson's method (Watson and Watson, 1953) the leaf area was calculated as follows:

$$\textit{Leaf area /plant} = \frac{\textit{Total area of leaves discs} \times \textit{total dry weight of leaves}}{\textit{Dry weight of leaves disc}}$$

Then the L.A.I was calculated as follows:-

$$\textit{L.A.I} = \textit{leaf area per plant/ground area}$$

3.5.2 Yield attributes

3.5.2.1 Head diameter (mm)

Measured with a meter tape across the center of the head two or three measurements were taken in different directions and the mean head diameter were obtained.

3.5.2.2 Number of seed per head

Five heads were taken from each sub-plot, and the number of seeds per head was obtained.

3.5.2.3 1000-seed weight (g)

100 seeds were counted from the bulk seed yield of each sub-plot, weighed and the mean 1000-seed was calculated.

3.5.2.4 Percentage of empty seeds per head.

Calculated as percentage of empty seeds to total number of seeds per head

3.5.2.5 Seed yield per head (g)

Five heads were randomly taken from each subplot and the seeds were weighed using assistive balance, and the mean seed yield per head was obtained.

3.5.2.6 Seed yield (ton/ha)

Seed yield /ha was obtained by harvesting all heads on area of one square meter (m^2) from the middle ridges in each subplot. The seeds were cleaned and weighed and the seed yield (ton/ha) was calculated.

3.5.2.7 Seed oil contents

The oil content of seeds was determined by soxhlet extraction method (A.O.A.C, 1984) as follow:

3.6 Statistical analysis

The collected data of the two seasons were statistically analyzed separately according to the analysis of variance (ANOVA) by using MSTAT-C computer software packages (Nielsen, 1992). Mean comparisons were worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability according to Gomez and Gomez (1984).

CHAPTR FOUR
RESULTS

4.1 Growth attributes

4.1.1 Plant height (cm)

Analysis of variance showed significant effects on plant height due to application of bio fertilizer (F) and sunflower hybrids at 45DAS (days after sowing) in summer season only where as interaction effects were none signification at all sampling occasions in the both seasons (Appendix 2). The combined analysis (seasonality) showed significant effect on mean plant height of interaction (F×V), (Appendix 3).

In this regard, addition of bio-fertilizer at rates of 6.25 and12.5 L/ha (F2, F3) significantly increased the mean plant height at 45DAS in summer season only (Table 1a and b). Also, differences due to hybrids were significant at 45DAS in summer season. In this regard, hysun33 (V_1) gave taller plants (Table 1a). Moreover, the (V_1) hybrid receiving (F) at rate of 06.25 L/ha (although none significant) recorded the highest plants compared to other treatments particularly at 60DAS in summer season (Table 1b). Also, in the combined analysis, interaction (F1×V1) treatment at 60 DAS received 06.25 L/ha recorded the taller plant (Table 1c).

4.1.2 Stem diameter (mm)

Analysis of variance showed a significant effect on stem diameter due to bio-fertilizer only at 45 DAS in both seasons (Appendix 4). However, the combined analysis showed significant effects on stem diameter due to seasonality and interaction (S×V) at 45DAS (Appendix 3).

Addition of bio-fertilizer (F3 and F4) significantly increased the stem diameter at 45DAS in summer and winter seasons, respectively (Tables 2a and b). On the other hand, winter season gave the thicker plant compared with summer season, although there were thicker plants of hysun33 (21.74 mm) in summer season (Table 2c).

4. 1.3 Number of leaves/plant

Statistical analysis showed a significant effect on number of leaves /plant due to hybrids at 45 DAS in summer season only Appendix (5). Moreover, the combined analysis showed significant effects due to hybrids (V) and interaction (S×F), (Appendix 3).

In this laggard, V_1 scored a great number of leaves in summer season (Table 3a). Interaction (S2×V2) treatment gave the greater number of leaves/plant compared to other interaction treatments (Table 3c).

Table 1a: Effects of bio-fertilizers levels and sunflower hybrids on mean plant height (cm) in summer 2011

Summer 2011 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	31.00	31.43	31.22	118.70	98.40	108.55	135.65	135.15	135.40
6.25	46.13	51.03	48.58	146.70	149.35	148.05	168.30	162.50	165.40
18.75	51.58	49.38	50.48	157.60	133.10	145.35	149.15	158.90	154. 25
12.50	38.58	47.33	42.95	144.35	140.20	142.27	156.15	154.50	155.30
25.00	40.73	37.85	39.29	143.65	119.40	131.25	152.70	138.68	145.69
Mean	**41.60**	**43.40**		**142.2**	**128.09**		**121.16**	**149.95**	
LSD F			**11.68**			**19.37**			**17.35**
LSD V			**6.36**			**8.73**			**12.29**
LSD F×V	**NS**			**NS**			**NS**		

F_1, F_2.F_3 .F_4.F_5 = represented the bio-fertilizer levels (Zero, 06.25, 12.5, 18.75 and 25.00 L/Ha).
V_1, V_2 = Hyszun 33 and Shambat cultivar.

Table 1b: Effects of bio-fertilizers levels and sunflower hybrids on mean plant height (cm) in winter2011/2012

Winter 2012 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	16.70	18.50	17.6	86.65	81.05	83.85	144.50	133.00	138.75
6.25	16.45	19.20	17.82	80.16	84.03	82.09	133.75	139.50	136.62
18.75	18.65	18.80	18.72	69.00	89.63	79.31	141.75	151.25	146.87
12.50	11.80	16.65	14.22	66.80	84.48	75.64	130.75	152.00	141.37
25.00	14.20	14.25	14.22	69.58	70.90	70.24	140.50	137.25	138.8
Mean	**15.56**	**17.48**					**138.25**	**142.6**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**NS**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (1c): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean plant height during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	146.17	137.10	141.63	146.35	136.9	154.15	138.20	138.55	135.65
6.25	150.72	152.60	143.63	153.8	149.52	148.65	152.80	158.95	146.25
18.75	141.37	159.00	150.18	149.7	150.6	138.40	144.35	161.10	156.90
12.50	139.80	155.55	147.67	145.42	149.9	132.50	147.100	158.35	152.75
25.00	147.35	117.43	132.39	131.93	132.8	160.25	134.45	103.62	131.25
Mean	**145.08**	**144.34**		**145.44**	**143.94**	**146.79**	**143.38**	**144.11**	**144.56**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**40.03**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×F									**40.03**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

F_1, F_2.F_3 .F_4.F_5 = represented the bio-fertilizer levels,

V_1, V_2 = Hysun 33 and Shambat cultivar and S = Seasonalit.

Table 2a: Effects of bio-fertilizers levels and sunflower hybrids on mean stem diameter in summer 2011

Summer 2011 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	8.36	9.36	8.86	10.99	10.08	10.53	8.36	8.17	8.26
6.25	14.51	8.36	11.43	21.64	22.79	22.21	9.85	9.61	9.73
18.75	9.32	9.03	9.17	24.91	24.23	24.57	14.27	9.98	12.125
12.50	8.57	19.45	14.01	22.90	22.24	22.57	9.59	8.75	9.17
25.00	10.08	10.06	10.07	18.23	17.25	17.74	8.99	9.15	9.07
Mean	**10.16**	**11.25**		**16.33**	**19.31**		**10.21**	**9.13**	
LSD F	**9.19**			**7.15**			**3.52**		
LSD V	**NS**			**NS**			**2.30**		
LSDF×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table 2b: Effects of bio-fertilizers levels and sunflower hybrids on mean stem diameter in winter2011/2012

Winter 2012 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	8.50	8.25	8.37	19.00	19.50	19.25	24.25	27.25	25.75`
6.25	8.25	8.25	8.25	19.25	19.50	19.37	18.25	21.25	-19.75
18.75	8.75	8.25	8.50	19.25	19.50	19.37	24.25	24.25	-24.25
12.50	6.00	7.50	6.75	16.25	15.50	15.87	17.25	20.00	-18.62
25.00	7.25	6.75	7.00	18.25	14.67		25.00	24.50	24.75
Mean	**7.75**	**7.80**		**-18.4**	**-17.73**		**-21.8**	**-23.45**	
LSD F	**1.88**			**1.81**			**8.49**		
LSD V	**NS**			**NS**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (2c): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean stem diameter during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	16.30	17.71	17.00	17.79	16.22	17.36	15.25	18.23	17.19
6.25	14.04	15.42	14.73	11.93	17.53	10.99	17.10	12.88	17.97
18.75	19.26	17.11	18.18	19.12	17.24	21.74	16.78	16.51	17.71
12.50	13.41	14.37	13.89	11.47	16.31	11.41	15.42	11.54	17.20
25.00	16.99	16.82	16.90	17.34	16.48	18.12	15.87	16.56	17.09
Mean	**00.16**	**16.29**		**15.53**	**16.76**	**15.92**	**16.08**	**15.14**	**17.43**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (3a): Effects of bio-fertilizers levels and sunflower hybrids on mean number of leaves in summer 2011

Summer 2011 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	18.28	17.95	18.11	30.45	27.70	29.07	29.01	27.53	28.31
6.25	21.60	22.15	21.87	29.60	28.15	28.87	29.70	28.80	29.25
18.75	24.05	22.70	23.37	33.05	30.00	31.52	29.05	32.90	30.97
12.50	21.55	22.65	22.1	32.65	29.95	31.3	30.00	28.20	29.1
25.00	21.8	20.55	21.17	32.95	30.60	31.77	29.25	27.65	28.45
Mean	**21.37**	**21.2**		**31.74**	**29.28**		**29.5**	**29.01**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**1.32**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a

Table 3b: Effects of bio-fertilizers levels and sunflower hybrids on mean number of leaves in winter2011/2012

Winter 2012 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	16.70	18.50	17.6	86.65	81.05	83.85	144.50	133.00	138.75
6.25	16.45	19.20	17.82	80.16	84.03	82.09	133.75	139.50	136.62
18.75	18.65	18.80	18.72	69.00	89.63	79.31	141.75	151.25	146.50
12.50	11.80	16.65	14.22	66.80	84.48	75.64	130.75	152.00	141.37
25.00	14.20	14.25	14.22	69.58	70.90	35.12	140.50	137.25	138.87
mean	**15.56**	**17.48**		**74.438**	**82.018**		**138.25**	**142.60**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**NS**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a.

Table (3c): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean number of leaves during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	31.22	30.38	30.8	31.01	30.6	31.15	31.30	30.87	29.90
6.25	29.47	30.27	29.87	29.15	30.62	28.20	30.75	30.05	30.50
18.75	29.77	32.82	31.29	29.07	33.52	28.25	31.30	29.90	35.75
12.50	30.62	30.57	30.59	30.92	30.27	31.60	29.65	30.25	30.90
25.00	31.25	28.57	29.91	30.1	29.72	32.20	30.30	28.00	29.15
Mean	**30.47**	**30.52**		**30.05**	**30.95**	**30.28**	**30.66**	**29.81**	**31.24**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**8.85**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1

4.1.4 Leaf area (cm)

Analysis of variance showed significant effects on leaf area due to hybrids at 45 DAS in summer season only (Appendix 6). In contrast, the combined analysis showed a significant effect on that trait hybrids and (S × F) interaction treatments (Appendix 3).

Differences due to hybrids were significant at 45 (DAS) in summer season. In this regard, (v1) hybrid recorded a larger leaf area but in winter season the order was reverse (Tables 4a and b). Also, (V1) hybrid, again, recorded a larger leaf area in combined compression (Tables 4c).

4.1.5 Leaf Area Index

In all treatments, the mean LAI increased progressively with the advancement of plant growth and reached its maximum value at 60 DAS. Analysis of variance showed that hybgrids treatment had significant effects on mean LAI in summer season only (Appendix 7). Differences due to fertilizer and hybrids also, were observed particularly at the combined analysis (Appendix 3). The effects of treatments, on mean LAI were similar to the aforementioned character (Tables. 5a, b and c).

Table 4a: Effects of bio-fertilizers levels and sunflower hybrids on leaf area (cm^2) in summer 2011

Summer 2011 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	206.75	195.40	201.07	109.53	85.58	97.55	182.13	142.00	162.06
6.25	261.90	246.60	254.25	140.30	133.41	163.85	195.55	181.08	188.3
18.75	281.40	276.00	278.7	163.20	122.18	142.69	200.97	192.00	196.48
12.50	257.23	423.30	340.26	165.38	113.25	139.31	184.78	195.50	190.14
25.00	273.85	194.80	234.32	152.07	90.56	121.31	222.53	312.75	267.64
Mean	**256.22**	**267.22**		**146.09**	**108.88**		**197.19**	**204.60**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**21.83**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (4b): Effects of bio-fertilizers levels and sunflower hybrids on mean leaf area (cm^2) in winter2011/2012

Winter 2012 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	19.25	19.25	19.25	81.50	69.50	75.50	94.75	87.50	91.12
6.25	24.00	14.00	19.00	85.00	97.75	91.37	119.25	89.50	104.37
18.75	21.50	18..25	19.87	92.25	85.50	88.87	108.00	89.25	98.62
12.50	11.50	20.50	16	58.50	61.00	59.75	113.50	65.00	89.25
25.00	12.00	10.75	11.37	70.50	89.50	80.00	101.75	86.25	94.00
Mean	**17.65**	**16.55**		**77.55**	**80.65**		**107.45**	**83.50**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**NS**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (4c): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean leaf area during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	138.43	114.75	126.5	130.96	122.22	157.57	119.30	104.35	125.15
6.25	157.40	135.28	146.34	320.7	132.33	178.60	136.20	142.10	128.47
18.75	154.48	140.62	147.55	157.03	138.07	172.67	136.29	141.40	139.85
12.50	149.13	130.25	139.6	125.51	153.87	134.67	163.60	116.35	144.15
25.00	162.13	199.50	180.8	226.9	134.63	173.52	150.75	280.47	118.52
Mean	**152.31**	**144.08**		**192.22**	**136.22**	**163.41**	**141.23**	**156.93**	**131.23**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (5a): Effects of bio-fertilizers levels and sunflower hybrids on mean leaf area index in summer 2011

Summer 2011 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	1.82	1.42	1.62	2.91	2.05	2.48	4.82	3.35	4.085
6.25	1.95	1.81	1.88	3.53	3.16	3.345	4.95	4.45	4.70
18.75	2.00	1.92	1.96	4.64	3.40	4.02	5.00	5.56	5.28
12.50	1.84	1.95	1.90	4.62	3.16	3.89	4.71	4.75	4.73
25.00	2..53	3.75	2.674	4.27	2.65	3.46	5.63	7.28	6.455
Mean	**1.97**	**2.04**		**3.99**	**2.88**		**5.022**	**5.078**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**0.58**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (5b): Effects of bio-fertilizers levels and sunflower hybrids on mean leaf area index in winter2011/2012

Winter 2012 / Treatments	30 Days			45 Days			60 Days		
	V1	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
0	3.72	3.60	3.66	3.31	2.43	2.87	4.29	4.15	4.22
6.25	2.46	2.61	2.53	3.28	3.73	3.50	4.81	4.09	4.45
18.75	4.04	3.32	3.68	3.72	3.18	3.45	5.01	4.22	4.615
12.50	1.72	3.635	2.68	1.86	2.16	2.01	5.26	3.02	4.14
25.00	2.19	3.92	3.06	2.58	3.60	3.09	4.85	3.65	4.25
Mean	**3.83**	**3.42**		**2.95**	**3.02**		**4.844**	**3.83**	
LSD F	**NS**			**NS**			**NS**		
LSD V	**NS**			**NS**			**NS**		
LSD F×V	**NS**			**NS**			**NS**		

Symbols and abbreviations as designated in Table a1.

Table (5c): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean leaf area index during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	4.55	3.75	4.15	4.35	3.94	5.11	3.99	3.59	3.90
6.25	4.87	4.26	4.56	4.93	4.2	5.50	4.24	4.37	4.16
18.75	5.00	4.88	4.94	4.91	4.97	5.48	4.53	4.35	5.42
12.50	4.98	3.88	4.43	3.81	5.05	4.24	5.72	3.39	4.38
25.00	5.23	5.46	5.34	6.58	4.11	5.96	4.50	7.20	3.73
Mean	**4.93**	**4.45**		**4.92**	**4.45**	**5.26**	**4.60**	**4.58**	**4.32**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**2.33**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**1.54**
$LSD_{0.05}$ V×F									**Ns**
$LSD_{0.05}$ S×F									**4.73**
$LSD_{0.05}$ S×V×F									**8.94**

Symbols and abbreviations as designated in Table c1.

4.2 Yield Components

4.2.1 Head diameter (cm)

Analysis of variance showed significant effects only due to addition of bio-fertilizer on head diameter at summer season where as other treatments were no significant at both seasons and combined analysis (Appendices 8 and 9). In this regard, the addition of 45EM gave the widest head (14.69 cm) compared to the narrowest one (11.79) recorded in control plots in summer season (Table 6a). In the combined analysis, although not significant, the interaction treatment (30FV2S2) recorded a larger head (17.87 cm) than all other treatments (Table 6b).

4.2.2Number of seed per head

In both seasons, all treatments showed none significant effect on mean number of seeds per head in both season (Appendices 8 and 9). Although, there were none significant effect of all treatments but application of 30ml EM on SH hybrids gave the highest number of seeds per head in both seasons (Table 7a). Generally, In summer season there were larger heads with greater number of seeds (Table 7b).

4.2.3 Seed yield/plant

Analysis of variance showed significant effects due to hybrids on seed yield per plant in summer season only (Appendices 8 and 9). In summer season, both hybrids were as par in their yields per plant but application of 30F fertilizer dose on V2 hybrid gave the heaviest seeds per plant (Table 8a). Generally, in summer season there were greater seeds weights per plant compared to winter season (Table 8b). Moreover, application of 30F fertilizer dose on V2 hybrid in summer season gave the heaviest seeds per plant (Table 8b).

Table (6a): Mean head diameter (cm) as affected by bio fertilizer and sunflower hybrids during summer 2011 and winter2011/ 2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V1	V2	Mean	V1	V2	Mean
0	11.28	12.30	11.79	16.75	20.55	18.6
6.25	14.63	13.58	14.11	17.90	19.10	18.5
18.75	14.78	14.10	14.44	18.00	19.55	18.77
12.50	14.80	14.58	14.69	16.75	17.60	17.17
25.00	14.23	13.08	13.66	18.55	18.60	18.57
Mean	**13.94**	**13.52**		**17.59**	**19.08**	
LSD F	**-**		**NS**			**NS**
LSD V			**NS**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1.

Table (6b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean head diameter during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	14.01	16.42	15.21	15.26	15.17	15.37	12.65	15.15	17.70
6.25	16.26	16.33	16.29	15.8	16.78	15.90	16.62	15.72	16.95
18.75	16.38	16.82	16.6	16.31	16.89	16.85	15.92	15.77	17.87
12.50	15.77	16.08	31.85	15.23	16.62	14.95	16.60	15.52	16.65
25.00	16.38	15.83	16.10	16.18	16.03	16.42	16.35	15.95	15.72
Mean	15.76	16.05		15.76	16.03	15.09	15.63	15.62	16.98
$LSD_{0.05}$ V									NS
$LSD_{0.05}$ F									NS
$LSD_{0.05}$ S									NS
$LSD_{0.05}$ V×S									NS
$LSD_{0.05}$ V×F									NS
$LSD_{0.05}$ S×F									NS
$LSD_{0.05}$ S×V×F									NS

Symbols and abbreviations as designated in Table c1.

Table (7a): mean No. of seeds/head as affected by bio-fertilizer and sunflower hybrids during summer 2011 and winter 2011/2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V1	V2	Mean	V1	V2	Mean
0	1075.0	929.5	1002.2	500.0	495.0	497.5
6.25	997.0	907.0	952	510.0	532.5	291.7
18.75	1155.5	1349.5	1252.2	468.7	626.7	547.7
12.50	1048.2	1095.0	1071.6	518.00	580.00	549
25.00	961.0	1188.5	1074.7	665.0	622.00	643.5
Mean	**1047.3**	**1093.9**		**532.2**	**571.2**	
LSD F			**NS**			**NS**
LSD V			**NS**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1.

Table (7b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean number of seeds/head during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	787.80	712.47	750.13	1002.40	497.50	1075.00	500.00	929.95	495.00
6.25	777.38	594.88	686.13	827.27	545.00	997.27	557.50	657.28	532.50
18.75	812.35	988.20	900.27	1252.80	547.75	1155.95	468.75	1349.65	626.75
12.50	845.90	900.14	873.01	1072.03	674.00	1048.80	643.00	1095.28	705.00
25.00	850.73	905.40	878.06	1075.12	681.00	961.45	740.00	1188.88	622.00
Mean	814.83	820.22		1045.92	589.05	1047.69	581.85	1044.21	596.25
$LSD_{0.05}$ V									NS
$LSD_{0.05}$ F									NS
$LSD_{0.05}$ S									NS
$LSD_{0.05}$ V×S									NS
$LSD_{0.05}$ V×F									280.6
$LSD_{0.05}$ S×F									NS
$LSD_{0.05}$ S×V×F									NS

Symbols and abbreviations as designated in table c1

Table (8a) Mean seed yield /plant (g) as affected by bio fertilizer and sunflower varieties during summer 2011 and winter 2011/2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V1	V2	Mean	V1	V2	Mean
0	60.55	54.5	57.5	56.2	62.7	59.4
6.25	87.7	78.1	82.9	66.2	64.2	65.2
18.75	76.9	92.3	84.6	60.0	59.7	59.8
12.50	77.05	78.3	77.67	77.5	63.7	70.6
25.00	87.8	84.5	86.1	75.5	55.25	65.3
Mean	**78**	**77.5**		**67.10**	**61.11**	
LSD F			**NS**			**NS**
LSD V			**9.05**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1

Table (8b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean seeds weight /head during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	66.475	58.625	62.54	057.5	67.57	60.55	72.40	54.50	62.75
6.25	79.475	71.475	75.4	087.4	67.7	87.70	71.25	78.65	64.25
18.75	64.225	78.07	71.14	082.4	59.8	68.45	60.00	96.40	59.75
12.50	78.025	75.35	76.68	78.12	75.2	78.55	77.50	77.70	73.00
25.00	86.66	67.85	80.43	89.76	71.7	95.32	78.00	84.22	65.50
Mean	**74.97**	**70.27**		**79.04**	**68.39**	**78.11**	**71.83**	**78.19**	**65.05**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

4.2.4 100-seed weight (g)

Generally, all treatments and their interactions had no significant effects on the mean 100-seed weight in both seasons (Appendix 8). However, in combined analysis, seasonality and F×V interaction had significant effects on 100-seed weight (Appendix 9). In this regard, application 0f 15EM on V2 hybrid increased100-seed weight in both seasons (Table 9a) and this increase was significant in combined analysis where the above treatment scored high 100-seedwieght (Table 9b).

4.2.5 Empty seed parentage

The analysis of variance of mean empty seeds/head showed none significant effects in both seasons (Appendices 8 and 9). Although, all treatments were none significant but the greater empty seeds per head were recorded in control treatment particularly in the summer season (Tables 10a and b).

4.2.6 Seed yield (ton/ha)

Statistical analysis showed none significant effect of all treatments on seed yield/ha in both seasons and in combined analysis (Appendices 8 and 9).

Although, there were none significant effects due to all treatments on seed yield per unit area but Shambat hybrid (V2) scored the highest seed yield/ ha in both seasons (Table 11a). Also, the supper set of V2 in increasing seed yield/ha was clear in combined analysis as shown in (Table 11b).

Table (9a): mean 100 seed weight as affected by bio-fertilizer and sunflower varieties during summer 2011 and winter 2011/ 2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V1	V2	Mean	V1	V2	Mean
0	5.64	5.59	5.61	11.32	10.74	11.03
6.25	6.96	9.45	8.20	8.56	12.25	10.40
18.75	6.69	7.02	6.855	11.31	7.88	9.59
12.50	7.35	7.13	7.24	13.15	10.91	12.03
25.00	8.75	7.01	7.88	11.25	9.69	10.47
Mean	**5.6**	**7.24**		**11.11**	**10.29**	
LSD F			**NS**			**NS**
LSD V			**NS**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1.

Table (9b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean of 100-seed weight during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	8.52	8.545	8.50	5.61	11.4	5.64	11.39	5.59	11.49
6.25	8.39	11.36	9.80	8.20	11.5	6.96	9.82	9.45	13.25
18.75	9.01	7.37	8.10	6.78	9.6	6.69	11.31	6.87	7.88
12.50	10.63	8.09	9.32	7.24	11.4	7.35	13.90	7.13	8.92
25.00	9.01	8.60	8.80	7.80	9.70	8.75	9.27	7.01	10.19
Mean	**9.11**	**8.78**		**7.13**	**10.73**	**7.08**	**11.14**	**7.21**	**10.35**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**1.81**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (10a): mean empty seeds % per head as affected by bio fertilizer and sunflower varieties during summer 2011 and winter 2011/2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V_1	V_2	Mean	V_1	V_2	Mean
0	5.69	4.51	5.10	3.66	3.61	3.63
6.25	2.48	3.04	2.76	3.19	3.57	3.38
18.75	1.12	2.50	1.81	3.76	3.68	3.7
12.50	2.96	3.04	3.00	2.83	1.09	1.48
25.00	2.67	5.07	3.87	2.81	3.76	3.28
Mean	**2.98**	**3.63**		**3.25**	**3.54**	
LSD F			**NS**			**NS**
LSD V			**NS**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1.

Table (10b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean empty seeds/head during 2011and 2012

Treatments	V1	V2	mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	4.09	3.66	3.9	9.75	2.9	4.46	3.72	5.29	2.03
6.25	1.81	2.02	1.9	2.6	2.5	1.52	2.11	1.08	2.95
18.75	1.20	2.03	1.6	2.2	1.01	1.13	1.28	3.27	0.79
12.50	2.23	2.31	2.27	1.9	2.7	1.87	2.59	1.87	2.75
25.00	2.23	4.04	3.1	1.6	4.7	1.44	3.02	1.71	6.37
Mean	**2.31**	**2.81**		**3.61**	**2.76**	**2.08**	**2.54**	**2.64**	**2.98**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (11a): Mean seed yield/ha as affected by bio fertilizer and sunflower varieties during summer 2011 and winter 2011/2012 seasons

Treatments	Summer 2011			Winter 2011/2012		
	V_1	V_2	Mean	V_1	V_2	Mean
0	3.91	5.37	4.64	3.66	3.61	3.63
6.25	2.62	2.85	2.73	3.19	3.57	3.38
18.75	3.16	2.38	2.77	3.76	3.68	3.70
12.50	3.04	2.88	2.96	2.83	3.09	2.48
25.00	3.06	3.12	3.09	2.81	3.76	3.28
Mean	**3.15**	**3.3**		**3.25**	**3.54**	
LSD F			**NS**			**NS**
LSD V			**NS**			**NS**
LSD F×V			**NS**			**NS**

Symbols and abbreviations as designated in Table a1.

Table (11b): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean seeds yield (t/ha) during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	3.799	4.494	4.14	4.64	3.64	3.917	3.680	5.375	3.612
6.25	2.909	3.191	3.04	2.73	3.35	2.620	3.197	2.857	3.525
18.75	3.466	3.034	3.24	2.77	3.72	3.165	3.767	2.383	3.685
12.50	2.970	2.987	2.97	2.99	2.96	3.108	2.832	2.885	3.090
25.00	2.936	3.358	3.14	3.09	3.19	3.062	2.810	3.128	3.587
Mean	**3.216**	**3.413**		**3.24**	**3.37**	**3.174**	**3.257**	**3.326**	**3.005**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

4.3 Soil properties

4.3.1 Soil pH

Combine analysis of variance showed only significant interaction (F×V) effect on soil pH (Appendix 10). In this regard, the difference between all fertilizers in pH was smaller. Similar trend was also, observed between two hybrids (Table12). Further, addition of (F1) on hybrids (V2) significantly increased soil pH (7.75) compared to lower pH (7.27) recorded in plots received F_1sowing with V2 (Table 12).

4.3.2 Soil calcium (Ca)

Combined analysis of variance showed significant effect of season(s), fertilizer (F), interactions(S×F, F×V) (Appendix 10). Table 13 showed a significant difference between fertilizer on Ca in the soil where addition of F5 increased Ca compared to other fertilizer doses, in this respect, the second season scored a higher Ca% in the soil.

4.3.3 ESC

Addition of fertilizer, hybrids and their interaction with seasonality showed significant effects on mean ESC (Appendix 10). The higher ESC(6.88) scored with addition of F3 on sowing V2 compared to lower ESC (1.15) recorded with addition of F2 on sowing V1 particularly in the S1 (Table 14).

4.3.4 Soil potassium (K)

Analysis of variance shoved no significant effect of all treatments on K% the soil (Appendix 10). Although, all treatments were none significant but application of F5 increased K% in the soil particularly with V1 in S2 (Table 15).

Table (12): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean soil pH during 2011and 2012

Treatment	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	7.27	7.75	7.51	7.50	7.52	7.25	7.30	7.76	7.74
6.25	7.44	7.54	7.49	7.51	7.46	7.43	7.45	7.60	7.47
18.75	7.45	7.45	7.45	7.37	7.49	7.44	7.47	7.30	7.51
12.50	7.48	7.33	7.40	7.39	7.43	7.44	7.53	7.34	7.34
25.00	7.58	7.41	7.49	7.39	7.59	7.45	7.72	7.34	7.47
Mean	**7.44**	**7.50**		**7.43**	**7.05**	**4.40**	**7.49**	**7.47**	**7.51**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×F									**0.12**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (13): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean calcium (Ca) during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	6.14	4.82	5.48	5.77	5.2	6.18	6.11	5.36	4.29
6.25	4.31	5.21	4.76	3.44	6.04	2.68	5.95	4.20	6.14
18.75	6.58	4.30	5.44	5.39	4.63	6.61	4.44	4.18	4.82
12.50	4.35	6.21	5.28	4.9	5.61	3.88	4.82	6.02	6.41
25.00	6.99	7.41	7.2 0	5.88	8.53	5.12	8.87	6.65	8.19
Mean	**5.67**	**5.59**		**5.08**	**6.00**	**4.89**	**6.04**	**5.28**	**-**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**2.69**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**3.44**
$LSD_{0.05}$ S×F									**2.91**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (14): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean EsC during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	3.38	2.72	3.05	2.77	3.32	2.72	4.04	2.83	2.60
6.25	2.00	2.88	2.44	1.32	3.55	1.15	2.85	1.49	4.26
18.75	3.24	6.79	5.01	5.46	4.56	4.05	2.44	6.88	6.69
12.50	2.30	4.20	3.25	3.36	3.14	2.65	1.96	4.08	4.32
25.00	2.67	4.08	3.37	3.10	3.64	2.47	2.87	3.74	4.42
Mean	**2.72**	**4.13**		**3.02**	**3.64**	**2.61**	**2.83**	**3.08**	**4.47**
$LSD_{0.05}$ V									**2.88**
$LSD_{0.05}$ F									**2.79**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**4.85**
$LSD_{0.05}$ S×F									**2.40**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c.

Table (15): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean K% during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	0.168	0.116	0.141	0.197	0.121	0.140	0.126	0.11	0.117
6.25	0.118	0.206	0.160	0.190	0.128	0.116	0.120	0.277	0.136
18.75	0.208	0.136	0.172	0.186	0.158	0.227	0.188	0.145	0.128
12.50	0.166	0.157	0.323	0.158	0.164	0.165	0.166	0.152	0.162
25.00	0.163	0.131	0.147	0.141	0.153	0.153	0.174	0.130	0.132
Mean	0.165	0.149		0.174	0.145	0.016	0.155	0.163	0.135
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

4.3.5 SAR

Combined statistical analysis showed a significant effects of fertilizer, hybrids, S×V and FXV (appendix 10). In season S_1 Application of F_3 significantly scored the highest SAR value (34.65) compared with other values in table 16. However, hybrids V_2 gave a higher values of SAR (40.8 and 20.45) particularly with F3andF4 (Table 16).

4.3.6 Soil sodium (Na)

Combine analysis of variance revealed that fertilizer, S×V and S×F×V interactions had significant effects on mean NA in soil (Appendix 10).

Sowing of V_2 significantly increased Na in the soil (Table 17). Also, sowing of V_2 in the S_2 season secured the lightest Na% (37.7) compared to other hybrids in both seasons. Furthermore, application of F_2 to V_2 in S_1 significantly scored the highest value of Na (59.7) as seen in (Table 17).

4.3.7 Seed Oil %

Application of bio- fertilizer to hybrids and its interactions (F ×S, F × V and S×F×V) were significantly affected Seed Oil **%** in sunflower (Appendix 10).

Application of F_4 significantly increased fat% particularly of V_2 in S_1 season (Table 18). In this regard, although the differences between hybrids were none significant, but addition of bio-fertilizer was enhanced oil % in both seasons (Table 19).

4.3.8 Soil traits

Companied analysis showed significant effects on soil traits only due to seasonality (Appendix 10). Table 20 showed that in $S_{1,}$ using of bio-fertilizer on these two hybrids was enhanced soil properties compared to second season.

4.3.9 Nitrogen %

Statistical analysis of data indicated that, seasonality; hybrids and S×F interaction were significantly affected N% in the soil (Appendix 10). The highest N% (0.14) was detected in S_2 (Table 21) and this character also, increased with application of F_5 (0.15 N%) particularly with V_2 in the S_2 season.

Table (16): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean SAR during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	12.85	14.83	13.84	13.69	13.98	12.89	12.81	14.50	15.16
6.25	10.62	14.67	12.64	9.4	15.84	9.66	11.59	9.25	20.10
18.75	14.20	40.79	27.49	30.6	24.33	18.93	9.47	42.38	39.20
12.50	13.12	20.45	16.78	18.26	15.31	16.05	10.20	20.48	20.43
25.00	12.10	17.96	15.03	15.8	14.24	14.19	10.00	17.45	18.48
Mean	**12.58**	**21.74**		**17.55**	**16.74**	**14.34**	**10.81**	**20.81**	**22.67**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**17.44**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in table c1

Table (17): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean (Na) during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	22.40	22.89	22.64	23.06	22.23	22.54	22.27	23.58	22.19
6.25	16.28	25.25	20.76	11.98	29.54	10.44	22.12	13.52	36.97
18.75	25.53	58.90	42.21	47.00	37.41	34.36	16.69	59.65	58.14
12.50	19.40	35.12	27.26	29.68	24.83	23.07	15.73	36.30	33.94
25.00	21.57	34.43	28.00	22.39	29.11	22.14	21.00	22.65	37.22
Mean	21.04	35.32		26.82	28.62	22.51	19.56	31.14	37.09
$LSD_{0.05}$ V									1.56
$LSD_{0.05}$ F									24.57
$LSD_{0.05}$ S									NS
$LSD_{0.05}$ V×S									2.97
$LSD_{0.05}$ V×F									2.82
$LSD_{0.05}$ S×F									21.24
$LSD_{0.05}$ S×V×F									3.98

Symbols and abbreviations as designated in Table c1.

Table (19): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean Seed Oil during 2011 and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	35.62	35.47	35.54	37.03	34.05	35.61	35.63	38.46	32.48
6.25	36.21	36.08	36.14	38.00	34.29	35.40	37.03	40.61	31.56
18.75	35.23	36.98	36.10	38.87	33.34	37.80	32.66	39.9	34.03
12.50	37.62	39.43	38.52	39.4	37.64	38.52	36.73	40.30	38.56
25.00	37.59	37.95	37.77	38.27	37.26	38.66	36.51	37.88	38.02
Mean	36.45	37.18		38.31	35.32	37.02	35.71	39.43	34.93
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**2.33**
$LSD_{0.05}$ S									**NS**
$LSD_{0.05}$ V×S									**1.54**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**4.73**
$LSD_{0.05}$ S×V×F									**8.94**

Symbols and abbreviations as designated in Table c1.

Table (20): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean soil traits during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	3.32	2.46	2.89	3.31	2.47	3.61	3.04	3.01	1.90
6.25	3.96	2.07	3.01	3.35	2.68	4.98	2.95	1.73	2.41
18.75	3.21	3.03	3.09	3.48	5.53	3.60	2.83	3.36	2.70
12.50	3.78	2.41	3.09	2.80	3.38	3.60	3.95	2.01	2.81
25.00	2.23	2.93	2.58	2.82	2.33	2.23	2.23	3.42	2.44
Mean	**3.03**	**2.58**		**3.15**	**3.28**	**3.06**	**3.00**	**2.71**	**2.45**
$LSD_{0.05}$ V									**NS**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**0.73**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**NS**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

Table (21): Effects of bio-fertilizer, sunflower hybrids and seasonality on mean N% during 2011and 2012

Treatments	V1	V2	Mean	S1	S2	V1S1	V1S2	V2S1	V2S2
0	0.136	0.122	0.129	0.133	0.124	0.137	0.135	0.129	0.114
6.25	0.139	0.119	0.129	0.118	0.14	0.126	0.153	0.111	0.127
18.75	0.126	0.116	0.121	0.108	0.133	0.108	0.144	0.109	0.123
12.50	0.127	0.111	0.119	0.126	0.112	0.133	0.120	0.119	0.104
25.00	0.132	0.125	0.128	0.110	0.294	0.111	0.154	0.110	0.140
Mean	**0.132**	**0.119**		**0.119**	**0.161**	**0.123**	**0.141**	**0.116**	**0.122**
$LSD_{0.05}$ V									**0.05**
$LSD_{0.05}$ F									**NS**
$LSD_{0.05}$ S									**0.004**
$LSD_{0.05}$ V×S									**NS**
$LSD_{0.05}$ V×F									**0.042**
$LSD_{0.05}$ S×F									**NS**
$LSD_{0.05}$ S×V×F									**NS**

Symbols and abbreviations as designated in Table c1.

CHAPTER FIVE
DISCUSSION

The efficiency of Effective recommended Microorganisms as a bio-fertilizer is attributed to its enhanced uptake of nitrogen and role in accelerating the mineralization processes of organic matter and helping the release of nutrients resulting in, enhancing the utility values of soil organic matter contents and cation exchange capacity. This might explain the results obtained in most of the growth and yield parameters measured in this study.

In the present study, hysun-33 and Shambat hybrids differ significantly with each other in their morphological and growth parameters (plant height, stem diameter and leaf area index). This might be due to different genotypes in similar environmental conditions. Differences in plant growth parameters between two hybrids were under genetic control as well as phenotypic difference as reported by Arnon and Aslam, (1991). The effect was more pronounce in combined application of bio-fertilizer F3 on the hysun-33 hybrid than other applications. Moreover, the differences in yield components (head diameter, number of seeds/head, seeds weight/plant, 100-seed weight and final seeds yield per unit area) between two hybrids might be due to higher genetic potential and better adaptability under Shambat climatic conditions. These results were in agreement with Akhtar (1985) and Nadeem (1989).

Results of the present study revealed that the effects due to bio-fertilizers application on plant height, leaf area index (LAI) plant^{-1} and stem diameter were significant. The above parameters were greater in bio-fertilizer at rate of 30 g than other fertilization treatments particularly F1, F5 and control treatments. These results indicated that application of bio-fertilizer at rate of 30 g had tremendous effects on plant growth and development compared to control and other levels of bio-fertilizer application in sunflower. These increases might be attributed to the role of nitrogen in activation of metabolic and photosynthetic processes, also similar results were reported by many researchers (Soleimani *et al*., 2010; Akbari *et al*., 2011; Petra *et al*., 2013). They

concluded that the increase in the growth parameters might be attributed to enhanced uptake of nitrogen, due to addition of bio-fertilizer, by sunflower plants. However the increase in growth characters due to bio-fertilizers might. The overall enhancement of growth under bio-fertilizer possibly might explain the increase in yield components (head diameter, number of seeds/head, seeds weight/plant, 100-seed weight and final seeds yield per unit area) observed in this study. These results were in accord with the results reported by Soleimani *et al*. (2010) in head diameter and 2011; Petra *et al*. (2013) in number of seeds per head. Similarly Prama Nik and Beara (2013) stated that, addition of bio-fertilizer resulted in higher seed yield of sunflower and they attributed these higher seed yield to increase in plant height, LA, filled seeds, 100-seed weight as well as stem diameter. The variation in empty seeds percentage due to addition of bio-fertilizer observed in this investigation was agreed with result reported by Petra *et al*. (2013) who stated that addition of bio-fertilizer increased filled seeds of sunflower. Seed oil content is considered an important parameter to determine the quality of sunflower seed. The increase in that trait due to application of bio-fertilizer may be due to increase in seeds yield as a result of the above application. Also, Ahmed and El-Araby (2012) concluded that fatty acids were increased with using of bio-fertilizer. The highest number of seeds per head in Shambat hybrid (by using bio-fertilizer F3 level) can be related to the longer growth period and higher active leaf.

The differences in growth, yield components and soil properties observed due to seasonality might be due to increase in these parameters in summer season compared to winter season. Also, the superiority of shambat hybrid in these characters might be due to varietal characteristics or hereditary characters to a certain climatic conditions and adaptability. However, the concomitant enhance met of growth parameters would then improve crop productivity.

In conclusion, under conditions of this investigation, application of bio-fertilizer at rate of 12.50L/ha to Shmabat hybrid sunflower could be recommended for increasing seed yield and oil % in sunflower plant.

CHAPTER SIX
CONCLUSIONS

1. The results indicated that application of bio-fertilizer, enhanced sunflower growth.
2. The overall enhancement of growth under bio-fertilizer possibly might explain the increase in yield and most of its related parameters.
3. The highest number of seeds per head in Shambat hybrid (by using bio-fertilizer F3 level can be related to the longer growth period and higher active leaf.
4. The high seed oil content observed in the present study was exacerbated under treatments that resulted in improved seed yield.
5. The differences in growth, yield components and soil properties observed due to seasonality might be due to increase in these parameters in summer season compared to winter season.
6. The superiority of Shambat hybrid in these characters might be due to varietal characteristics or hereditary characters to a certain climatic conditions and adaptability. However, the concomitant enhance met of growth parameters would then improve crop productivity.
7. In conclusion, under conditions of this investigation, application of bio-fertilizer at rate of 12.50L/ha to Shmabat hybrid sunflower could be recommended for increasing seed yield and oil % in sunflower plant.

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APPENDICES

Appendix table (1) Oil content determination

Oil content was determined by using so xylem extraction method (A .O.A.C., 1984) five grams of seed samples were accurately weighed in an empty thimble. The thimble was then placed in sox let extraction apparatus using petroleum spirit (40-60ċ) as a solvent, the pre-weighed thimble round bottom flask 2/3full of solvent was fitted to the extraction .the apparatus was then assembled .the extraction was left to continue for eight hours .the apparatus was then carefully dismounted and the solvent was evaporated to dry mess in an oven at 105ċ.

$$\text{Oil content } \% = \frac{\text{the weight of oil extracted (gm)} \times 100}{\text{weight of the sample}}$$

Appendix (2): Mean squares of the plant height as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		Summer			winter		
Source of variations	**DF**	**PNT1**	**PNT2**	**PLN3**	**PNT1**	**PNT2**	**PLN3**
Replicates	3	127.49^{ns}	701.79^{ns}	775.06^{ns}	24.14^{ns}	339.34^{ns}	345.62^{ns}
Fertilizer(f)	4	476.87^{ns}	2082.54^{**}	1013.31^{ns}	36.53^{ns}	236.55^{ns}	114.91^{ns}
Error(a)	12	114.98	316.14	253.84	28.60	436.34	261.81
Variety (v)	1	32.40^{ns}	1990.92^{**}	59.780^{ns}	36.86^{ns}	574.26^{ns}	189.22^{ns}
SXV	4	48.829^{ns}	314.59^{ns}	149.24^{ns}	7.96^{ns}	249.35^{ns}	311.53^{ns}
Error(b)	15	89.31	168.19	332.83	13.14	472.16	162.54
Total	39	-	-	-	-	-	-
C.V(a)%	-	25.23	13.15	10.53	32.37	26.70	11.52
C.V(b)%		22.23	9.59	12.06	21.94	27.77	9.07

Appendix (3): Mean squares of the number of leaves per plant as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		Summer			winter		
Source of variations	DF	Leaves1	Leaves2	Leaves3	Leaves1	Leaves2	Leaves3
Replicates	3	13.25^{ns}	11.74^{ns}	7.98^{ns}	4.46^{ns}	103.55^{**}	3.60^{ns}
Fertilizer(f)	4	30.95^{ns}	15.25^{ns}	7.16^{ns}	3.25^{ns}	12.21^{ns}	4.46^{ns}
Error(a)	12	7.12	9.80	4.57	1.72	5.57	9.91
Variety (v)	1	1.89^{ns}	57.6^{**}	5.26^{ns}	2.20^{ns}	5.63^{ns}	6.40^{ns}
SXV	4	3.56^{ns}	0.83^{ns}	14.44^{ns}	3.12^{ns}	5.31^{ns}	13.33^{ns}
Error(b)	15	8.26	3.84	8.05	3.23	6.10	5.35
Total	39	-	-	-	-	-	-
C.V(a)%	-	12.46	10.27	7.27	10.48	9.16	9.96
C.V(b)%	-	13.42	6.43	9.65	14.38	9.58	7.31

Appendix (4): Mean squares of the stem diameter as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		Summer			winter		
Source of variations	DF	StimDim1	StimDim 2	StimDim 3	StimDim1	StimDim2	StimDim3
Replicates	3	458.86^{*}	654.64^{**}	11.923^{ns}	1.42^{ns}	8.2^{ns}	347.15
Fertilizer(f)	4	35.20^{ns}	251.9^{**}	17.216^{ns}	5.52^{ns}	18^{**}	82.37 *
Error(a)	12	71.15	43.11	10.49	3.08	2.78	60.74
Variety (v)	1	11.78^{ns}	1.76^{ns}	11.67^{ns}	0.025^{ns}	0.40^{ns}	6.10^{ns}
SXV	4	75.75^{ns}	1.57^{ns}	6.70^{ns}	1.40^{ns}	0.65^{ns}	6.71^{*}
Error(b)	15	60.16	9.44	11.66	1.525	5.93	5.32
Total	39	-	-	-	-	-	-
C.V(a)%	-	78.78	33.62	33.50	22.30	9.01	34.44
C.V(b)%		72.43	15.73	35.30	15.88	13.16	10.19

Appendix (5): Mean squares of the mean leaf area per plant as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		Summer			winter		
Source of variations	DF	LA1	LA2	LA3	LA1	LA2	LA3
Replicate	3	21918.9^{ns}	7297.06^{*}	1637.7^{ns}	73.33^{ns}	475.38^{ns}	1051.02^{ns}
Fertilizer(f)	4	21882.7^{ns}	2786.08^{ns}	12515.0^{ns}	99.83^{ns}	1268.8^{ns}	297.9^{ns}
Error(a)	12	11102.5	1100.17	11501.4	80.354	297.02	1751.87
Variety (v)	1	1208.9^{ns}	13763.7^{**}	558.98^{ns}	12.1^{ns}	96.1^{ns}	5736.02^{ns}
SXV	4	16808.7^{ns}	961.36^{ns}	4938.02^{ns}	93.537^{ns}	335.66^{ns}	506.83^{ns}
Error(b)	15	11701.03	1049.4	9175.75	90.25	452.433	1798.20
Total	39	-	-	-	-	-	-
C.V(a)%	-	40.25	26.00	53.37	52.42	21.78	43.83
C.V(b)%		41.33	25.39	47.67	55.55	26.89	44.41

Appendix(6): Mean squares of the leaf area index per plant as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		Summer			Winter		
Source of variations	**DF**	**LAI1**	**LAI2**	**LAI3**	**LAI1**	**LAI2**	**LAI3**
Replicate	3	16371.74^{ns}	5.24^{*}	10.82^{ns}	34444.96^{ns}	3.46^{**}	2.02^{ns}
Fertilizer(f)	4	12512.04^{ns}	2.93^{ns}	6.37^{ns}	2296.59^{ns}	2.91^{**}	0.30^{ns}
Error(a)	12	11501.47	0.79	6.70	39108.0	0.28	3.65
Variety (v)	1	558.98^{ns}	12.28^{**}	0.03^{ns}	34863.12^{ns}	0.04^{ns}	10.30^{ns}
SXV	4	4938.02^{ns}	0.50^{ns}	2.78^{ns}	27265.6^{ns}	1.17^{ns}	1.29^{ns}
Error(b)	15	9175.75	0.75	5.519	32073.07	0.86	3.87
Total	39	-	-	-	-	-	-
C.V(a)%	-	53.37	25.94	51.30	63.26	17.73	43.31
C.V%		47.67	25.28	46.53	57.28	31.10	45.38

Appendix (7): Mean squares of the some soil characters as affected by seasonality and bio-fertilizers on two sunflower hybrids (*Helianthus annuus*)

Source of variations	DF	pH	Ca.	ESC	Na	Fat	Soil traits	N	K`	SAR
Season(s)	1	0.05^{ns}	22.98^{**}	3.26^{ns}	6.26^{ns}	142.79^{**}	5.69^{*}	0.002^{**}	20975.41^{ns}	20.130^{ns}
Replicate	6	0.02^{ns}	1.97^{ns}	1.45^{ns}	88.24^{ns}	1.78^{ns}	0.42^{ns}	0.000^{ns}	20950.89^{ns}	17.819^{ns}
Fertilizer(f)	4	0.03^{ns}	13.63^{**}	14.70^{**}	1133.71^{**}	25.57^{**}	0.77^{ns}	0.000^{ns}	20938.45^{ns}	571.47^{**}
S×F	4	0.05^{ns}	8.38^{*}	5.48^{*}	423.53	21.00^{**}	1.62^{ns}	0.002^{**}	20954.51^{ns}	90.48^{ns}
Error(a)	24	0.016	2.03	1.64	94.08	4.63	2.48	0.000^{**}	20960.45	28.52
Variety(v)	1	0.05^{ns}	0.142^{ns}	39.88^{**}	4078.91^{**}	10.67^{ns}	10.48^{ns}	0.004^{**}	20968.06^{ns}	1679.67^{**}
S×V	1	0.03^{ns}	4.955^{ns}	0.64^{ns}	245.90^{**}	28.03^{*}	0.094^{ns}	0.001^{ns}	20946.19^{ns}	127.48^{**}
F×V	4	0.27^{**}	11.37^{**}	9.73^{**}	587.01^{**}	3.85^{ns}	4.11^{ns}	0.000^{ns}	20960.14^{ns}	395.80^{**}
S×F×V	4	0.01^{ns}	0.93^{ns}	1.43^{*}	47.65^{**}	38.35^{**}	2.98^{ns}	0.000^{ns}	20962.59^{ns}	9.51^{ns}
Error(b)	30	0.01	41.07	0.41	7.63	5.67	2.77	0.000	20958.75	8.04
Total	79									
C.V%		1.53	20.76	18.76	9.80	6.47	56.54	15.08	886.06	16.52

Appendix (8): Mean squares of the some growth characters as affected by seasonality and bio-fertilizers on two sunflower hybrids (*Helianthus annuus*)

Source of variations	DF	Plant height	Stem diameter	Number of leaves	Leaf area	LAI
Season(s)	1	13.69^{ns}	31.16*	9.870^{ns}	385.74^{ns}	0.48^{ns}
Replicate	6	813.72^{ns}	733.73**	19.66**	46242.3**	8.89ns
Fertilizer(f)	4	993.04^{ns}	50.16^{ns}	5.91^{ns}	64242.3^{ns}	3.49*
S×F	4	142.23 ^{ns}	53.48^{ns}	22.06**	4360.4*	2.49^{ns}
Error(a)51	24	506.43	34.97	5.06	8116.0^{ns}	5.42
Variety (v)	1	11.17	1.62^{ns}	0.06*	1356.8*	4.62*
SXV	1	133.38ns	23.62*	2.08^{ns}	14122.7^{ns}	13.34^{ns}
F×v	4	1536.53*	9.02^{ns}	17.78^{ns}	2655.5^{ns}	1.13^{ns}
S×FXV	4	1107.22ns	7.10^{ns}	4.82^{ns}	3049.0^{ns}	2.85^{ns}
Error(b)	30	461.30	8.48	7.39	4118.5	4.11
Total	79	-		-	-	
C.V%		14.84	18.04	8.92	43.30	43.21

Appendix (9): Mean squares of the some yields characters as affected by seasonality and bio-fertilizers on two sunflower hybrids (*Helianthus annuus*)

Source of variations	DF	Head dim.	Empty seeds	Seeds wt/plant	No.seeds/plant	*100-seed wt*	Yield/ha
Season(s)	1	5.35^{ns}	2.35^{ns}	1887.62^{ns}	4176111.77^{**}	258.75^{**}	0.33^{ns}
Replicate	6	84.37^{**}	23.56^{**}	1008.03^{ns}	90092^{ns}	5.75^{ns}	1.62^{ns}
Fertilizer(f)	4	4.31^{ns}	13.80^{ns}	765.83^{ns}	141582.63^{ns}	7.07^{ns}	3.62^{ns}
S×F	4	1.96^{ns}	15.03^{ns}	701.00^{ns}	101817.94^{ns}	9.06^{ns}	2.22^{ns}
Error(a)	24	4.97	5.97	841.71	127679.49	6.22	1.73
Variety(v)	1	5.77^{ns}	4.98^{ns}	224.31^{ns}	580.50^{ns}	2.14^{ns}	0.77^{ns}
S×V	1	12.40^{ns}	0.27^{ns}	235.43^{ns}	1624.50^{ns}	4.27^{ns}	0.04^{ns}
F×V	4	4.97^{ns}	2.95^{ns}	412.61^{ns}	75689.26^{*}	17.84^{**}	0.73^{ns}
S×FXV	4	6.31^{ns}	5.25^{ns}	148.61^{ns}	59541.26^{ns}	9.87^{ns}	0.88^{ns}
Error(b)	30	4.06	2.10	170.34^{ns}	28896.98^{ns}	3.16^{ns}	0.92^{ns}
Total	79			41817.44	10164614.05	719.23	109.38
C.V%		12.57	56.47	17.81	20.79%	19.88%	28.66%

Appendix (10): Mean squares of yield characters as affected by bio-fertilizers on two sunflower hybrids (*Helianthus annuus*) during summer and winter seasons

Seasons		**Summer**				**winter**			
Source of variations	DF	No,seeds/ plant	Seeds wt/plant	yield/ha	100-seed wt	No,seeds/ plant	Seeds wt/plant	yield/ha	100-seed wt
Replicates	3	103012.02	1590.22	2.264	4.05	108399.93	107.23	0.957	7.36
Fertilizer(f)	4	103687.1^{ns}	1107.92^{ns}	5.08^{ns}	8.19^{ns}	24629.82^{ns}	169.06^{ns}	0.73^{ns}	6.49^{ns}
Error(a)	12	108203.52	1593.49	2.64	8.63	25039.18	231.16	0.68	13.42
Variety (v)	1	21669.02^{ns}	2.13^{*}	0.27^{ns}	0.26^{ns}	15132.10	354.05^{ns}	0.850^{ns}	6.79^{ns}
SXV	4	55006.77^{ns}	189.66^{ns}	1.33^{ns}	4.64^{ns}	11811.10	234.21^{ns}	0.35^{ns}	14.88^{ns}
Error(b)	15	84963.62	180.52	1.41	2.83	15456.16	105.17	0.27	5.88
Total	39	3538377.3	31793.03	85.77	209.87	1018408.40	6640.37	20.42	363.77
C.V(b)%		27.23	17.27	36.70	23.50	22.53	15.99	15.42	22.66

Appendix.11: oil sampling and Physico-Chemical characteristic:

Soil samples were collected using auger at two depths of 30 and 60 cm in the two seasons. The samples were taken for two times; Pre-cultivation and three samples were taken randomly and post harvest from all plots. Soil analyzed in soil laboratory at Faculty of Agriculture.

Soil texture was determined using hydrometric method (Bouyoucos, 1962; Gee and Bauder, 1986). Saturated soil paste was prepared adding distilled water to 250 g soil in a plastic beaker while stirring with a spatula. Saturated soil paste was kept overnight to allow salt dissolution and equilibration (Richards, 1954), then transferred to the suction funnel with filter paper in place and vacuumed. The extract was collected in labeled polyethylene bottles for analysis. The pH of soil suspension with soil: water ratio of 1:5 and water samples was determined using the 105 Ion analyzer pH meter (McLean, 1982; Thomas, 1996). Electrical conductivity (EC) was measured using a digital EC meter, Wiss. Techn. Werkstatten (WTW) D12 Weilheim (Rhoades, 1982).

Soil saturation extracts, were analyzed for Na and K concentrations using a Perken-Elmer flame photometer model No.2380. The concentrations of Na and K were calculated in mmol (+) L-1 (Richards, 1954). For determination of Ca and Mg, 3 mL of soil saturation extract was taken into a 15 mL, wide mouthed porcelain crucible and 1 mL of NH4CI plus NH4OH and few drops Eriochrome Black-T were added. The sample was titrated against 0.01 N EDTA until the color was changed from wine red to blue or green (Richards, 1954). Using values of Na and Ca+Mg concentrations [mmol (+) L-1] in soil saturation extracts, the SAR of the soils and water was calculated using the formula (Richards, 1954):

$$SAR = \frac{[Na]}{\sqrt{\frac{[Ca+Mg]}{2}}}$$