# SUNFLOWER BASED INTERCROPPING WITH LEAFY VEGETABLES



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# SUNFLOWER BASED INTERCROPPING WITH LEAFY VEGETABLES

BY

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# CERTIFICATE

This is to certify that thesis entitled **"SUNFLOWER BASED INTERCROPPING WITH LEAFY VEGETABLES"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University Dhaka-1207, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE AND POSTHARVEST TECHNOLOGY** embodies the result of a piece of *bona fied* research work carried out by **MOHAMMAD GOLAM MOWLA,** Roll No. 00212, Registration No. 23981 / 00212, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged by him.

Dated: 21.5.06
Dhaka, Bangladesh

(Md. Ruhul Amin)
Professor
Supervisor

DEDICATED TO MY BELOVED PARENTS

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# SUNFLOWER BASED INTERCROPPING WITH LEAFY VEGETABLES

BY

**Mohammad Golam Mowla**

## ABSTRACT

An experiment was conducted at the Horticultural Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2004 to February 2005 to investigate the sunflower based intercropping with leafy vegetables. There were two variety of sunflower viz. Kironi, Sunwheat-103 and four intercrop viz. non-intercrop, Red amaranth, Bengal spinach and Pak-choi. The treatment combinations were set in a Randomized Complete Block Design (RCBD) with three replications. Growth and yield parameters were recorded and the cost benefit analysis was computed to assess the yield potentiality and profitability of sunflower and intercropping of leafy vegetable. Sunflower variety had significant effect on plant height, number of leaves, diameter of the head, seed yield, 1000 seed weight and oil content. The highest seed yield (961.11 kg/ha) was obtained from variety Kironi. Intercropped leafy vegetables intercropping had remarkable effcet on growth, flowering and yield. The combinations of variety and intercrop significantly influenced the plant height, number of leaves, diameter of the head, seed yield and 1000 seed weight. The highest seed yield (1133 kg/ha) was found in the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$). Highest intercrop yield (13.69 t/ha) obtained from the dwarf variety and Red amaranth intercrop ($V_DI_L$) treatment combination. Economic analysis showed that tall variety sunflower ($V_T$) with Red amaranth intercrop ($I_L$) gave the best economic return (Tk 77539/ha) and benefit cost ratio of 2.45.

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| | | |
|---|---|---|
| Abstr. | = | Abstract |
| AEZ | = | Agro Ecological Zone |
| Agron. | = | Agronomy |
| Agric. | = | Agriculture |
| BARI | = | Bangladesh Agricultural Research Institute |
| BAU | = | Bangladesh Agricultural University |
| BCR | = | Benefit Cost Ratio |
| cm | = | Centimeter |
| cv. | = | Cultivar |
| DAS | = | Days After Sowing |
| DM | = | Dry Matter |
| DW | = | Dry Weight |
| *et al* | = | *et alii (and others)* |
| FAO | = | Food and Agricultural Organization |
| Fig. | = | Figure |
| FW | = | Fresh Weight |
| g | = | Gram |
| Hort. | = | Horticulture |
| i.e | = | That is |
| J. | = | Journal |
| K | = | Potassium |

| | | |
|---|---|---|
| kg | = | Kilogram |
| LSD | = | Least Significant Difference |
| m | = | Meter |
| MP | = | Murate of potash |
| N | = | Nitrogen |
| NS | = | Non-significant |
| P | = | Phosphorus |
| Res. | = | Research |
| RCBD | = | Randomized Complete Block Design |
| SAU | = | Sher-e-Bangla Agricultural University |
| Sci. | = | Science |
| Soc. | = | Society |
| t/ha | = | Ton per hectare |
| tk | = | Taka |
| TSP | = | Triple Super Phosphate |
| Viz. | = | Namely |
| % | = | Percentage |
| @ | = | At the rate of |

# CHAPTER -1
# INTRODUCTION

# CHAPTER -1

# INTRODUCTION

Bangladesh is one of the densely populated country of the world. The population of the country is increasing at an alarming rate and becomes very difficult to balance between production of food and population growth. Many efforts have been taken to increase the food production of the country and it increased several folds during the past two decades. Further increase of food production through horizontal expansion is not possible due to limited cultivable land. Therefore, food production should be increased vertically with the adoption of modern varieties, improved cultural techniques and appropriate cropping systems.

Intercropping is the growing of two or more crops simultaneously in the same piece of land in alternating rows or sets of rows. Intercropping is one of the techniques of vertical expansion of crops production. Intercropping has several advantages over monoculture; such as enhances efficient use of environmental factors (e.g. light, nutrient and soil moisture) and labours, reduces the adverse effect of various biotic and abiotic stress, provides diversity of food, generate income, gives stability in production, offers insurance against crop failure, gives higher return and total productivity per unit area (Gangasarma and Gajendra, 1985; Kushwada, 1985 and Prasad *et al.*, 1985). Intercropping compatible crops can be of great value in achieving the improved productivity without requiring significant additional resources. All possible space in the crop field are fully utilized in intercropping system. Vegetables are the main component of human food that supplies proteins, carbohydrates, fats, vitamins and minerals. Our vegetable production is much less

than requirement. However, limited scope of bringing additional land for vegetable production, demands intervention of growing more vegetable per unit area and time i.e. vertical expansion. Intercropping among different vegetables like other form of multiple cropping can play an important role in increasing vegetable production (Rashid, 1987). While intercropping is widely practiced with cereals, the benefits of intercropping vegetables both from our economic and dietary aspects have been largely ignored. However, it is viewed that intercropping will be very successful for more vegetable production if proper crop combinations are identified. Intercropping is considered as a very efficient technique in maximizing the vegetable production per unit area, if plant competition is minimized by selecting suitable crops and adoption of proper plant population spatial arrangement, nutrient and moisture management (Midmore, 1993).

Sunflower (*Helianthus annuus* L.) is an important oil seed crop all over the world. It is a member of family compositae. Sunflower has originated in the South-western part of North America and Mexico (Heiser, 1976). '*Helianthus*' originates from Greek word 'Helios' meaning sun and 'anthos' meaning flower. According to Heiser (1976), there are sixty-seven (67) recognized species is the genus *Helianthus*, seventeen (17) of which can be considered as cultivated sunflower (Weiss, 1983). The commercial varieties grown for seed are considered *H. annuus* var. *marcocarpus* (DC) CK-II with *H. annuus* sub sp. *lenticularis* nearest wild relative (Skoric,1988). The species most closely related to *H. annuus* is considered to be *H. argophyllus* native to texas (Heiser, 1976). Most ornamentals should apparently be referred to *H. annuus* sub sp. *annuus*, the weed sunflower of Western-north America. Sunflower was wild crop at its place of origin and the seeds were used for food by the people of

that region. Cultivation of sunflower was started in North America when the Europeans migrated there. They reintroduced the cultivated sunflower from Europe in the late 19th century. Sunflower was introduced to Europe in the 16th century (Weiss, 1983). It became a very popular ornamental plant there and established as an oil seed crop in the Eastern Europe. Some high yielding Russian cultivars viz., 'Peredovik', 'Mennonite' and 'Sunrise' were introduced to Europe and America after the Second World War.

World sunflower production has expanded during the last decade to become the second leading oil seed crop followed by soybean (Kromer, 1974). Sunflower is considered to be an efficient user of radiation energy because of its high photosynthetic nature and comparative superiority to other oil seed crop in terms of oil composition and yield (Rahman, 1980). All parts of sunflower plant have been their economic use (Figure 1). Rahman (1980) reported that, sunflower seed contain 25-48% oil (depending on the extraction method), 27% protein, 14% carbohydrate and produces 569 calories per 100 gm. As edible oil sunflower oil is of high quality. Harmful erucic acid is absent in sunflower oil. Hence, the oil is considered for superior to mustard oil. Its particular value is that it contains vitamin-A, D, E and K. The average composition of oil is 55-60% linoleic acid and 25-30% oleic acid. Oil cake from sunflower is high in the protein content and is an excellent livestock feed and a popular fertilizer. The whole plant, including the threshed heads can be used as fodder. The seeds can be eaten as raw, roasted or salted or made into flour. Head contain about 7% crude protein, 4% oil, 43% nitrogen free extracted substances, 14% mineral substances and less cellulose than alfalfa.

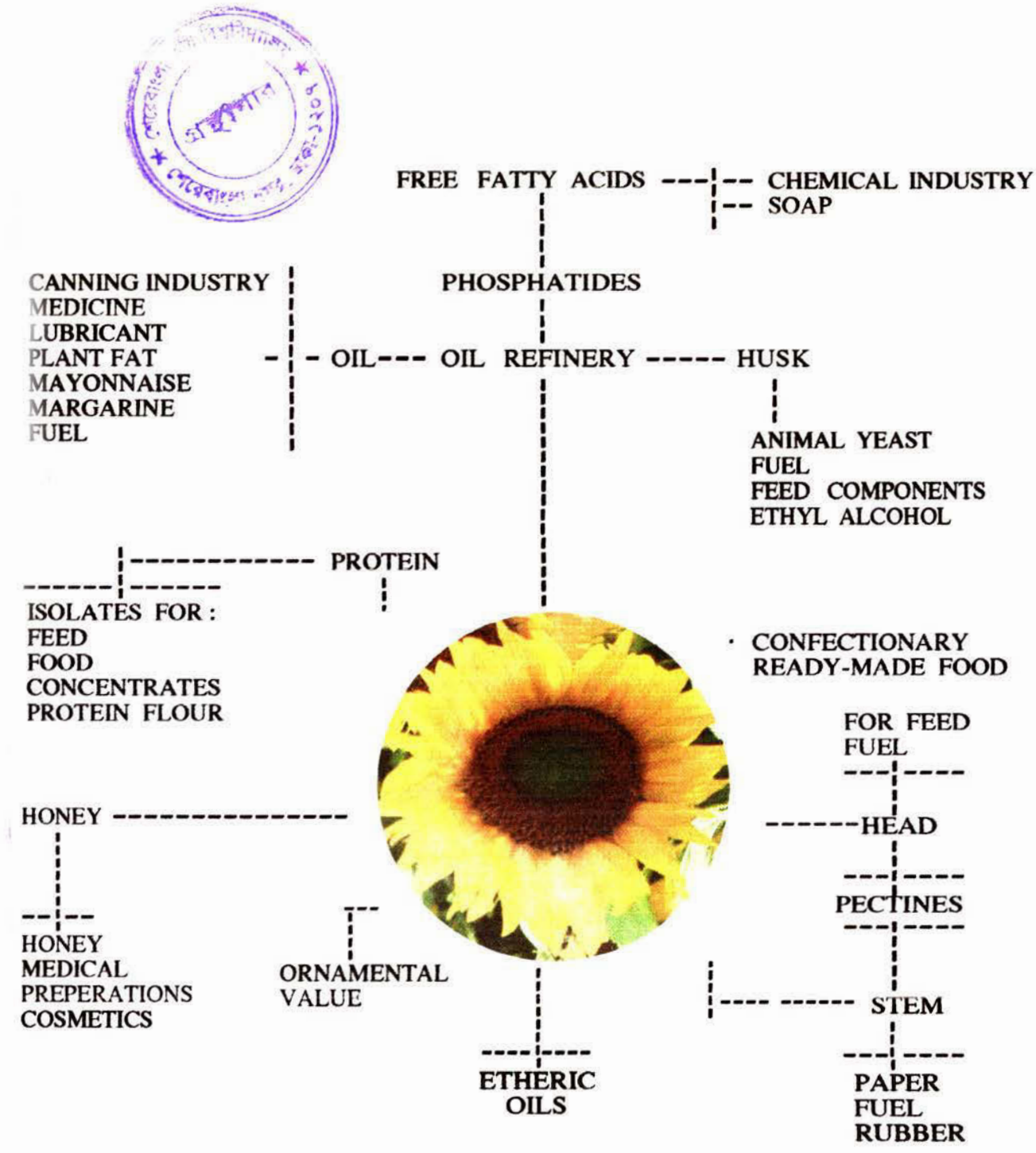



Figure 1. Economic value of Sunflower

Sunflower is considered as one of the most important oilseed crop in many western and eastern countries of the world. It is now widely produced in Rumania, Turkey, Bulgaria, Argentina, Spain, Yugoslavia, USA, South Africa, Russia, India and many other countries. The commercial cultivation of sunflower was started in India during 1972-73 with few imported varieties from Russia and Canada (Sindagi, 1985). In Bangladesh, sunflower is a very minor crop. It has been introduced as an oil seed crop by BARI (Bangladesh Agricultural Research Institute) and MCC (Mennonite Central Committee). In our country sunflower was introduce by MCC in 1972. The MCC has provided seed directly to the farmers. The BARI has recently introduced seeds of few high yielding varieties viz., 'Kironi' and 'BARI Sunflower-2' in 1982 and 2004 respectively. The oil seed section of BARI is conducting experiments at different substations of the country. Its production is limited to very small areas of Rajshahi, Noakhali and Jamalpur districts (Khaleque, 1986). It is however, a popular ornamental plant in Bangladesh. There is considerable scope to grow sunflower as an oil crop after harvest of transplanted aman (T-aman) rice in some northern districts of the country. Sunflower can be cultivated at any time of the year, i.e. Kharif-1, Kharif-2 and Rabi (Sindagi, 1985). Hence, it can play an important role in reducing the chronic shortage of edible oil in the country. As sunflower is planted in rows there is ample scope of intercropping with leafy vegetables that will increase the production of vegetables.

Intercropping become most productive and economic when both the crops differ with genetic make up, photosynthetic pathway, growth habit, growth duration and demand of different growth resources (Fukai and Trenbath, 1993). Intercropping is a common practice in many tropical countries.

Available information in respect of production potential, profitability of sunflower-leafy vegetable intercropping system under Bangladesh condition is inadequate. In view of aforesaid situation, the present study was undertaken with the following objectives—

1. To study the effect of different intercrop on different stages of sunflower development.

2. To find the suitable intercrop combinations for higher yield and better economic return.

# CHAPTER-2

# REVIEW OF LITERATURE

# CHAPTER-2

# REVIEW OF LITERATURE

Sunflower is the second most popular oil crop in the world trade. Many research works have been conducted on various aspects of this important oil crop in different parts of the world. But few research works have been carried out on sunflower based intercropping in Bangladesh. However, a review of literature related to the present study has been presented in this chapter.

Maloy and Sarkar (2001) conducted an experiment to find out the yield optimization through sunflower based intercropping system. Sunflower, green gram, black gram and sesame were planted singly and sunflower (paired row) was intercropped with green gram, black gram or sesame (single or paired rows). They observed that plant height and total dry matter were maximum when sunflower was grown singly followed by intercropping with green gram or black gram. Dry matter accumulation was higher in sunflower intercropped with green gram or black gram than with sesame. The highest total productivity in terms of sunflower equivalent has been recorded through two rows of sunflower intercropped with one row of green gram (27.6 q/ha), followed by sunflower intercropped with two rows of green gram (26.33 q/ha).

Lopez *et al.* (2001) carried out an experiment to investigate the effect intercropping sunflower and maize in Mozambique. Maize sunflower intercropping ratio (25:75, 50:50 and 75:25), in comparison with pure stand crop of two sunflower

(20 GN and Black Rekord) and maize (Natuba and Manica) cultivars. Both Maize cultivars, yield/plant decreased in relation to density. The intercropping 75:25 maize: sunflower ratio showed the highest seed yield/ha (5195 kg/ha).

The performance of sunflower (*Helianthus annuus)* with intercrops under various planting pattern. Three planting patterns (2:1, 3:1 and 4:1 ratio under replacement series) and three intercrop (Red gram, Sesame and Bengal gram). Result revealed that planting of component crops at 3:1 ratio under replacement series was optimum for better growth, increase sunflower grain yield equivalent (1019 kg/ha) and higher net income (Rs. 6392 Tk/ha) with higher BCR (2.69). The yield of intercrops reduced by 17.7% and 33.8% and 3:1 ratio and 4:1 ratio compared to 2:1 ratio. (Chellaiah *et al.* 2001)

Shanwad *et al.* (2001) conducted an experiment to study the integrated nutrient management in sunflower pigeon pea intercropping system. Combination of 3 organic sources (Farmyard manure, vermicompost and poultry manure) and 5 fertilizer levels (0, 25, 50, 75 and 100% recommended dose). Sunflower and pigeon pea 30 cm x 60 cm spaced with 2:1 row proportions. Result revealed that application of poultry manure + 100% Recommended dose of fertilizer (RDF) to sunflower and 50% RDF to pigeon pea, farmyard manure + 100% RDF to sunflower and 50% RDF to pigeon pea were suitable combinations in intercropping system.

The effect of preceding crops and nitrogen fertilizer on sunflower and peanut in monoculture and in association. Sunflower and groundnuts in pure stands or a 2:2 intercrop were grown after faba beans or wheat and given 15, 30 or 45 kg N/ fodder.

Sunflowers yield was higher after faba beans than after wheat. Intercropping slightly increased sunflower yield but decreased groundnut yields from 819 to 543 kg/feddan. Increasing N rate did not significantly affect yield of either crop. [1 feddan = 0.42 ha]. (Greish 1999)

Muhammad *et al.* (1999) carried out an experiment to investgate the effect of intercropping of sunflower with mungbean. Sunflower cv. Hysun-33 and mungbean cv. NM-54 were grown separately or intercropped ratios of 1:1, 1:2, 1:3, 3:1, 3:2 and 3:3 in field trail. The highest sunflower yield of 4.13 t/ha was obtained from the sole crop. It was closely followed by 2:3 and 2:2 ratios with 4.12 and 4.08 tons respectively.

Sarkar and Chakraborty (1999) conducted an experiment to find out the potential and feasibility of sunflower based intercropping systems under different seeding methods in rice fallow land. Sunflower, green gram, black gram and sesame were sole cropped or paired rows of sunflowers were intercropped with 1 or 2 rows of the other crops or the other crops were broadcast sown. Intercropping sunflowers with 1 row of green gram gave the highest sunflower and sunflower equivalent yields, momentary advantage net return, income equivalent ratio.

Reddy *et al.* (1998) conducted an experiment to study the effect of moisture stress and management practices on productivity of rainfed sunflower. The observed that sunflowers not exposed to water stress gave 54 and 51% additional seed yield and return respectively, than unirrigated sunflowers. Supplemental irrigation of 5 cm of the flowering and grain-filling stage and addition of 10 µg extra N at grain filling and

provision of soil cover from an intercrop of prevent soil moisture stress during vegetative growth stabilized seed yield and income from sunflowers (yields ranged from 1.81 t/ha in the unirrigated crop to 1.88 t in the stress free crop).

Mondal *et al.* (1998) studied the effect of intercropping soybean with maize and sunflower. Soybean, sunflowers and maize were grown alone or soybean was intercropped with sunflowers or maize in different row arrangement. Soybean yield was 1.64 t/ha in a pure stand and 0.36-1.52 t when intercropped. Maize and sunflower yields were also decreased by intercropping but LER of 1.18-1.59 indicated the overall benefit of intercropping. The highest LER and soybean yield were given when 3 rows of soybean were grown between 2 paired rows of maize. The treatment also gave the highest gross margin.

Masood *et al.* (1998) carried out an experiment to study of genotypic compatibility and spatial arrangements in spring sunflowers and green gram intercropping. Green gram:Sunflower row ratio of 4:1, 6:1 or 6:2. Green gram seed yield was decreased by intercropping. The total productivity of the system and land use efficiency was markedly increased by intercropping. Green gram (cv. ps 16/sunflower (6:2) intercrop produced the highest mean sunflowers equivalent yield of 1726 kg/ha.

Yadav *et al.* (1998) carried out the experiment on influence of nitrogen and row spacing with different intercrops on growth and nitrogen uptake of sunflower. Sunflowers were sole cropped at row spacing of 50 or 60 cm or intercropped with Palak (spinach beets) at 60 cm row spacing and a 1:1 row ratio or with bottle gourds

at 60 cm row spacing and a 3:1 row ratio. Crops were given 40, 60 or 80 kg N/ha. Dry matter accumulation and N uptake increased with increasing N-rate, while light transmission ratio decreased. Dry matter accumulation and N-uptake were greatest in sole cropped sunflowers at 60 cm spacing and lowest at 50 cm spacing.

Yadav *et al.* (1998) studied on the effect of response of spring sunflower to nitrogen and row spacing with different intercrops for rice fallows of eastern Madhya Pradesh. Sunflowers were sole cropped at row spacings of 50 or 60 cm or intercropped at 60 cm row spacing with Palak at a 1:1 row ratio or bottle gourds at a 3:1 row ratio. Crops were given 40, 60 or 80 kg N/ha. Yields of all 3 crops increased with increasing N rate. Sunflower yield was greatest in the sole crop at 60 cm spacing, followed by intercropping with bottle gourds.

Galal (1998) studied the effect of different intercropping systems on yield and yield components of maize and sunflower. Sunflower and maize were grown in pure stands or intercropped in different row arrangements. Yield of both crops was highest in pure stands and progressively decreased with decreasing proportion in the intercropping system. Maize was the dominant component in all intercropping system, as indicated by positive values for aggressively.

Karam *et al.* (1998) carried out on the experiment of the response of mungbean and urdbean/sunflower intercropping to varying planting pattern. Mungbean cv. T44, urdbean cv. T9 and sunflower cv. Modern were grown in pure stands or in 3:1, 6:2, 4:1 or 8:2 sunflower legume intercrops. Yield of all crops was decreared by intercropping. Sunflower equivalent yield and net monetary returns were highest from

the sole of sunflowers. Land equivalent ratio was only above 1 in the 6:2 sunflower: mungbean-intercropping system.

Nyakatwa and Nyati (1998) studied the effect of maize and sunflower relation sowing time and rainfall distribution under three cropping systems in a semi-arid region of Zimbabwe. Maize and sunflowers in sole, inter and relay cropping system. Sowing after average sowing date of the area reduced maize grain yields in sole, inter and relay cropping by 65.6, 37.6 and 74.9 kg day-1 respectively. Maize grain yields in 1989/90 were respectively 3.6, 2.1 and 2.3 ton/ha in sole, inter and relay cropping due to above-average rainfall at sowing. Similar values for sunflowers in the same year were 0.9, 0.4 and 0.1 t/ha respectively. Relay cropping maize and sunflowers at 11000 plants /ha of each crop was the best cropping system.

Sarkar *et al.* (1998) studied the effect of potential and feasibility of intercropping of sunflower with pulses and oil seeds under different planting patterns on rice fallow land. Sunflower cv. Modern grown in uniform rows or paired rows were intercropped with green gram cv. T44, black gram cv. T9, groundnuts cv. AR 12-24 or sesame cv. B67. Sunflower yield were greatest with green gram, while sunflower equivalent yields were greatest with sunflowers in uniform rows intercropped with groundnut followed by sunflowers in paired rows intercropped with groundnut.

Shinde *et al.* (1998) carried out an experiment on the sunflower based intercropping system under rainfed conditions. Sunflower groundnut and soybeans were grown alone or sunflower was intercropped with the legumes. The sunflower

seed yield equivalent, gross and net monetary returns and cost benefit ratios were lowest with sole sunflowers. Sunflowers intercropped with groundnuts, where the sunflowers row spacing was 45 cm x 45 cm produced sunflower and groundnut seed yields of 1338 and 136 kg/ha respectively and the highest net returns.

Muhammad *et al.* (1998) studied the effect of economic feasibility of intercropping raya and sunflower at different plant densities in autumn planted sugarcane. In their field study raya and sunflower were grown at 25, 50 or 100 cm plant spacing. Sugarcane yield was decreased by up to 7.5% by sunflowers and 17.5% by raya. Net returns were increased by intercropping, but not significantly.

Lal *et al.* (1998) carried out an experiment to study the response of sunflower genotypes to raw spacing and fertility levels. Four sunflower cultivars were grown at 45 or 60 cm row spacing and given 40:60:40, 60:90:60 or 80:120:80 kg N: $P_2O5$:$K_2O$/ha seed yield was little affected by spacing, increased with up to 60:90:60 kg N: $P_2O5$:$K_2O$/ha and was higher in cv. Modern (0.73 t/ha) than in EC 68414, Arun or KBSH (0.56-0.60 t).

Sandhu *et al.* (1998) studied the effect of seeding and row spacing and row spacing for different cultivars of sunflower. This experiment seed yield of sunflowers was not significantly different between sowing dates from 20 January to 20 February. Among the cultivars, hybrid MSFH-8 gave significant higher seed yield than Rumsun Record and improved periodic. Field was higher from spacings or 45 and 60 cm than with 74 cm spacing.

Haldar *et al.* (1998) carried out an experiment of spacing and nitrogen requirement of sunflower in Easternghat highland Zone of orissa. Sunflower cv. Modern were grown at 45x30 cm or 60 x 30 cm row spacings and given 0-100 kg N/ha. Seed yield was highest with the 45x30 cm spacing (743 kg/ha) with 100 kg N (902 kg).

Fagbayide *et al.* (1997) studied the effect of growth and yield of sunflower in maize and cassava intercrop. Sunflower, sunflowers + maize, sunflowers + cassava and sunflowers + maize + cassava. Result showed that intercropping sunflowers with maize or maize + cassava significantly depressed. When sunflower was cropped with cassava the LER value showed a 20% advantage. Overall analysis showed that cassava was highly compatible with sunflower sole sunflowers and sunflowers + cassava seed yields were not significantly different. The lowest yield was obtained in the three-crop mixture.

Gouri *et al.* (1997) studied the effect of intercropping sunflower with legumes on yield and economics. In this experiment sunflower were grown alone or intercropped with pigeon peas, cowpeas, soybean or black gram with normal (45x30 cm) or paired row (30/60x30 cm) spacing of sunflowers. Each legume was also grown alone. Sunflower equivalent yield and economic returns were highest from pigeon peas grown alone, followed by sunflowers (normal) + pigeon peas and sunflowers (paired) + Pigeon peas intercropping system.

Rajkumara and Sahu (1997) carried out an experiment on the economics of intercropping of mungbean and urdbean in spring planted sunflower. Sole crop

sunflowers, mungbean, urdbeans as well as intercrops of mungbean or undbeans with sunflower in 4:1, 6:1 or 6:2 row ratios were compared in field trails. The sole cropped sunflowers, mungbean, urdbeans yielded 1280, 975 and 795 kg/ha respectively. Intercropping decreased the seed yields of all the crops compared with the sole crops. The highest sunflower equivalent yields (1475 kg/ha), land equivalent ratios, net returns and benefit cost ratios were obtained by intercropping sunflowers with mungbeans in 4:1 or 6:2 row ratios.

Hari *et al.* (1997) studied the effect of radiation use efficiency (RUE) among gram, wheat, mustard, sunflower and their intercrops. They were determined in the following cropping systems: T1, gram + mustard (4:1 row ratio): T2, wheat + mustard (6:1): T3, gram + mustard (2:1): T4, gram: T5, mustard: T6, wheat + mustard (10:1): T7, Sunflower: and T8, wheat. The mean value of RUE of photosynthetically active radiation was greatest in T7 (3.59 g MH-1) and lowest in T3 (1.53 g MJ-1). Intercropping of mustard in gram and wheat generally improved their RUE compared with sole crops.

Pavlov *et al.* (1997) investigated the effect of chemical composition and nutritive value of the winter pea-cereal mixture, maize and sunflower on intensively cultivated soil. The digestibility and food value of the winter mixture was established. Intensive cropping of a pea-cereal mixture and maize increased the crude protein yield by 81.7% compared to maize cropped alone sunflower and maize-sunflower mixtures had lower crude protein yields and feed units than maize.

Pavlov *et al.* (1997) studied the effect of winter pea-cereal mixtures, maize, and sunflower under conditions of intensive land utilization. A winter mixture wheat + pea or wheat + barley + pea as a first crop were examined. Intensive utilization of land increased by 113, 142 and 6% the amount of obtainable biomass compared to maize cultivated alone. Sunflower and maize sunflower mixtures had lower productivity than maize alone yields. The proportion of winter pea and barley in the total yield decreased and that of wheat increased when rainfall and moisture were land.

Kulmi and Soni (1997) carried out on the experiment of the relative productivity and economic of sole, mixed and intercropping systems of wheat and sunflower under partial irrigated condition. Wheat and sunflower intercropped in 2:1, 2:2, 4:1 or 4:2 row ratio or crops were grown under a mixed cropping system in 1:1, 2:1 or 4:1 ratios. Wheat equivalent yield was highest (3.29 t/ha) when wheat and sunflowers were intercropped in a 4:1 row ratio.

Flenet *et al.* (1996) investigated the effect of row spacing effects on light extinction coefficients of corn, sorghum, soybean and sunflower. The effects of time of day and stage of crop development on k for different row spacings. Seeds of all species were sown in rows 0.35, 0.66, or 1.00 m apart. Measurements of canopy light interception were taken near solar noon to two dates before anthesis. At anthesis, extinction coefficients were determined at 08.45, 10.15 and 11.45 hr. (solar time). The extinction coefficient showed a linear decrease as row spacing increased. Stage of crop development and stage of development x row spacing interaction did not significantly affect K during the period of measurements. The effect of time of day

was significant for all four crops and the time of day x row spacing interaction was significant for soybeans and sunflowers.

Shinde *et al.* (1996) studied the effect of the partitioning of photosynthetically active radiation in sunflower based intercropping systems under rainfed conditions. This experiment interception of photosynthetically active radiation was monitored during crop growth in sole sunflowers cv. SS-56, groundnuts cv. Phule Pragati and soybean cv. MACS-124 and Sunflower intercropped with the legume.

Banys *et al.* (1996) carried out an experiment of maize-sunflower intercrops: agronomic characteristics maize cv. Riberiral BR120 was intercropped with sunflowers within rows, with two maize plants to one sunflower plant. Result showed that this was a viable form of intercropping.

Lingaraju *et al.* (1996) studied the effect of sunflower and pigeon pea intercropping in North-eastern dry zone of Karnataka. Sunflower cv. Modern and pigeon peas cv. GS-1 were grown alone or were intercropped in sunflower: pigeon pea row ratios of 1:1, 2:1, 3:1 or 4:2. Sunflower/pigeon pea (3:1) intercropped produced respective mean seed yields of 1.09 and 0.43 t/ha, the highest mean LER of 1.29 and the highest net returns.

Pradeep and Sundaram (1996) conducted an experiment on the effect of planting geometry, intercropping and weed management on rainfed sunflower. From a comparison of various parameters, it was concluded that a planting geometry of 30/60 x 30 cm with fodder cowpeas as an intercrop and two hand weeding or application of

1 kg pendimethalin/ha 3 days after sowing and 1 hand weeding would give the highest yield of sunflowers.

Pradeep and Sundaram (1996) conducted an experiment on the economic of chemical weed control in sunflower based intercropping situation under rainfed conditions. In this experiments weed counts and weed dry matter were higher in sole sunflower crops than the intercrops with cowpeas or coriander. Among the weed control treatments, crop yield was highest with hand weeding twice (1238 kg/ha) followed by pendimethalin (1 kg) + hand weeding once. Net returns were higher for intercropped than sole cropped sunflowers and highest for the pendimethalin + hand weeding once treatment. The benefit lost ratio was higher for sunflower coriander intercrop (1.57) than for the sunflower sole crop (1.54).

Shinde *et al.* (1996) investigated the effect of light use efficiency of sunflower intercropping systems under rainfed condition. Groundnut and soybean were grown alone or sunflowers sown in paired rows (46-90 cm) were intercropped with the legumes at intra-row spacing of 30 or 45 cm. The sunflower/soybean (30 cm) intercrop produced the highest DM yield and had the highest light use efficiency.

Sharanappa and Shivaraj (1995) conducted an experiment on the influence of pre-season crops on productivity of rice-sunflower sequences and soil fertility status. They observed that the biomass yield and the total productivity of rice and sunflowers were highest with *Sesbania rostrata* green manure, followed by sunhemp green manure. Incorporation of the green manure crops intercropped with maize or sole soybean did not improve the yield significantly. The soil organic carbon and available

N, P and K contents were improved on inclusion of sunhemp or *S. rostrata* in the sequence. Biomass yield and economic yield of rice and sunflower were highest with application of 100 kg N/ha.

Sarkar and Chakraborty (1995) conducted an experiment on the yield components and yield of sunflower sesame, and green gram as influenced by irrigation and intercropping. The crops were irrigated at 30 days after sowing (DAS), 30+40 DAS or 30+40+50 DAS. Seed yields increased with up to two irrigations for both sole and intercrops. Under intercropping, sunflower seed yield was decreased slightly (from 1.08 to 1.05 t/ha in 1989/90 and from 1.05 to 1.0 t/ha in 1990/91), whereas the yields of sesame and green gram were decreased by over 60%.

Kabelma (1995) carried out an experiment to find out the effect of row spacing on yield of two sunflower cultivars. In this experiment sunflowers cv. Oro-9 and Record were sown by broadcasting or at 5 row spacings between 20 and 100 cm. A spacing of 60 cm gave the best results with a 60% greater yield than the broadcast control.

Natarjan and Zharare (1994) evaluated the effect of intercropping groundnut with maize and sunflower for enhancing the productivity of groundnut based cropping on light textured soils in Zimbabwe. The evaluating results of the experiments emphasized the need for planting a higher density of maize than suggested by the intercrop row proportion and thereby increase the total population density of the intercrop to maximize the yield advantages from maize groundnut combinations.

# CHAPTER -3

# MATERIALS AND METHODS

# CHAPTER -3

# MATERIALS AND METHODS

The experiment for the present study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2004 to February 2005 to investigate the sunflower based intercropping with leafy vegetables. The materials and methods that were used for conducting the experiment have been presented in this chapter.

## 3.1. Climate

The experimental area is under the sub-tropical climate characterized by the three (3) distinct seasons, the monsoon or rainy season extending from May to October, winter or dry season from November to February and the premonsoon period or hot season from March to April. Information regarding the monthly maximum and minimum temperature, rainfall, relative humidity, soil temperature and sunshine as recorded by Bangladesh Meteorological Department, Agargaon, Dhaka, during the period of study have been presented in Appendix I.

## 3.2. Site and Soil

The experimental site was located at 8.45 m elevation above sea level with a latitude of $23^0 46'$ N and longitude of $90^0 23'$ E and medium high land belonging to the Modhupur tract under AEZ No. 28 (FAO 1971). The soil of the experimental plot was sandy loam in texture. The land was well drained with good irrigation facilities. The nutrient status of soil of farm area was determined by the Soil Resources

Development Institute (SRDI), Farmgate, Dhaka. The soil was analysed and the analytical data are presented in Appendix II.

### 3.3. Planting Materials

The experiment was conducted with seeds of sole crop Sunflower (*Helianthus annuus* L.) cv. 'Kironi' and 'Sunwheat-103'. The varieties of sunflower along with their sources as types used in the experiment are mentioned below-

**Sunflower**

| Cultivar | Type | Source |
|---|---|---|
| Kironi (Tall) | Non-hybrid (Composite) | Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur |
| Sunwheat-103 (Dwarf) | Hybrid | |

The experimental intercropping seeds were collected from their following source –

**Intercrop**

| Local Name | English Name | Scientific Name | Family | Source |
|---|---|---|---|---|
| Lalsak | Red amaranth | *Amaranthus tricolor* | Amaranthaceae | Horticulture Research Centre (HRC), BARI, Gazipur |
| Palongsak | Bengal spinach | *Beta vulgeris var. bengalensis* | Chenopodiaceae | |
| Batisak | Pak-choi | *Brassica campestries var. chinensis* | Cruciferae | |

### 3.4. Land Preparation

The land of experimental field was first opened on October 24, 2004 with a power tiller. Then it was exposed to the sunlight for seven (7) days prior to the next ploughing. After that the experimental land was properly prepared several ploughed

and cross ploughed to obtain a good tilth by a power tiller. During land preparation weeds and stubbles of the previous crops were collected and removed from the field. The clodes were broken by laddering and mallet before final land preparation. Special care was taken to remove the rhizomes of durba grass and mutha. Well decomposed cowdung and basal doses of fertilizers were applied during final land preparation. Irrigation and drainage channels were prepared around the plots before sowing of the seeds. Finally the land was uniformly leveled and the soils were finally pulverized.

### 3.5. Experimental design and layout

The two factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three (3) replications. Each block was divided into eight (8) plots, where eight (8) treatments were assigned at random. Thus, there were 24 (8x3) unit plots in the experiment. The size of the unit plot was 3.0 m x 1.5 m. The distance between the block was 0.5 m and between the adjacent plot was 0.3 m. The layout of the experiment has been shown in Figure 2.

### 3.6. Treatments of the experiment

There were two factors in this experiment. The factors with their different levels are given below –

Factor A: Variety

i. $V_T$ : Variety Tall (Kironi)

ii. $V_D$ : Variety Dwarf (Sunwheat-103)

Factor B: Intercrop

i. $I_O$ : No intercrop (Control)

ii. $I_L$ : Intercrop Lalsak (Red amaranth)

iii. $I_P$ : Intercrop Palongsak (Bengal spinach)

iv. $I_B$ : Intercrop Batisak (Pak-choi)

### 3.7. Manure and Fertilizers

The crop was fertilized with the following doses of manure and fertilizers as recommended by Anonymous (1992).

| Manure and fertilizers | Dose/ha (kg) |
|---|---|
| Cowdung | 12000 |
| Urea | 200 |
| TSP | 200 |
| MP | 150 |
| Gypsum | 170 |

Half of Urea and total amount of cowdung, TSP, MP, Gypsum were applied as basal dose and the remaining Urea was applied as top dressing at 25 and 50 days after seed sowing i.e. after first and second irrigation.

### 3.8. Sowing of seeds

The seeds of sunflower were sown on November 7, 2004. Sunflower seed line sowing in the plot. Plant to plant spacing 25 cm and row to row distance 50 cm and depth 1.5 cm. Two seeds were placed through the holes by trace distance. On the other hand, intercrops (Red amaranth, Bengal Spinach and Pak-choi) were sown at the same date between the rows of the sunflower by broadcasting method.

### 3.9. Intercultural Operations

#### 3.9.1. Thinning

The number of sunflower seeds sown in each plot was two times as many plants were kept to grow according to the treatment. After a week of germination the plants were thinned to the number to be kept in the treatment combinations. Only one seedling per hill was maintained.

#### 3.9.2. Weeding

Weeding was done as and when required to keep the plots free from weeds and to pulverize the soil.

#### 3.9.3. Disease and Pest Management

Few plants were infected by the leaf blight disease. It was not severe attack. Some leaves were attacked in the field by this disease. The disease controlled by applying Diatheane M-45. At early stage Cutworm (*Agrotis ypsilon*) insect attacked some seedlings. This insect was controlled by spraying Dursban 20 EC (at the concentration of 0.02%).

#### 3.9.4. Irrigation

The plots were irrigated as and when necessary during the crop period.

### 3.10. Harvesting

Sunflowers were harvested on February 08, 2005 after 94 days from seed sowing. Different intercrops harvested in different times. Intercrop Red amaranth was

harvested December 01, 2004, Bengal spinach was harvested December 04, 2004 and Pak-choi was harvested December 02, 2004 respectively.

### 3.11. Collection of Data

The experimental plots were observed frequently to record changes in plant characters at different physiological stages of growth. In each unit plot ten (10) plants were selected at random, labelled and marked with tags for collection of data. Data were collected on different growth, yield components and yield. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The following observations were made regarding plant growth, yield attributes as affected by different intercrops and variety of sunflower.

#### 3.11.1. Plant Height

Plant height were measured in centimeter by a meter scale at 15, 30 45, 60 and 75 DAS from the point of attachment of the leaf to the ground level to the tip of the head of ten (10) randomly selected plants and the mean was calculated.

#### 3.11.2. Number of Leaves per Plant

All leaves of each plant were counted separately at 15, 30, 45, 60 and 75 DAS. Randomly selected ten (10) plants and the mean were calculated.

#### 3.11.3. Days to First Flowering

It was achieved by recording the days required for first flowering of the plant from each unit plot.

### 3.11.4. Days to 50% Flowering

It was achieved by recording the days taken for 50% flowering of the plant from each unit plot.

### 3.11.5. Days to Maturity

It was achieved by recording the days required for maturity of the plant from each unit plot.

### 3.11.6. Diameter of the Head

To measure the diameter of the head a slide calipers was used. The average diameter of the head was measured in centimeter at harvest.

### 3.11.7. Weight of Head

It was calculated from weight of head obtained from ten (10) randomly selected plants divided by the total number of head obtained from ten plants.

### 3.11.8. Number of Total Seed/Head

All seeds of the head counted from ten (10) randomly selected plants and then their mean was calculated.

### 3.11.9. Number of Developed Seed/Head

It was calculated from the number of developed seed obtained from ten (10) randomly selected plants from each unit plot divided by ten (10) heads.

### 3.11.10. Number of Undeveloped Seed/Head

It was calculated from the number of undeveloped seeds obtained from ten (10) randomly selected plants from each unit plot divided by ten (10) heads.

### 3.11.11. Seed Yield/Plot

The yield per plot was calculated in kilogram and was found out.

### 3.11.12. Seed Yield (kg/ha)

It was calculated in kilogram by converting the yield per plot to per hectare.

### 3.11.13. Weight of 1000 Seed

It was calculated in gram per 1000 seed for each treatment/treatment combinations.

### 3.11.14. Fresh Stalk Weight

It was recorded from the weight of the stalk collected from ten (10) randomly selected plants from each unit plot from which mean was found out.

### 3.11.15. Dry Stalk Weight

It was recorded from the weight of the dry stalk from ten randomly selected plants from each unit plots from which mean was found out.

### 3.11.16. Oil Content (%)

It was calculated by percentage and the oil extracted from seed by electric ghani.

### 3.12.1. Marketable yield of intercrop per plot (kg)

It was calculated by subtracting the total amount of non-marketable yield from the gross yield.

### 3.12.2. Marketable yield of intercrop per hectare (ton)

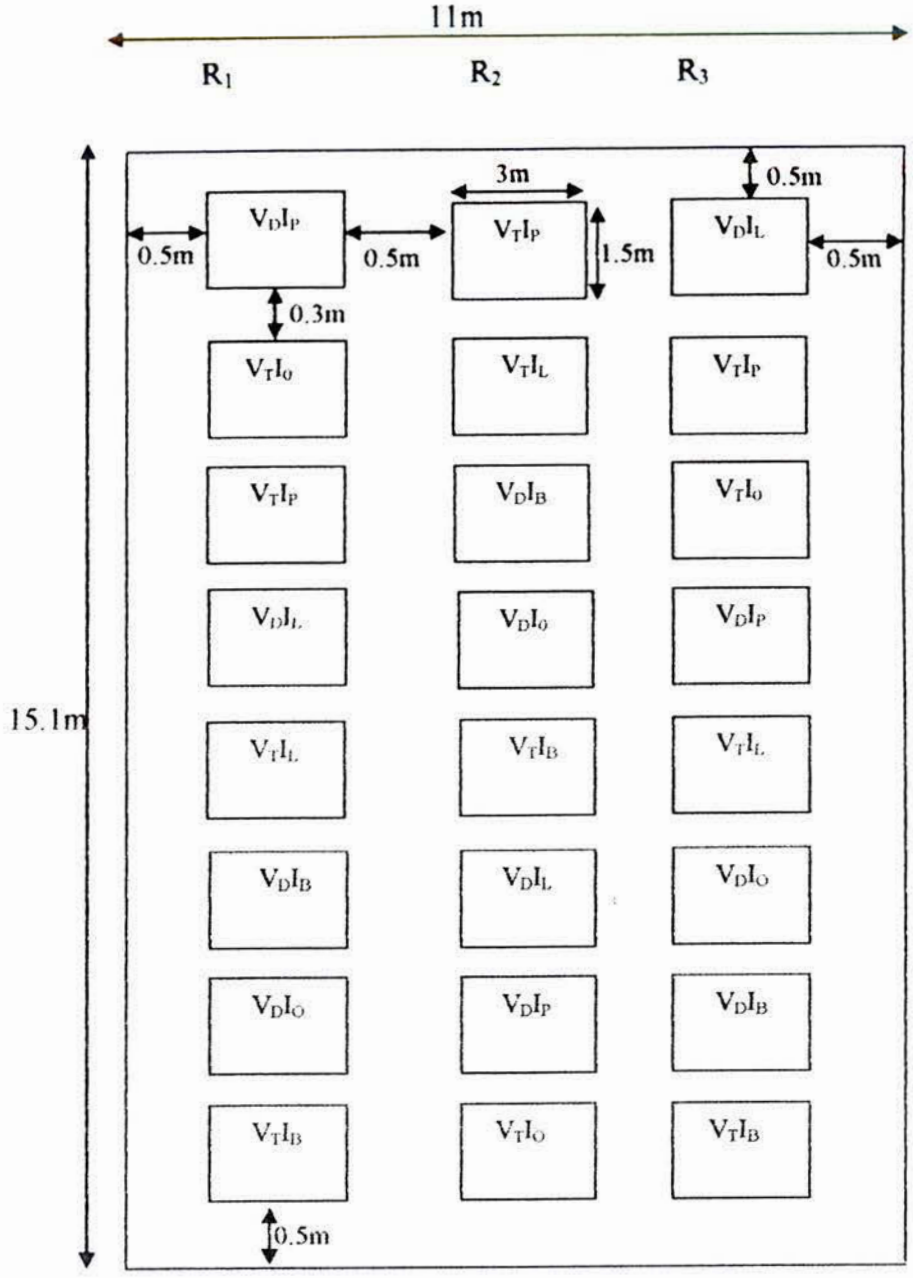
It was calculated by conversion of the marketable yield of intercrop per plot and recorded in ton.

### 3.13. Statistical Analysis

The data collected from the experimental plots were statistically analysed.The mean value for all tratment was calculated and the analysis of variance (ANOVA) for the character was accomplished by F-variance test. The significance of difference between pair of means was tested by the least significant difference (LSD) test at 5% and 1% level of probability.

### 3.14. Economic Analysis

The cost of production was analyzed in order to find out the most economic combination of sunflower and leafy vegetables intercropping. All input cost and interest on fixed (land) and running capital were considered for computing the cost of production. The interest were calculated @ 14% for 6 months. The value of land per hectare was considered to be Tk. 1,000000.




$V_T$ = Tall Variety (Kironi)

$V_D$ =Dwarf Variety (Sunwheat-103)

$I_O$ = No Intercrop (Control)

$I_L$ = Intercrop Lalsak (Red amaranth)

$I_P$ = Intercrop Palongsak (Bengal spinach)

$I_B$ = Intercrop Batisak (Pak-choi)

Design = RCBD (Randomized Complete Block Design), Factor = 2, Treatment =8,

Plot Size = 3 m × 1.5 m

Plot to Plot distance = 0.3 m

Block to Block distance = 0.5 m

Total Area = 166.1 $m^2$

**Figure 2. Layout of the experiment**

# CHAPTER-4

# RESULTS AND DISCUSSION

# CHAPTER-4

# RESULTS AND DISCUSSION

The present study was conducted to investigate the sunflower based intercropping with leafy vegetables. The analysis of variances (ANOVA) of the data on different yield contributing characters are given in Appendix III. The result of the experiment as influenced by different combinations have been presented and discussed in this chapter under the following sub-headlines.

## 4.1. Plant Height

The plant height at different varieties exhibited wide variation (Table 1). The variation in the plant height was highly significant (Appendix III). During the period of plant growth the tallest plant (133.70 cm) was found from var. Kironi ($V_1$) at 75 DAS (Days After Sowing), which was statistically dissimilar to the variety of Sunwheat - 103 ($V_D$). The shortest plant height (53.95cm) was found from var. Sunwheat-103 ($V_D$) at the same days (Table 1).

The results of main effect of intercropping on plant height of sunflower at 15, 30, 45, 60 and 75 DAS have been presented in (Figure 3). There was significant difference among different intercropping for plant height. At 75 DAS, the maximum plant height (101.88cm) was recorded against the control intercrop ($I_0$), which was statistically different from the rest treatment and minimum plant height (87.49 cm) was found from intercrop Bengal spinach ($I_p$). This might be due to more available space and resources such as nutrients, water, light, other resources etc. in control

intercropping. Plant height reduced gradually with different leafy vegetables cultivation. Because, both plants were in competition to the nutrient and natural resources. Maloy and Sarkar (2001) also reported that plant height was maximum when sunflower was grown singly.

Plant height was found to be significantly due to the combined effect of variety and intercropping leafy vegetable at different days after sowing (Table 2). In case of the treatment combinations, it was observed that plant height gradually increased with increasing time. At 75 DAS, the maximum plant height (142.62 cm) was found in the treatment combination of tall variety ($V_T$) and control intercrop ($I_0$), which was statistically dissimilar to other treatment combinations. The minimum plant height (48.29 cm) was found from the treatment combination of dwarf variety ($V_D$) and intercrop Bengal spinach ($I_P$), which was statistically dissimilar to the other treatment combinations. There was significant interaction between sunflower variety and leafy vegetables intercropping at 75 DAS (Appendix III).

### 4.2. Number of Leaves per Plant

A good foliage indicates higher growth, development and productivity of a plant. The number of leaves of different varieties of sunflower varied significantly (Appendix III). It was apparent that the number of leaves increased in both variety with passage of time (Table 1). The maximum number of leaves (27.42) was found from variety Kironi (Tall) at 75 DAS (days after sowing) and the lowest number of leaves (17.96) was found from variety Sunwheat - 103 (dwarf), which was statistically dissimilar at 75 DAS (Table 1). The number of leaves per plant in sole cropping

indicated better growth of the plant than intercropping, which might be due to the utilization of wider space and lesser competition for nutrients, light and water etc.

The variation in number of leaves was significant due to the effect of intercropping. At 75 DAS, the control intercrop ($I_0$) gave highest number of leaves 24.58) and the lowest (20.81) was obtained from intercrop Bengal spinach (Figure 4) at the same days.

The combined effects of sunflower variety and intercropping leafy vegetables significantly influnencd the number of leaves of the plant at different DAS and the results have been presented in Table 2. At 75 DAS, the maximum number of leaves (29.57) was found in tall variety ($V_T$) and control intercrop ($I_0$), which was statistically dissimilar with other treatment combinations. On the other hand, dwarf variety sunflower ($V_D$) and Bengal spinach intercropping ($I_P$) gave the minimum number of leaves per plant (16.66), which was statistically dissimilar with variety and intercrop. The interaction effect of variety and intercrop was also found significant at all DAS (Appendix III).

Table 1. Main effects of variety on plant height and number of leaves of sunflower at different days after sowing (DAS)

| Treatments | Plant height (cm) at | | | | | Number of leaves at | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS |
| $V_T$ | 9.81 | 25.42 | 52.35 | 94.20 | 133.70 | 6.99 | 9.94 | 16.11 | 22.18 | 27.42 |
| $V_D$ | 5.06 | 11.18 | 26.78 | 36.81 | 53.95 | 5.27 | 6.98 | 8.40 | 12.17 | 17.96 |
| LSD (0.05) | 0.41 | 0.97 | 1.06 | 1.76 | 4.51 | 0.48 | 0.90 | 0.93 | 0.91 | 0.87 |
| (0.01) | 0.58 | 1.34 | 1.47 | 2.44 | 6.02 | 0.66 | 1.26 | 1.26 | 1.26 | 1.21 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |

** Significant at 1% probability

$V_T$ = Variety Tall (Kironi)

$V_D$ = Variety Dwarf (Sunwheat-103)

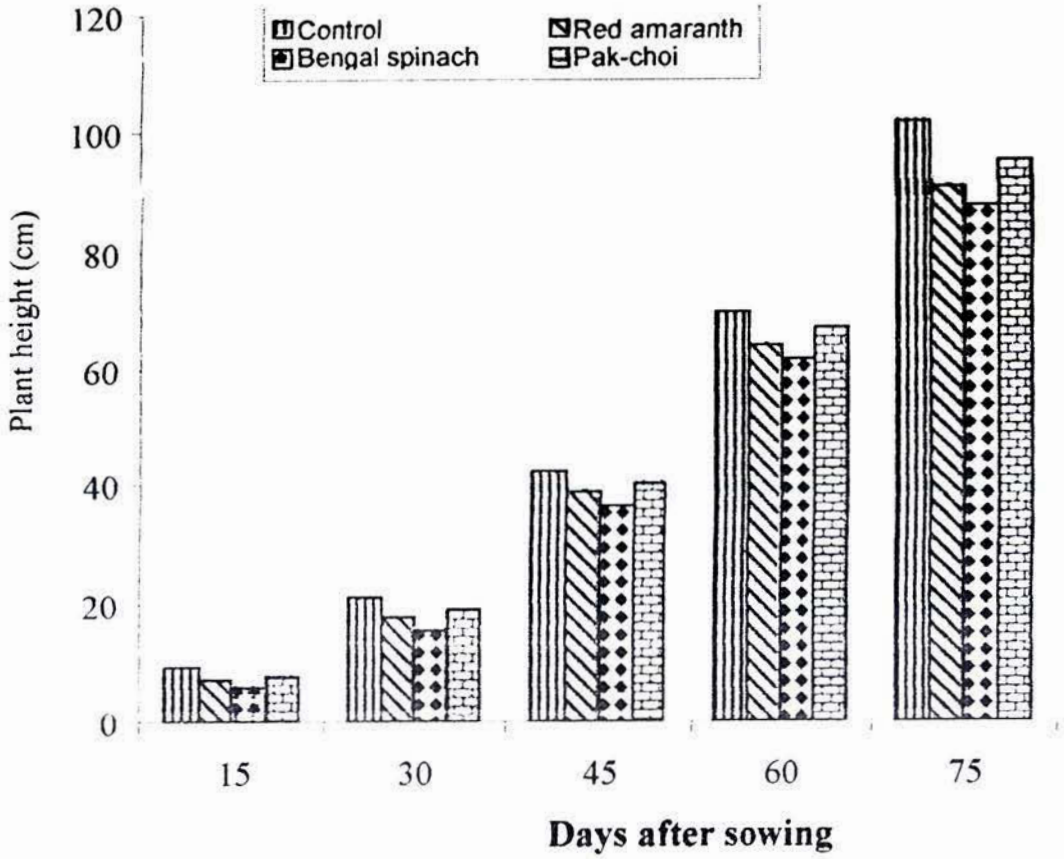



**Figure 3. Effects of Intercropping with leafy vegetables on plant height of Sunflower at different Days after sowing**

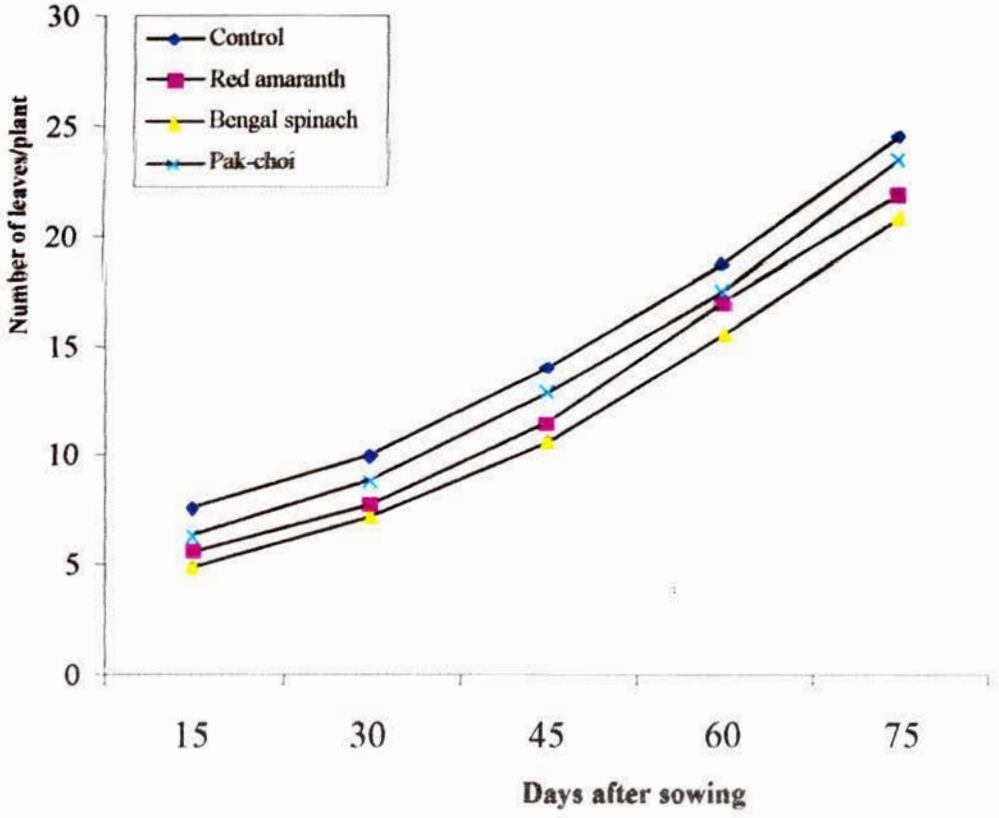



**Figure 4. Effects of Intercropping on number of leaves of sunflower at different Days after sowing**

Table 2. Combined effects of variety and Intercropping on plant height and number of leaves of Sunflower at different days after sowing (DAS)

| Treatment combinations | Plant height (cm) at | | | | | Number of leaves at | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS |
| $V_TI_o$ | 11.72 | 28.45 | 55.89 | 98.87 | 142.62 | 8.33 | 11.55 | 18.43 | 23.69 | 29.57 |
| $V_TI_L$ | 9.06 | 24.16 | 51.36 | 92.01 | 130.95 | 6.50 | 9.33 | 15.01 | 21.97 | 26.33 |
| $V_TI_P$ | 8.41 | 22.74 | 49.13 | 89.86 | 126.70 | 5.85 | 8.61 | 14.10 | 20.67 | 24.97 |
| $V_TI_B$ | 10.05 | 26.03 | 53.05 | 95.98 | 134.53 | 7.33 | 10.28 | 16.92 | 22.40 | 28.81 |
| $V_DI_0$ | 6.87 | 13.79 | 29.07 | 40.45 | 61.14 | 6.87 | 8.46 | 9.59 | 13.75 | 19.58 |
| $V_DI_L$ | 4.78 | 10.80 | 26.55 | 35.97 | 57.05 | 4.78 | 6.28 | 7.95 | 11.90 | 17.50 |
| $V_DI_P$ | 3.45 | 8.29 | 23.91 | 33.08 | 48.29 | 4.03 | 5.82 | 7.14 | 10.39 | 16.66 |
| $V_DI_B$ | 5.15 | 11.85 | 27.80 | 37.75 | 55.34 | 5.42 | 7.38 | 8.95 | 12.76 | 18.13 |
| LSD (0.05) | 0.59 | 1.37 | 1.50 | 2.49 | 6.38 | 0.68 | 1.28 | 1.32 | 1.28 | 1.23 |
| (0.01) | 0.82 | 1.90 | 2.08 | 3.45 | 8.85 | 0.94 | 1.78 | 1.83 | 1.78 | 1.71 |
| Level of significance | * | * | * | * | * | NS | * | * | ** | * |

** Significant at 1% probability

* Significant at 5% probability

NS Not significant

$V_T$ = Variety Tall (Kironi) $I_0$ = No intercrop

$V_D$ = Variety Dwarf (Sunwheat-103) $I_L$ = Intercrop Red amaranth

$I_P$ = Intercrop Bengal spinach

$I_B$ = Intercrop Pak-choi

### 4.3. Days to First Flowering

The number of days required to first flowering of the plant significantly influenced by variety (Table 3). The average days required for first flowering ranged from 46.25 to 48.83 days. The longest time (48.83 days) was required for first flowering in dwarf variety and the tall variety sunflower required shortest time (46.25 days). Time required to first flowering was found to be delayed gradually with the decrease of plant type. This might be due to the fact that tall variety had more reserve food, shorter dormancy period, completed vegetative growth quickly and resulted in quick flower initiation.

In present study, the days required to first flowering of the plant was significantly influenced by intercropping of leafy vegetables (Table 4). However, it was found that the highest days (48.66) were required at intercrop Bengal spinach ($I_P$) and the lowest days (46.16) were required in control intercrop ($I_O$).

The combined effect of variety and intercrop was not significantly influenced by the days required for first visible flowering of the plant and the results have been presented in Table 5. The longest time (50.00) for first flowering was required by the treatment combination of dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$), which was statistically similar with the other treatment combinations. The shortest period (45.00 days) required for first flowering was found from the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$), which was statistically similar with the other treatment. There was no significant interaction effect between variety and intercrop for first visible flowering (Appendix III).

Table 3. Main effects of variety on yield and yield contributing characters of sunflower

| Treatments | Days to first flowering | Days to 50% flowering | Days to maturity | No. of total seed per head | No. of developed seed per head | Diameter of the head (cm) | Weight of head (gm) |
|---|---|---|---|---|---|---|---|
| $V_T$ | 46.25 | 51.75 | 86.83 | 360.00 | 261.03 | 19.63 | 1923.33 |
| $V_D$ | 48.83 | 55.66 | 85.41 | 200.63 | 169.50 | 7.52 | 404.27 |
| LSD (0.05) | 2.23 | 2.06 | 4.11 | 5.53 | 3.61 | 1.98 | 75.09 |
| (0.01) | 3.10 | 2.86 | 5.71 | 7.81 | 15.21 | 2.39 | 119.23 |
| Level of significance | ** | ** | NS | ** | ** | ** | ** |

** Significant at 1% Probability

NS Not significant

$V_T$ = Variety Tall (Kironi)

$V_D$ = Variety Dwarf (Sunwheat-103)

Table 3. Continued

| Treatments | No. of undeveloped seed per head | Seed yield per plot (kg) | Seed yield (kg/ha) | 1000 seed weight (gm) | Fresh Stalk weight (gm) | Dry stalk weight (gm) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| $V_T$ | 98.96 | 0.43 | 961.11 | 67.50 | 1726.66 | 690.16 | 29.33 |
| $V_D$ | 31.38 | 0.28 | 622.22 | 47.29 | 431.66 | 171.91 | 22.12 |
| LSD (0.05) | 3.82 | 0.01 | 49.86 | 3.28 | 86.16 | 7.74 | 1.44 |
| (0.01) | 5.31 | 0.01 | 69.21 | 4.55 | 119.6 | 10.74 | 2.00 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** |

** Significant at 1% Probability

NS Not significant

$V_T$ = Variety Tall (Kironi)

$V_D$ = Variety Dwarf (Sunwheat-103)

Table 4. Main effects of Intercropping on yield and yield contributing Characters of sunflower.

| Treatments | Days to first flowering | Days to 50% flowering | Days to maturity | Diameter of the head (cm) | Weight of head (gm) | No. of total seed per head | No. of developed seed per head | No. of undeveloped seed per head | Seed yield per plot (kg) | Seed yield (kg/ha) | 1000 seed weight (gm) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $I_O$ | 46.16 | 52.16 | 84.16 | 15.57 | 1222.91 | 294.33 | 225.21 | 69.61 | 0.42 | 944.44 | 60.66 | 28.78 |
| $I_L$ | 48.17 | 54.33 | 86.50 | 12.88 | 1144.83 | 275.01 | 210.92 | 64.07 | 0.33 | 744.44 | 56.39 | 24.72 |
| $I_P$ | 48.66 | 54.83 | 88.66 | 12.10 | 1109.37 | 263.00 | 202.72 | 60.27 | 0.29 | 644.44 | 54.62 | 22.52 |
| $I_B$ | 47.16 | 53.49 | 85.16 | 13.81 | 1177.06 | 288.91 | 222.21 | 66.70 | 0.37 | 833.33 | 57.91 | 26.88 |
| LSD (0.05) | 2.23 | 2.06 | 4.11 | 1.21 | 93.15 | 5.63 | 3.61 | 3.82 | 0.01 | 49.86 | 3.28 | 1.44 |
| (0.01) | 3.10 | 2.86 | 5.71 | 1.69 | 129.3 | 7.81 | 15.21 | 5.31 | 0.01 | 69.21 | 4.55 | 2.00 |
| Level of significance | ** | ** | NS | ** | ** | ** | ** | ** | ** | ** | ** | ** |

** Significant at 1% Probability
NS Not significant

$I_0$ = No intercrop
$I_L$ = Intercrop Red amaranth
$I_P$ = Intercrop Bengal spinach
$I_B$ = Intercrop Pak-choi

Table 5. Combined effects of variety and Intercropping on yield and yield contributing characters of sunflower

| Treatment combination | Days to first flowering | Days to 50% flowering | Days to maturity | Diameter of the head (cm) | Weight of head (gm) | No. of total seed per head | No. of develop-ed seed per head | No. of undevel-oped seed per head | Seed yield per plot (kg) | Seed yield (kg/ha) | 1000 seed weight (gm) | Fresh Stalk weight (gm) | Dry stalk weight (gm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_TI_O$ | 45.00 | 51.00 | 85.00 | 22.16 | 1983.33 | 380.33 | 277.07 | 103.26 | 0.51 | 1133.33 | 70.50 | 1800.00 | 720.00 |
| $V_TI_L$ | 46.67 | 52.00 | 87.00 | 18.83 | 1900.00 | 357.67 | 253.17 | 98.50 | 0.42 | 933.33 | 66.46 | 1680.00 | 672.00 |
| $V_TI_P$ | 47.33 | 52.67 | 89.00 | 17.66 | 1860.00 | 334.67 | 240.87 | 93.80 | 0.36 | 800.00 | 64.80 | 1633.33 | 653.33 |
| $V_TI_B$ | 46.00 | 51.33 | 86.33 | 19.88 | 1950.00 | 373.33 | 273.03 | 100.30 | 0.44 | 977.78 | 68.27 | 1793.33 | 715.33 |
| $V_DI_O$ | 47.33 | 53.33 | 83.33 | 8.87 | 462.50 | 208.33 | 173.36 | 35.97 | 0.34 | 755.56 | 50.83 | 440.00 | 176.00 |
| $V_DI_L$ | 49.67 | 56.67 | 86.00 | 6.93 | 391.67 | 198.36 | 168.67 | 29.69 | 0.25 | 555.56 | 46.33 | 430.00 | 170.00 |
| $V_DI_P$ | 50.00 | 57.00 | 88.33 | 6.54 | 358.75 | 191.33 | 164.58 | 26.75 | 0.22 | 488.89 | 44.45 | 423.33 | 168.33 |
| $V_DI_B$ | 48.33 | 55.66 | 84.00 | 7.74 | 404.17 | 204.50 | 171.39 | 33.11 | 0.31 | 688.89 | 47.56 | 433.33 | 173.33 |
| LSD (0.05) | 3.16 | 2.92 | 5.82 | 1.72 | 131.7 | 7.967 | 15.49 | 5.41 | 0.01 | 70.52 | 4.63 | 121.08 | 10.95 |
| (0.01) | 4.39 | 4.05 | 8.08 | 2.39 | 182.08 | 11.06 | 21.50 | 7.57 | 0.02 | 97.87 | 6.43 | 169.01 | 15.19 |
| Level of significance | NS | NS | NS | * | ** | ** | * | * | * | ** | * | * | ** |

** Significant at 1% Probability * Significant at 5% Probability NS Not significant

$V_T$ = Variety Tall (Kironi) $I_0$ = No intercrop

$V_D$ = Variety Dwarf (Sunwheat-103) $I_L$ = Intercrop Red amaranth

$I_P$ = Intercrop Bengal spinach

$I_B$ = Intercrop Pak-choi

### 4.4. Days to 50% Flowering

The time taken to complete 50% visible flowering of the plant was significantly influenced by variety of sunflower (Table 3). The average days required for 50% flowering ranged from 51.75 to 55.66 days. The longest time (55.66 days) taken for 50% visible flowering in dwarf variety sunflower ($V_D$) and shortest time (51.75 days) visible flowering in tall variety sunflower ($V_T$). Tall variety had more reserve food and quick completion of vegetative growth and helped in quick flowering of the crop.

In the present study, the days required for 50% visible flower of the plant was significantly influenced by intercropping (Table 4). However, it was noticed that the longest time (54.83 days) required in intercrop Bengal spinach ($I_P$) and the shortest time (52.16 days) required in control intercrop ($I_0$).

The combined effect of variety and intercrop was not significantly influenced by the days required for 50% visible flowering of the plant and the results have been presented in Table 5. The longest time (57.00 days) for 50% flowering was required by the treatment combination of dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$), which was statistically similar with other treatment combination. The shortest period (51.00 days) required for 50% flowering was found from the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$). There was no significant interaction between variety and intercrop (Appendix III).

### 4.5. Days to Maturity

In the present experiment the days to maturity was not significantly influenced by varieties of sunflower (Table3). Tall variety sunflower required maximum days (86.83) to achieve maturity. On the other hand dwarf variety needed 85.41 days for the same.

The variation in days to maturity was not significantly influenced by leafy vegetable intercropping (Table 4). However, it was found that the highest days (88.66) were required at Bengal spinach intercropping ($I_p$) and the lowest days (84.16) required in control intercrop ($I_0$).

The combined effects of variety and intercrop were not significantly influenced the days to maturity and the results have been presented in Table 5. Also there was no significant interaction effect between variety and intercrop in this respect (Appendix III).

### 4.6. Diameter of the Head

The different varieties of sunflower exhibited wide variation in respect of mean diameter of individual head. The maximum diameter of head was recorded from tall variety Kironi (19.63 cm) and dwarf variety Sunwheat-103 gave the minimum diameter (7.52cm) of individual head (Table 3).

The main effect of intercropping was found to be significant and the results have been presented in Table 4. The maximum diameter of the head (15.57cm) was obtained from the control intercrop ($I_O$) and the minimum diameter of the head (12.10cm) was found in Intercrop Bengal spinach ($I_P$).

The combined effects of variety and intercrop were significant and the results have been presented in Table 5. The maximum diameter of head (22.16cm) was observed in the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$) and the minimum diameter of the head (6.54cm) was found in the treatment combination of dwarf variety sunflower ($V_D$) and Intercrop Bengal spinach ($I_P$). The interaction effect of variety and intercrop was also found significant in respect of diameter of the head (Appendix III).

### 4.7. Weight of Head (gm)

Weight of head was significantly influenced by variety (Table 3). The maximum weight of head (1923.33 gm) was obtained from plants grown from tall variety sunflower ($V_T$) and the lowest (404.27 gm) from dwarf variety sunflower ($V_D$). It was observed that tall variety contain large head size and high yield than dwarf one. Increase of head size may increase weight and kernel yield.

The results on main effect of intercrop on weight of head have been presented in Table 4. The maximum weight of head (1222.91gm) was obtained from the control intercrop ($I_0$) and the minimum weight of head (1109.37gm) was found in Bengal spinach intercropping ($I_P$).

The results on weight of head as influenced by the combined effects of variety and intercrop have been presented in Table 5. The treatment combination of tall variety planted at control intercrop produced the highest weight of head (1983.33 gm). On the other hand, dwarf variety ($V_D$) planted at intercrop Bengal spinach ($I_P$) gave the lowest weight of head (358.75gm). Analysis of Variance showed that there was significant interaction between variety and intercrop for weight of head (Appendix III).

**4.8. Number of Total Seeds per Head**

The number of total seeds per head in different varieties exhibited significant variation (Table 3). The maximum number of total seeds (360.00) harvested per head was obtained from tall variety Kironi ($V_T$). The lowest number of total seeds (200.63) was recorded from dwarf variety Sunwheat-103 ($V_D$). It was found that seeds per head increase with the increase of plant height. This was due to increase of head diameter. The number of seeds per head is determined by the number of disk flowers formed.

The number of total seeds per head was also significantly influenced by intercropping (Table 4). It was found that the maximum number of total seeds (294.33) was observed at control intercrop ($I_0$). The lowest number of seeds (263.00) was found from the intercrop Bengal spinach ($I_P$).

The combined effect of variety and intercrop significantly influenced the number of total seeds per head and the results have been presented in Table 5. The maximum number of total seeds per head (380.33) was noted from the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$). The minimum number of total seeds per head (191.33) was found in the treatment combination of

dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$). There was significant interaction between variety and intercrop in respect of the number of total seeds per head (Appendix III).

### 4.9. Number of Developed Seed per Head

The number of developed seed per head varied significantly among the varieties. The highest number of developed seed per head was recorded from variety Kironi (261.03) in Table 3. The lowest number of developed seed per head was obtained from var. Sunwheat-103 (169.50).

The variation in the number of developed seed per head was significantly influenced by the intercropping (Table 4). The highest number of developed seed per head (225.21) was found from the control intercrop ($I_0$) and the lowest number of developed seed per head (202.72) was obtained from intercrop Bengal spinach ($I_P$). Without intercrop sunflower plant got maximum nutrient elements, vigorous growth, large head size and maximum number of developed seed. In intercropping, the nutrient elements were divided between the two crops. So, the plant cannot absorb enough nutrient for the developed seed form.

The combined effect of variety and intercrop had significant influence on the number of developed seed per head (Table 5). It was observed that the highest number of developed seed per head (277.07) was recorded in the treatment combination of tall variety sunflower Kironi ($V_T$) and control intercrop ($I_0$). The lowest number of developed seed per head (164.58) was recorded in the treatment combination of dwarf variety sunflower Sunwheat-103 ($V_D$) and Intercrop Bengal spinach ($I_P$). There was

significant interaction between variety and intercrop in respect of the number of developed seed per head (Appendix III).

### 4.10. Number of Undeveloped Seed per Head

Number of undeveloped seed exhibited significant variation due to different varieties of sunflower (Table 3). The lowest number of undeveloped seed per head (31.38) was obtained from dwarf variety Sunwheat-103 ($V_D$). The highest number of undeveloped seeds per head (98.96) was obtained from tall variety Kironi ($V_T$).

The results on main effect of intercropping on the number of undeveloped seed per head have been presented in (Table 4). The highest number of undeveloped seed per head (69.61) was recorded in the control intercrop ($I_0$) and the lowest number of undeveloped seed per head (60.27) was obtained from intercrop Bengal spinach ($I_P$).

The combined effect of variety and intercrop significantly influenced the number of undeveloped seed per head and the results have been presented in Table 5. The maximum number of undeveloped seed per head (103.26) was noted from the treatment combination of tall variety sunflower Kironi ($V_T$) and control Intercrop ($I_0$). The minimum number of undeveloped seed per head (26.75) was found in the treatment combination of dwarf variety sunflower Sunwheat - 103 ($V_D$) and intercrop Bengal spinach ($I_p$). There was significant interaction between variety and intercrop in respect of the number of undeveloped seed per head (Appendix III).

### 4.11. Seed Yield per Plot (kg)

Significant variation was recorded in the seed yield per plot among the varieties of sunflower (Table 3). Variety Kironi produced significantly higher yield per plot (0.43 kg) than the remaining varieties and the lowest seed yield (0.28 kg) per plot was produced by variety Sunwheat-103.

Seed yield per plot was significantly influenced by intercrop (Table 4). The highest seed yield per plot (0.42 kg) was recorded from the control intercrop ($I_0$) and the lowest seed yield per plot (0.29 kg) was recorded from the intercropping Bengal spinach ($I_P$).

The combined effect of variety and intercrop significantly influenced the seed yield per plot and the results have been presented in Table 5. The highest seed yield per plot (0.51 kg) was recorded in the treatment combination tall variety sunflower ($V_T$) and control intercrop ($I_0$). The lowest seed yield per plot (0.22 kg) was recorded in the treatment combination of dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$). There was significant interaction between variety and intercrop in respect of seed yield per plot (Appendix III).

### 4.12. Seed Yield (kg/ha)

A significant variation in respect of seed yield per hectare was recorded among the different varieties of sunflower. The highest seed yield was recorded from variety Kironi (961.11 kg/ha) and the lowest seed yield was obtained from variety Sunwheat-103 (622.22 kg/ha) in Table 3. The increase of 1000 seed weight increased in seed yield (kg/ha). Increase of seed number per plant ensures high yield.

Seed yield per hectare was significantly influenced by intercropping (Table 4). The highest seed yield (944.44 kg/ha) was recorded from the control intercrop ($I_0$) and the lowest seed yield (644.44 kg/ha) was recorded from the Bengal spinach intercropping ($I_P$).

The combined effect of variety and intercrop had significant influence on seed yield per hectare (Table 5). It was observed that the highest seed yield (1133.33 kg/ha) was recorded in the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$). The lowest seed yield (488.89 kg/ha) was recorded in the treatment combination of dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$). There was significant interaction between variety and intercrop (Appendix III).

**4.13. 1000 Seed Weight (gm)**

Significant variation was observed in case of 1000 seed weight as influenced by different varieties of sunflower (Table-3). Tall variety Kironi produced significantly heaviest seeds (67.50gm) and dwarf variety Sunwheat-103 obtained the lightest (47.29gm) 1000 seed weight. It was observed that tall variety sunflower Kironi contains large head size, larger seed size and the heaviest than dwarf one. So, 1000 seed weight of tall variety is heavier than dwarf one.

The variation in the weight of 1000 seed due to the intercrop was statistically significant (Table 4). The heaviest 1000 seed weight (60.66 gm) was found from the control intercrop ($I_0$) and the lightest 1000 seed weight (54.62gm) was found from the Bengal spinach intercropping ($I_P$).

The combined effect of variety and intercrop significantly influenced the weight of 1000 seed and the results have been presented in Table 5. The heaviest 1000 seed weight (70.50 gm) was recorded in the treatment combination tall variety ($V_T$) and control intercrop ($I_0$). The lightest 1000 seed weight (44.45 gm) was recorded in the treatment combination of dwarf variety ($V_D$) and intercrop palongsak ($I_0$). There was significant interaction between variety and intercrop in respect of 1000 seed weight (Appendix III).

### 4.14. Fresh Stalk Weight (gm)

In the present experiment the fresh stalk weight was significantly influenced by the variety of sunflower (Table 3). The highest fresh stalk weight (1726.66gm) was obtained from tall variety ($V_T$) and the lowest fresh stalk weight (431.66gm) was obtained from dwarf variety sunflower ($V_D$).

The main effect of intercropping on fresh stalk weight was found to be significant and the results have been presented in Figure 5. The highest fresh stalk weight (1120.00gm) was obtained from the control intercrop ($I_0$) and the lowest fresh stalk weight (1028.33gm) was obtained from the intercrop Bengal spinach ($I_P$). Fresh stalk weight of the plant depends on the plant height, vigour of the plant, competative crops etc. In control plot the plants absorb the maximum nutrients without competition of intercrop and the plant height gradually increased, gave vigorously growth and resulted the increase of fresh stalk weight.

The combined effect of variety and intercrop was significantly influenced on fresh stalk weight and the results have been presented in Table 5. The highest fresh

stalk weight (1800.00gm) was obtained in the treatment combination of tall variety ($V_T$) and control intercrop ($I_0$) and the lowest fresh stalk weight (423.33gm) was obtained in the treatment combination of dwarf variety ($V_D$) and Bengal spinach intercrop ($I_P$). The interaction effect in these respect was significant (Appendix III).

### 4.15. Dry Stalk Weight (gm)

Dry stalk weight of plant was significantly influenced by the variety of sunflower (Table 3). The maximum dry stalk weight (690.16gm) was obtained from tall variety ($V_T$) and the lowest (171.91gm) from the dwarf variety ($V_D$).

The results on main effect of intercropping on dry stalk weight have been presented in Figure 5. The maximum dry stalk weight (448.00gm) was obtained from the control intercrop ($I_0$) and the minimum dry stalk weight (410.83gm) was found in intercropping Bengal spinach ($I_P$).

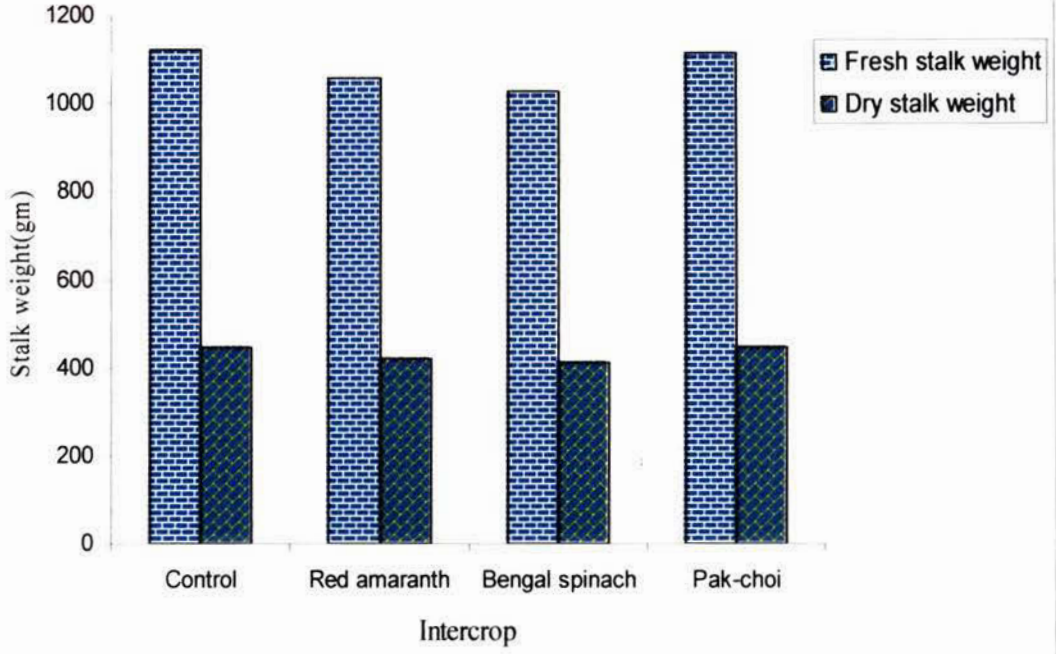



**Figure 5. Effect of intercropping on fresh and dry stalk weight of sunflower**

The results on dry stalk weight as influenced by the combined effects of variety and intercrop have been presented in Table 5. The treatment combination of tall variety ($V_T$) and control intercrop ($I_0$) produced the highest dry stalk weight (720.00 gm). On the other hand, dwarf variety ($V_D$) and intercropping Bengal spinach ($I_P$) gave the lowest dry stalk weight (168.33 gm). Analysis of variance showed that there was significant interaction between variety and intercrop for dry stalk weight of plant (Appendix III).

**4.16. Oil Content (%)**

Different variety as evident from Table 3, significantly varied in respect of oil content of seed. The highest percentage of oil content (29.33%) was found from tall variety Kironi ($V_T$) the lowest (22.12%) was found from dwarf variety Sunwheat-103 ($V_D$). It was observed that tall variety contain large head, increase the total number of seeds per head and the dwarf plants contain less number of seeds per head than tall one. Increase the total number of seeds per head and seed size may increase the percentage of oil content.

In the present experiment, the oil content was significantly influenced by the intercrop (Table 4). The highest percentage of oil content (28.78%) was found from the control intercrop ($I_0$) and the lowest (22.52%) was found from intercropping Bengal spinach ($I_P$).

The interation effects of variety and intercrop were not significantly influenced the percent of oil content (Figure 6) and the results have been presented in (Appendix III).

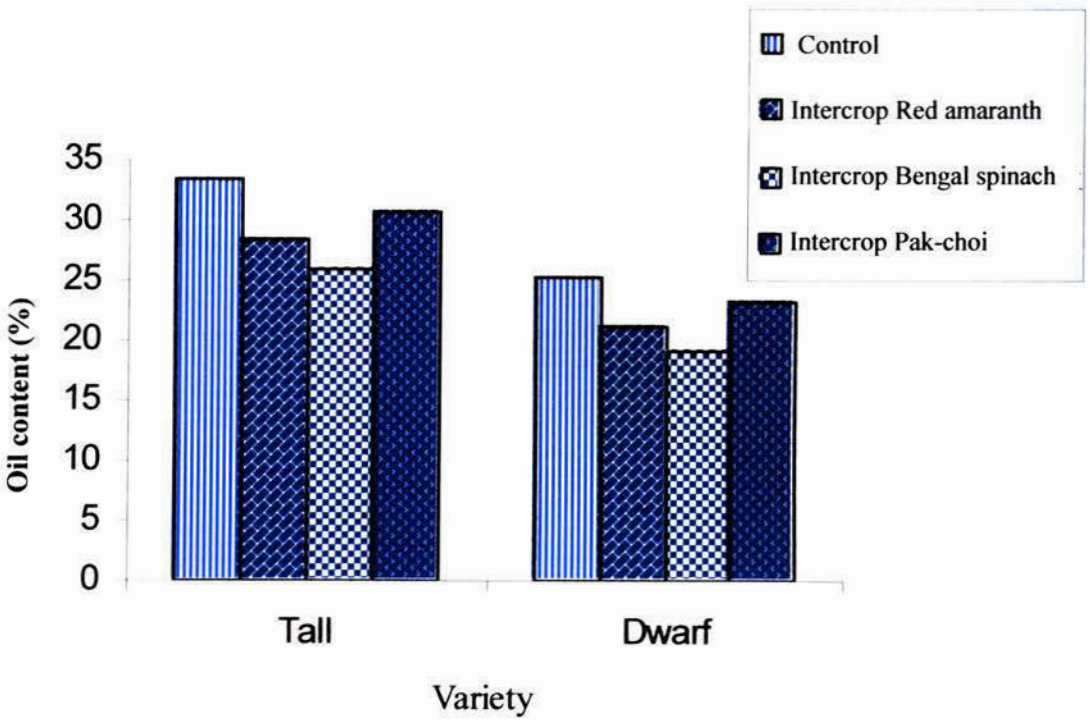



**Figure 6. Combined effects of variety and intercrop on oil content of sunflower**

### 4.17. Additional marketable yield from intercrop

The highest Red amaranth yield (13.69 t/ha) was obtained from $V_DI_L$ treatment and the lowest yield (12.60 t/ha) was obtained from the $V_TI_L$ treatment combination. Moreover, $V_DI_I$ treatment combination produced the highest Bengal spinach yield (10.74 t/ha) and the lowest yield (9.63 t/ha) came from $V_TI_P$ treatment combination. The highest Pak-choi yield (7.78 t/ha) was obtained from the $V_DI_B$ treatment combination and the lowest yield (7.41 t/ha) was recorded from the treatment combination of $V_TI_B$. All of the yield have been presented in Table 6.

**Table 6. Additional marketable yield from intercrop**

| Treatment | Marketable yield of intercrop (t/ha) | | |
|---|---|---|---|
| combinations | Red amaranth | Bengal spinach | Pak-choi |
| $V_TI_0$ | — | — | — |
| $V_TI_L$ | 12.60 | — | — |
| $V_TI_P$ | — | 9.63 | — |
| $V_TI_B$ | — | — | 7.41 |
| $V_DI_0$ | — | — | — |
| $V_DI_L$ | 13.69 | — | — |
| $V_DI_P$ | — | 10.74 | — |
| $V_DI_B$ | — | — | 7.78 |

$V_T$ = Variety Tall (Kironi) $I_0$ = No Intercrop (Control)

$V_D$ = Variety Dwarf (Sunwheat-103) $I_L$ = Intercrop Red amaranth

$I_P$ = Intercrop Bengal spinach

$I_B$ = Intercrop Pak-choi

### 4.17. Economic Analysis

Input cost for land preparation, fertilizer, seed, pesticide, intercultural operations and manpower required for all the operations including harvesting of crops was recorded for unit plot and converted into cost per hectare. Price of sunflower and intercrops was considered on market rate basis. The data has been presented in Table 7 and Appendix IV.

Cost of production varied due to price of seed of different crops. Lowest production cost (46628 Tk/ha) was involved in the treatment combination of tall variety sunflower ($V_T$) and control intercrop ($I_0$) which was the highest cost of production (57873 Tk/ha) was involved in the treatment combination of dwarf variety sunflower ($V_D$) and intercropping Bengal spinach ($I_P$).

The lowest gross return of (105553 Tk/ha) was obtained from the treatment combination of dwarf variety sunflower ($V_D$) and intercrop of Bengal spinach ($I_P$) and the highest gross return of (131133 Tk/ha) was obtained from the treatment combination of tall variety sunflower ($V_T$) and Red amaranth intercropping ($I_L$) on the other hand, the highest net return of (77539 Tk/ha) was obtained from the treatment combination of tall variety sunflower ($V_T$) and Red amaranth intercrop ($I_L$) and the lowest net return of (47680 Tk/ha) was obtained from the treatment combination of dwarf variety sunflower ($V_D$) and intercrop Bengal spinach ($I_P$). The benefit cost ratio was found to be highest (2.45) in the treatment combination of tall variety sunflower ($V_T$) and Red amaranth intercrop ($I_L$). On the other hand, the lowest (1.82) benefit cost ratio was obtained from dwarf variety sunflower ($V_D$) and Bengal spinach intercrop ($I_P$).

From economic point of view, it is apparent from the above result that tall variety sunflower ($V_T$) with Red amaranth intercrop ($I_L$) was more profitable than the rest of the treatments.

Table 7. Cost of production and economic return of sunflower and intercrop treatment combinations

| Treatment combinations | Yield of Sunflower (kg/ha) | Marketable yield of Intercrop (t/ha) | | | Gross return (Tk/ha) | | | | | Total cost of production (Tk/ha ) | Net return (Tk/ha) | Benefit cost ratio (BCR) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Red amaranth | Bengal spinach | Pak-choi | Sunflower | Red amaranth | Bengal spinach | Pak-choi | Total | | | |
| $V_TI_O$ | 1133 | - | - | - | 113333 | - | - | - | 113333 | 46628 | 66705 | 2.43 |
| $V_TI_L$ | 933 | 12.60 | - | - | 93333 | 37800 | - | - | 131133 | 53494 | 77539 | 2.45 |
| $V_TI_P$ | 800 | - | 9.63 | - | 80000 | - | 28890 | - | 108890 | 57216 | 51674 | 1.90 |
| $V_TI_B$ | 977 | - | - | 7.41 | 97778 | - | - | 22230 | 120008 | 54588 | 65420 | 2.19 |
| $V_DI_O$ | 755 | - | - | - | 113334 | - | - | - | 113334 | 47284 | 66050 | 2.39 |
| $V_DI_L$ | 555 | 13.69 | - | - | 83334 | 41070 | - | - | 124407 | 54150 | 70257 | 2.29 |
| $V_DI_P$ | 488 | - | 10.74 | - | 73333 | - | 32220 | - | 105553 | 57873 | 47680 | 1.82 |
| $V_DI_B$ | 688 | - | - | 7.78 | 103333 | - | - | 23340 | 126673 | 55209 | 71464 | 2.30 |

Price of Sunflower: Tall (Kironi) @ Tk. 100/kg
Dwarf (Sunwheat –103) @ Tk. 150/kg

Price of Intercrop: Red amaranth @ Tk. 3/kg
Bengal spinach @ Tk. 3/kg
Pak-choi @ Tk. 3/kg

Benefit cost ratio= Gross return ÷Total cost of production

# CHAPTER-5

# SUMMARY AND CONCLUSION

# CHAPTER-5

## SUMMARY AND CONCLUSION

An experiment was carried out at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during November 2004 to February 2005 to investigate the Sunflower based intercropping with leafy vegetables. There were two levels of variety ($V_T$ and $V_D$) and four levles of Intercrop ($I_0$, $I_1$, $I_P$ and $I_B$). The two factor experiment was laid out in randomized complete block design with three replications. There were altogether 8 (eight) treatment combinations in this experiment.

Data on growth and yield contributing characters were recorded by taking randomly ten (10) plants sample from each plot for sunflower. Yield of sunflower were recorded from all the plants from unit plot. Data were collected for plant height, number of leaves, days to first flowering, days to 50% flowering, days to maturity, diameter of head, no. of total seed per head, no. of developed and undeveloped seed per head, seed yield, 1000 seed weight, fresh and dry stalk weight and oil content (%). The collected data were statistically analyzed.

The results of the experiment showed that variety had significant influence on all the parameters except days to maturity. Intercropping had significant effect on all the parameters studied except days to maturity. Combined effect of variety and intercropping had significant effect on all of the parameters studied except in number

**of leaves (15 DAS), days to first flowering, days to 50% flowering, days to maturity and oil content (%).**

The height of plant and number of leaves per plant at different stages of growth i.e. 15, 30, 45, 60 and 75 DAS was recorded. At 75 DAS, the highest plant height (133.70cm) and the maximum number of leaves (27.42) were obtained from tall variety ($V_T$). Intercrop had significant effect on plant height and number of leaves per plant at different stages.

The longest time (50.00 days) for first flowering was found in dwarf variety ($V_D$) at intercropping Bengal spinach ($I_P$) and the shortest period (45.00 days) for tall variety ($V_T$) at control intercrop ($I_O$). The longest time (57.00 days) for 50% flowering was required by the treatment combination of dwarf variety ($V_D$) at Bengal spinach intercropping ($I_P$).

Days to maturity of plant were not significantly influenced by variety and intercrop cultivation. The maximum duration (89.00 days) was noted from the treatment combination of tall variety sunflower ($V_T$) and Bengal spinach intercropping ($I_P$). The minimum duration (84.00 days) was recorded in the treatment combination of dwarf variety ($V_D$) at Pak-choi intercropping ($I_B$).

Diameter of the head significantly influenced by variety and intercrop. The maximum diameter of the head (22.16cm) was obtained from tall variety ($V_T$) and control intercrop ($I_O$) and the minimum diameter of head (6.54cm) were recorded from dwarf variety ($V_D$) and Bengal spinach intercropping ($I_P$).

There were significant variations on weight of head among the different variety and intercrop. The highest weight (1923.33gm) was recorded from the tall variety ($V_T$) and the lowest weight (404.27gm) was obtained from dwarf variety ($V_D$). On the other hand, the maximum weight (1222.91gm) was found from the control intercrop ($I_O$) and the minimum weight (1109.37gm) was recorded from the intercrop Bengal spinach ($I_P$).

Maximum number of seed per head (380.33) was produced by the treatment combination of tall variety sunflower ($V_T$) at control intercropping ($I_O$) and the minimum of seed per head by the treatment combination of dwarf variety ($V_D$) at intercrop Bengal spinach ($I_P$).

The combined effect of variety and intercrop had significant effect in respect of number of developed and undeveloped seed per head. The maximum number of developed and undeveloped seed per head (277.07, 103.26) was noted from tall variety sunflower with control intercrop and the minimum member of developed and undeveloped seed per head (164.58, 26.75) was recorded from the treatment combination of dwarf variety sunflower ($V_D$) with intercrop Bengal spinach ($I_P$).

Seed yield were influenced by the different variety and intercrop. The highest seed yield (1133.33 kg/ha) was obtained from tall variety ($V_T$) at control intercrop (Io) and the lowest seed yield (488.89 kg/ha) was found from the treatment combination of dwarf variety ($V_D$) and intercrop Bengal spinach.

**Maximum 1000 seed weight was produced by the treatment combination of tall variety ($V_T$) and control intercrop ($I_O$) and the minimum by the treatment combination of dwarf variety and Bengal spinach intercropping.**

There were significant variation on fresh stalk weight and dry stalk weight among the different variety and intercrop used. The highest fresh stalk weight and dry stalk weight (1726.66, 690.16 gm) was obtained from tall variety ($V_T$) and from the intercrop cultivation the maximum fresh stalk weight and dry stalk weight (1120.00, 448.00) was recorded control intercrop ($I_O$).

Oil content was influnced by the different variety and intercrop. The highest oil content (32.33%) was obtained from the treatment combination of tall variety and control intercrop and lowest oil content (19.05%) was found from the treatment combination of $V_DI_P$ (Dwarf variety + intercrop Bengal spinach)

Cost and return analysis exhibited that the highest gross return (131133 Tk/ha) was obtained from tall variety ($V_T$) + Red amaranth intercrop ($I_L$) which was followed by dwarf variety + intercrop Pak-choi (126673 Tk/ha). The highest net return was obtained from tall variety + Red amaranth intercorp (77539 Tk/ha) followed by dwarf variety + Pak-choi intercrop (71464 Tk/ha).It appeared from benefit cost ratio that tall variety ($V_T$) + Red amaranth intercrop ($I_L$) had the highest benefit cost ratio (2.45) which was closely followed by tall variety ($V_T$) + control intercrop ($I_O$).

**From all the above information, it may be concluded that tall variety sunflower** ($V_T$) + Red amaranth intercrop ($I_L$) was the best intercropping combination and a **farmer may cultivate tall variety sunflower with Red amaranth as intercropping** system for maximizing land use efficiency and get yield advantage and maximum benefit. However, further trial may be done to confirm the findings.

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# APPENDICES

# APPENDICES

Appendix I. Monthly records of temperature, rainfall and relative humidity of the experimental site during the period from **October 2004 to** March 2005.

| Year | Month | *Air temperature ($^0$C) | | | Relative humidity (%) | **Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Mean | | |
| 2004 | October | 30.97 | 23.31 | 27.14 | 75.25 | **208** |
| | November | 29.45 | 18.63 | 24.04 | 69.52 | **00** |
| | December | 26.85 | 16.23 | 21.54 | 70.61 | **00** |
| 2005 | January | 24.52 | 13.86 | 19.19 | 68.46 | **04** |
| | February | 28.88 | 17.98 | 23.43 | 61.04 | **03** |
| | March | 32.22 | 21.78 | 27.00 | 66.69 | **155** |

* Monthly average ** Monthly total

Source: Bangladesh Meteorological Department (Climate division) , Agargaon, Dhaka-1207.

Appendix II.Chemical characteristics of soil of the experimental field

| Soil Properties | Analytical Data | Status | Critical Value |
|---|---|---|---|
| $P^H$ | 5.3 | Strongly acidic | |
| Organic carbon (%) | 0.45 | Very low | |
| Total nitrogen (%) | 0.09 | Very low | **0.12** |
| Phosphorus (ppm) | 41.89 | Very high | **10.0** |
| Potash (me/100g soil) | 0.18 | Low | **0.12** |
| Sulphur (ppm) | 43 | Very high | **7.0** |

Source: Soil Testing Laboratory, Soil Resources Development Institute (SRDI). Farmgate, Dhaka

Appendix III. Analysis of variance (ANOVA) on the growth and yield parameters of sunflower under leafy vegetables intercropping

| Source of variation | Degrees of freedom | Mean sum of squares | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant height (cm) at | | | | | Number of leaves per plant at | | | | |
| | | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS |
| Replication | 2 | 0.68 | 3.23 | 12.22 | 23.12 | 75.70 | 1.34 | 2.064 | 3.88 | 11.52 | 14.04 |
| Factor A (Variety) | 1 | 135.23** | 2065.72** | 10172.28** | 3626.89** | 68588.10** | 17.802** | 52.48** | 356.43** | 600.60** | 303.09** |
| Factor B (Intercrop) | 3 | 12.03** | 32.23** | 39.45** | 62.23** | 118.30** | 7.80** | 9.00** | 13.63** | 10.56** | 13.89** |
| Interaction (AxB) | 3 | 0.41* | 2.45* | 2.86* | 7.60* | 45.42* | 0.05NS | 2.15* | 2.27* | 5.47* | 9.02* |
| Error | 14 | 0.11 | 0.61 | 0.73 | 2.02 | 12.27 | 0.15 | 0.53 | 0.56 | 0.54 | 0.90 |

* Singificant at 5% level of probability

** Singificant at 1% level of probability

NS Not significant

Appendix III Continued.

| Source of variation | Degrees of freedom | Mean sum of squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Days to first flowering | Days to 50% flowering | Days to maturity | Diameter of the head (cm) | Weight of head (gm) | No. of total seed/head | **No. of developed seed/head** |
| Replication | 2 | 36.12 | 24.50 | 16.62 | 3.52 | 20402.00 | 136.12 | **861.12** |
| Factor A (Variety) | 1 | 40.01** | 91.96** | $12.05^{NS}$ | 880.27** | 13845259.56** | 152392.77** | **50272.21**** |
| Factor B (Intercrop) | 3 | 7.38** | 8.17** | $22.71^{NS}$ | 12.95** | 13911.79** | 1196.55** | **646.74**** |
| Interaction ( A×B) | 3 | $0.15^{NS}$ | $1.71^{NS}$ | $0.81^{NS}$ | 4.14* | 57167.54** | 271.34** | **266.13*** |
| Error | 14 | 3.26 | 2.78 | 11.05 | 0.96 | 5659.14 | 20.69 | **78.26** |

* Significant at 5% level of probability

** Significant at 1% level of probability

NS Not significant

Appendix III. Continued.

| Source of variation | Degrees of freedom | Mean sum of squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No. of undeveloped seed/head | Seed yield/plot (kg) | Seed yield (kg/ha) | 1000 seed weight (gm) | Fresh stalk weight (gm) | Dry stalk weight (gm) | **Oil content (%)** |
| Replication | 2 | 66.12 | 0.002 | 8450.00 | 7.87 | 19012.50 | 544.50 | **12.50** |
| Factor A (Variety) | 1 | 27406.39** | 0.14** | 689058.23** | 2451.87** | 1006214.76** | 1611498.42** | **312.12**** |
| Factor B (Intercrop) | 3 | 94.46** | 0.02** | 97963.13** | 39.27** | 12005.78** | 1947.02** | **43.83**** |
| Interaction ( A×B) | 3 | 38.25* | 0.001* | 16210.42** | 28.35* | 52380.38* | 1298.37** | **0.11**$^{NS}$ |
| Error | 14 | 9.55 | 0.0001 | 1621.42 | 7.01 | 4841.07 | 39.07 | **1.36** |

* Significant at 5% level of probability
** Significant at 1% level of probabilit
NS Not significant

Appendix IV. Detailed computation of the cost and return of sunflower and leafy vegetables (Red amaranth, Bengal spinach, Pak-choi) cultivation under intercropping

A. Input cost (a) Material cost (Tk.)

| Treatment combinations | Sunflower seed | Manure and fertilizers | | | | | Pesticide | Red amaranth seed | Bengal spinach seed | Pak-choi seed | Sub total I(a) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cowdung (10 ton/ha) | Urea (200 kg/ha) | TSP (200 kg/ha) | MP (150 kg/ha) | Gypsum (170 kg/ha) | | | | | |
| $V_TI_o$ | 1000 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | - | - | **17010** |
| $V_TI_L$ | 1000 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | 600 | - | - | **17610** |
| $V_TI_P$ | 1000 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | 4000 | - | **21010** |
| $V_TI_B$ | 1000 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | - | 1600 | **18610** |
| $V_DI_0$ | 1600 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | - | - | **17610** |
| $V_DI_L$ | 1600 | 5000 | 1400 | 3200 | 1350 | 3060 | 200 | 600 | - | - | **18210** |
| $V_DI_P$ | 1600 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | 4000 | - | **21610** |
| $V_DI_B$ | 1600 | 5000 | 1400 | 3200 | 1350 | 3060 | 2000 | - | - | 1600 | **19210** |

$V_TI_o$ = Sunflower Tall (Kironi) + No Intercrop

$V_TI_L$ = Sunflower Tall (Kironi)+ Intercrop Lalsak (Red amaranth)

$V_TI_p$ = Sunflower Tall (Kironi)+ Intercrop Palongsak (Bengal spinach )

$V_TI_B$ = Sunflower Tall (Kironi) + Intercrop Batisak (Pak-choi)

$V_DI_0$ = Sunflower Dwarf (Sunwheat-103) + No Intercrop

$V_DI_L$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Lalsak (Red amaranth)

$V_DI_P$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Palongsak (Bengal spinach)

$V_DI_B$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Batisak (Pak-choi)

Sunflower seed :Tall(Kironi) : @ Tk.100/kg Dwarf (Sunwheat-103) : @ Tk.200/kg

Intercrop: Red amaranth : @ Tk.200/kg Bengal spinach : @ Tk. 100/kg Pak-choi : @ Tk.200/kg

Cowdung : @ **Tk. 0.50/kg**

Urea : @ **Tk. 7/kg**

TSP : @ **Tk. 16/kg**

MP : @ **Tk.9/kg**

Gypsum : @ **Tk.18/kg**

Appendix IV Continued

b. Non-material cost (Tk)

| Treatment combinations | Land Preparation | Manure and fertilizers application | Seed sowing | Intercultural operations | Harvesting | | Sub total I (b) | **Total input cost I (a) + I (b)** |
|---|---|---|---|---|---|---|---|---|
| | | | | | Sole Crop | Intercrop | | |
| $V_TI_o$ | 6580 | 1050 | 2100 | 1050 | 8400 | - | 19180 | **36190** |
| $V_TI_L$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **42460** |
| $V_TI_P$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **45860** |
| $V_TI_B$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **43460** |
| $V_DI_o$ | 6580 | 1050 | 2100 | 1050 | 8400 | - | 19180 | **36790** |
| $V_DI_L$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **43060** |
| $V_DI_P$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **46460** |
| $V_DI_B$ | 6580 | 1050 | 2100 | 1120 | 8400 | 5000 | 25250 | **44060** |

Labour cost @ **Tk. 70/day**

$V_TI_o$ = Sunflower Tall (Kironi) + No Intercrop

$V_TI_L$ = Sunflower Tall (Kironi)+ Intercrop Lalsak (Red amaranth)

$V_TI_p$ = Sunflower Tall (Kironi)+ Intercrop Palongsak (Bengal spinach )

$V_TI_B$ = Sunflower Tall (Kironi) + Intercrop Batisak (Pak-choi)

$V_DI_o$ = Sunflower Dwarf (Sunwheat-103) + No Intercrop

$V_DI_L$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Lalsak (Red amaranth)

$V_DI_P$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Palongsak (Bengal spinach)

$V_DI_B$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Batisak (Pak-choi)

Appendix IV. Continued

B. Overhead cost (Tk.)

| Treatment combinations | Overhead cost (Tk.) | | | Sub total (overhead cost) | **Total cost of production (Input cost + overhead cost)** |
|---|---|---|---|---|---|
| | Interest on fixed capital (for 6 months) | Interest (14%) on running capital for 6 months | Miscellaneous cost (5%) of total input cost | | |
| $V_TI_o$ | 7000 | 2533 | 905 | 10438 | **46628** |
| $V_TI_L$ | 7000 | 2972 | 1061 | 11033 | **53494** |
| $V_TI_p$ | 7000 | 3210 | 1146 | 11356 | **57216** |
| $V_TI_B$ | 7000 | 3042 | 1086 | 11128 | **54588** |
| $V_DI_0$ | 7000 | 2575 | 920 | 10495 | **47284** |
| $V_DI_L$ | 7000 | 3014 | 1076 | 11090 | **54150** |
| $V_DI_P$ | 7000 | 3252 | 1161 | 11413 | **57873** |
| $V_DI_B$ | 7000 | 3084 | 1101 | 11149 | **55209** |

$V_TI_o$ = Sunflower Tall (Kironi) + No Intercrop

$V_TI_L$ = Sunflower Tall (Kironi)+ Intercrop Lalsak (Red amaranth)

$V_TI_p$ = Sunflower Tall (Kironi)+ Intercrop Palongsak (Bengal spinach )

$V_TI_B$ = Sunflower Tall (Kironi) + Intercrop Batisak (Pak-choi)

$V_DI_0$ = Sunflower Dwarf (Sunwheat-103) + No Intercrop

$V_DI_L$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Lalsak (Red amaranth)

$V_DI_P$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Palongsak (Bengal spinach)

$V_DI_B$ = Sunflower Dwarf (Sunwheat-103) + Intercrop Batisak (Pak-choi)