PERFORMANCE OF SESAME (*Sesamum indicum* L.) INTERCROPPED WITH MUNGBEAN (*Vigna radiata* L.)

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PERFORMANCE OF SESAME (*Sesamum indicum* L.) INTERCROPPED WITH MUNGBEAN (*Vigna radiata* L.)

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CERTIFICATE

This is to certify that the thesis entitled **" PERFORMANCE OF SESAME((Sesamum indicum L.) INTERCROPPED WITH MUNGBEAN(Vigna radiata L.)** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree **of MASTER OF SCIENCE (MS) in AGRONOMY**, embodies the results of a piece of bona fide research work carried out by **KEYA AKTER, Registration. No. 12-05059 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.**

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. Md. Shahidul Islam)
Supervisor

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The Author

PERFORMANCE OF SESAME (*Sesamum indicum* L.) INTERCROPPED WITH MUNGBEAN (*Vigna radiata* L.)

ABSTRACT

A field experiment was conducted to find out the performance of sesame (*Sesamum indicum* L.) intercropped with Mungben(*Vigna radiata* L.) at the Agronomy field of Sher-e Bangla Agricultural University, Dhaka-1207 during February 2018 to May 2018. The trial was laid out in a randomized complete block design with three replications. The treatment comprised of two sesame varieties BARI Til-3 and BARI Til-4 and two mungbean varieties BARI Mung-5 and BARI Mung-6. The treatments were ,T1= Sesame sole (BARI Til-3), T2= Sesame sole (BARI Til-4), T3=Mungbean sole (BARI Mung-5), T4= Mungbean sole (BARI Mung-6), T5=Intercropping (BARI Til-3+BARI Mung-5), T6= Intercropping (BARI Til-3+ BARI Mung-6), T7=Intercropping (BARI Til-4+BARI Mung-5), T8= Intercropping (BARI Til-4+ BARI Mung-6). Data on different parameters, yield and yield contributing characters were recorded and variation was observed. Results indicated that maximum plant height of sesame plant (21.93cm, 92.25cm and 109.20cm at 30, 60 and 90 days after sowing (DAS) respectively were found from T_6 (BARI Til-3+BARI Mung-6). Maximum leaf dry weight of sesame (3.7g and 5.76 g at 60 and 90 (DAS) respectively were found from T_6. Maximum stem dry weight of sesame in intercropping were (4.9g, 11.73g at 60 and 90 days after sowing (DAS) respectively also recorded from T_6. Among the intercropping patterns, the highest sesame yield (1.31t/ha) obtained from T_6 (BARI Til-3 with BARI Mung-6). The highest benefit-cost ratio and harvest index (%) were also obtained in treatment T_6 (3.21 and 0.40%). Highest gross return and net return were also obtained from T_6 (176368, 121368 Tk ha^{-1}). So, mungbean may he intercropped with sesame. Among the varieties combination BARI Til-3 showed better performance with BARI Mung-6.

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Chapter 1

Introduction

INTRODUCTION

The world during 21st century is facing shrinkage of land resources, increasing small holdings, heavy population pressure and consequently showing more hungry faces particularly in the developing countries. For this it is so difficult to have balance between production of food and population growth. Now it is more important to increase agricultural production per unit area of land. Efforts have been taken to increase the food production of the country and as a result 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 further increased vertically with the adoption of modern varieties, improved cultural technique and appropriate cropping systems like intercropping. Intercropping is an age old practice and has been recognized as a very common practice throughout the developing tropics (Willey, 1981). It is considered as the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms. Intercropping is defined as the growth of two or more crops in proximity in the same field during a growing season to promote interaction between them. Intercropping is also one of the important techniques to intensify production (Beet. 1977). Intercropping is not only a mean of augmentation of crop production and monetary return over space and time but also provides insurance against total crop failures and / or provides better avenues of employment for the rural folk (Bandyopadhyay, 1984).

In modern agriculture, intercropping is considered to be an effective and most potential way of increasing crop production per unit area particularly on small farms. There is a need to grow more than one crop in a season to satisfy the diversified demands of the farm people. Intercropping is an advance agro-technique and is considered to be an effective and potential mean of increasing crop production per unit area particularly farmers with small holdings (Ali *et al.,* 2000).

Bangladesh agriculture is constrained by low crop productivity due to limited land resources. Intercropping is a modern agronomic technique, effective and potential mean of increasing crop production per unit area and time (Ahmad and Anwar, 2001). Ghosh (2004) stated that intercropping offers to farmers the opportunity to engage nature's principle of diversity at their farms. Intercropping is a possible way of increasing the productivity on small farms, as it provides security against potential losses of monoculture. The yield losses of sole crop due to environmental condition may compensate by intercrop (Fukai and Ternbath, 1993).

Intercropping has several advantages over monoculture, because it enhances efficient use of environmental factors (e.g. light, nutrient and soil moisture) and labors, 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 using additional resources. All possible space in the crop field is fully utilized in intercropping system. Economical viability of intercropping system depends on many factors such as production potential of component crops, cost of production and market prices of the commodities.

Sesame (*Sesamum indicum L.*) belongs to the family Pedaliaceae is one of the important oil crops, which was widely grown in different parts of the world. It's a high valued crop grown in developed countries. It is grown for seed and oil, both for consumption and has been grown for thousand of years. Today its major production area are the tropics and sub tropics of Asia and Africa. Sesame seeds are considered as microcapsule for health and nutrition. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as 'the queen of oils'. Sesameolin, a constituent of the oil, is used for its synergistic effect in pyrethrum, which increases the toxicity of insecticides (Chaubey *et al*., 2003). The sesame oil cake is a very good cattle feed since it contain protein of high biological value and appreciable quantities of phosphorus and potassium. The cake is also used as manure (Malik *et al*., 2003). Sesame seed may be eaten fried mixed with sugar or in the form of sweet meats. The crop is cultivated either as a pure stand or as a mixed crop with aus rice, jute, groundnut, millets and sugarcane. Major sesame producing countries in the world are India, China, Nigeria, Myanmar and Tanjania.

In Bangladesh, it is locally known as 'Til' and is the second important edible oil crop (Mondal *et al.,* 1997). Sesame is a versatile crop having diversified usage and contains 42-45% oil, 20% protein and 14-20% carbohydrate rich in tryptophan and methonine which is excellent feed for milch animal and layers (Hatam and Abbasi, 1994).

In Bangladesh total area under sesame production is 34,24800 ha. Quantity of production is 30,44700 ton and average yield 0.889 t/ha.The crop grown in both rabi and kharif seasons in Bangladesh but the kharif season covers about two-third of the total sesame producing areas.Major ssame producing areas are Khulna, Faridpur, Pabna ,Barishal, Rajshahi, Jessore, comilla, Dhaka, Patuakhali ,Rangpur, Sylhet and Mymensingh districts are the leading sesame producing areas of Bangladesh. Yield and quality of seeds of sesame are very low in Bangladesh. The low yield of sesame in Bangladesh, however, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz., unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities, weed infestation. Small farm is another constraints in sesame production. Sesame can't compete with cereals and other high valued crop in small farm. Sesame production can be increased by horizontally or by vertically because total crop productivity and net return per unit area are higher in intercropping than sole cropping.

Mungbean *(Vigna radiata L.* Wilczek) is one of the major pulse crops in Bangladesh. It is a crop of the tropics and sub-tropics and requires a warm temperature regime. Mung bean may be grown as an intercrop with other tall crops like maize, sorghum, cotton, jute, sugarcane, pigeonpea etc. Beside, mungbean grown as early kharif-l crops so it can be fitted in kharif-1 sesame crop for substantial increase of pulse production.

. **Therefore, this research work has been planned with the following objectives:**

-To identify best combination of varieties for ensuring higher yield of sesame.

-To improve the nitrogen economy in legume association.

-To minimize the incidence of insect, pest and diseases.

-To meet domestic need of farmer and family.

-To reduce the risk of sole cropping of sesame and mungbean.

-To produce higher yield through better use of natural resources.

Chapter 2

Review of Literature

REVIEW OF LITERATURE

Intercropping is defined as the growth of two or more crops in proximity in the same field during a growing season to promote positive interaction between them. Among different cropping systems, intercropping system was found to be a better practice for increased growth, yield and development. Insurance against total crop failure under unusual weather conditions or pest epidemics are the most important advantages of intercropping system. But very few research works related to intercropping have so far been carried out in Bangladesh. An attempt has been made to present a brief review pertaining to the research information available on present investigation titled "Performance of sesame (*Sesamum indicum* L.) intercropped with mungbean (*Vigna radiata* L). Due to paucity of adequate experimental evidences on all aspects of pulses based intercropping system, relevant information and other related work have also been given, wherever felt necessary.

Verma and Yadav (1983) working at Udaipur did not observe any adverse effect on growth characters of pigeon pea in sorghum -pigeon pea intercropping system. While Srinivasan (1983) noticed that sorghum as intercrop reduced the growth parameters viz., plant height, branches per plant, leaf area index, dry matter production and its distribution in different plant parts of pigeon pea much more than green gram intercrop under Delhi condition.

Venkateshwarlu (1984) at Delhi condition observed that pigeon pea intercropped with cowpea and sesame recorded less number of branches and dry matter production per plant than sole pigeon pea. Samui *et al*. (1984) found that the total dry matter production, leaf area index, relative growth rate and net assimilation rate of sunflower were high with 1:1 and 1:2 ratio of sunflower and groundnut at Kalayani (west Bengal.). They also reported reduction in these parameters in 1:3 intercropping system. Natrajan and Willey (1986) reported dry matter yield advantage due to intercropping as compared to sole cropping ranging from 0-19 percent for sorghum +

groundnut system. Bangali (1987) while working at Jobner observed that plant height, dry matter production and number of tillers per meter row length significantly increased under paired row planting of pearlmillet intercropped with cowpea and mungbean over sole pearlmillet.

In an experiment at IARI, New Delhi, it was found that groundnut had no significant effect on dry matter accumulation in sunflower in any combination (Blaise and Giri, 1996). Sharma (1997) conducted an experiment at Jobner (Rajasthan) on intercropping of clusterbean, cowpea and mungbean with pearlmillet and reported that intercropping significantly enhanced plant height, dry matter accumulation and branches per plant of clusterbean, cow pea and mungbean at all the successive stages.

Maiti *et al*. (1998) while working at Mohanpur (west Bengal) observed that when groundnut grown as sole or intercropped with sesame in 2:1 and 1:2 row ratio, the maximum plant height of groundnut was observed with 2:1 ratio which was significantly superior to sole groundnut and 1:2 row ratio with sesame. Sole groundnut recorded greater plant height than that obtained from 1:2 ratio.

Majumdar *et al*. (2002) conducted a field experiment at West Bengal and revealed that intercropping of sesame CV. B-67 and mungbean CV. B-105 in 1:1 ratio resulted in higher number of seeds per capsule, seed and stick yields of sesame compared to other intercropping ratio.

Sarkar *et al.* (2003) conducted a field experiment during rabi season of 2000 and 2001 to determine productivity and economic feasibility of sesame based intercropping systems viz., sesame sole, green gram sole, black gram sole, sunflower sole, groundnut sole, sesame + green gram (1:1 URS, 2:1 PRS), sesame + black gram (1:1 URS, 2:1 PRS), sesame + sunflower (1:1 URS, 2:1 PRS), sesame + groundnut (1:1 URS, 2:1 PRS). Result showed that all the growth parameters of sesame like plant height and branches per plant were higher in sole stands and reduced with all intercropping systems.

Ahlawat *et al.* (2005) conducted a field experiment during 2000-2002 at New Delhi to evaluate the productivity of chickpea based intercropping systems in 2:1, 3:1 and 4:1

row proportion with Indian mustard, linseed and barley. The result revealed that sole chickpea recorded significantly lower plant height than that recorded in its intercropping with Indian mustard. The plant height of intercrops was found nonsignificant.

Porwal *et al*. (2006) while working at Udaipur observed that branches per plant of castor increased when intercropped with green gram but is decreased with black gram, clusterbean and sesame as compared to sole castor.

Kumar and Thakur (2006) conducted a field experiment during kharif season of 2002 and 2003 at Kangra (H.P.) to find out the most appropriate sesame based intercropping systems i.e. sesame sole, soybean sole, black gram sole, sesame + soybean (1:1, :2 and broadcast) and sesame + black gram (1:1, 1:2 and broadcast). The result showed that sole planting of sesame recorded significantly maximum number of branches per plant, however this was at par with sesame + blackgram 1:1ratio.

Meena *et al.* (2008) conducted a field experiment during three kharif season at Bhuj (Gujrat) on cluster bean- sesame intercropping system and reported that among the different intercropping systems [sole cluster bean, sole sesame, clusterbean + sesame (1:2, 1:1 and 2:1 row ratio)], clusterbean + sesame (2:1) recorded significantly highest plant height of clusterbean and sesame over sole planting and other row ratios.

Mandimba *et al.* (1998) conducted an experiment at Brazza Ville (Congo) on intercropping of groundnutwith maize in 4:1 row ratio and observed that intercropping reduced the dry matter yield of groundnut.

Rani and Reddy (2010) carried out a field experiment at Guntur and found that plant height, number of branches per plant and total dry matter of sole pigeonpea was significantly higher over pigeonpea + soybean intercropping.

Goud and Andhalkar (2012) observed that dry matter accumulation, branches per plant, plant height and stem diameter of pigeon pea decreased when intercropped with soybean. Yadav (2012) at Jobner reported that dry matter accumulation, decreased in moth bean when intercropped with sesame, whereas plant height increased as compared to sole planting.

Singh (2007) conducted a field experiment in Kashmir. India, during the rainy (Kharif) season to study the response of sunflower-frenchbean intercropping to different row ratios (1:1 and 2:2) and nitrogen levels (0, 40. 80 and 120 kg/ha) under rainféd conditions. Intercropping reduced the values of growth parameters, yield attributes and seed yield of both sunflower and frenchbean compared with their sole crops. Both the intercroppings recorded significantly higher sunflower-equivalent yield (SEY), net income. Monetary advantage and benefit-cost ratio than their sole stands. Intercropping of sunflower+frenchbean under2:2ow ratio recorded significantly higher SEY (1231 kg/ha). land-equivalent ratio (1.25). net income (Rs/. 13138/ha) and benefit-cost ratio (1.95), and also indicated a modest competitive ratio (2.10:0.48), followed by sunflower+frenchbean in 1:1 ratio. Both sunflower and frenchbean in sole and intercropping responded favourably up to 80 kg N/ha only for leaf area index, dry matter accumulation, yield attributes, seed yield. N uptake, net income and benefit-cost ratio. The interaction effects of the factors showed that mean SEY responded to N application up to 80 kg/ha in 2:2 row ratio of sunfiower+frenchbean.

Narwal and Malik (1986) working at Hissar observed reduction in sunflower yield due to intercropping with green gram, clusterbean, soybean and groundnut. Verma and Srivastava (1987) also reported reduction in pod yield of groundnut when intercropped with pigeon pea.

In an investigation at Cuttuck (Orissa), Moorthy and Das (1999) indicated that sesame + green gram (3:1and 4:1) and sesame + groundnut (1:1) although appeared to be promising ones from the view point of LER, they with regard to sesame equivalent yield, were inferior to the sole crops of green gram and groundnut. Mahale *et al* (2008) conducted an experiment at college of agriculture, Dapolidurity during rabi season of 2005, reported that maximum seed yield of sesame was recorded in sesame-groundnut 3:1 ratio with 30 kg S/ha over sole sesame with 60 kg S/ha.

Dahantande *et al.* (1995) worked at Akola (Maharashtra) and reported that when groundnut and sesame intercropped in 1:1, 2:2, 3:3, 4:2, 2:1 or 3:1 row ratios, the total yield was highest under sole groundnut.

Subrahmaniyam *et al.* (2000) in a field experiment at Vridhachalam (T.N.) observed that when groundnut was intercropped with red gram, green gram, sunflower and cowpea in 4:1 row ratio, intercropping of groundnut with red gram gave the highest groundnut and intercrop yield and net return.

Sarkar *et al*. (2003) conducted a field experiment during rabi season of 2000 and 2001 to determine productivity and economic feasibility of sesame based intercropping systems viz, sesame sole, green gram sole, black gram sole, sunflower sole, groundnut sole, sesame + green gram (1:1 URS, 2:1 PRS), sesame + black gram (1:1 URS, 2:1 PRS), sesame + sunflower (1:1 URS, 2:1 PRS), sesame + groundnut (1:1 URS, 2:1 PRS). The yield attributing characters of Sesame such as number of capsules per plant, seeds per capsule and 1000- seed weight reduced with all the intercropping systems. Among different intercropping systems, paired row planting of sesame with groundnut recorded significantly higher seed yield of sesame.

Tripathi *et al.* (2005) found that the yield attributes viz., pods per plant, seeds per pod, 1000-seed weight and seed yield of chickpea was significantly higher in sole cropping then that recorded in intercropping with Indian mustard under both 6:2 and 8:2 planting patterns.

Kumar and Thakur (2006) conducted a field experiment during kharif season of 2002 and 2003 at Kangra (H.P.) to find out the most appropriate sesame based intercropping systems i.e. sesame sole, soybean sole, black gram sole, sesame + soybean (1:1, 1:2 and broadcast) and sesame + black gram (1:1, 1:2 and broadcast). They revealed that intercropping reduced the yield attributes of sesame viz., capsules per plant, seeds per capsule 1000-seed weight and seed yield in all systems. Among the different intercropping system the highest yield of sesame was obtained in sesame + blackgram (1:1) planting (0.266t ha^{-1}).

Meena *et al.* (2008) conducted a field experiment during three kharif season at Bhuj (Gujrat) on cluster bean- sesame intercropping system and reported that among the different intercropping systems [sole cluster bean, sole sesame, clusterbean +

sesame (1:2, 1:1 and 2:1 row ratio)], clusterbean + sesame in 2:1 row ratio recorded significantly maximum number of pods per plant, 1000- seed weight, harvest index of clusterbean and sesame than sole cropping.

Subrahmaniyam *et al.* (2000) in a field experiment at Vridhachalam (T.N) observed that when groundnut was intercropped with redgram, greengram, sunflower and cowpea at 4:1 row ratio, intercropping of groundnut with redgram gave the highest groundnut and intercrop yield.

Rathod *et al*. (2004) observed that when pigeonpea was intercropped with groundnut and frenchbean, growing of pigeonpea as sole crop recorded higher grain yield,stalk yield and harvest index as compared to intercropping system.

Singh *et al*. (2006) reported that maximum pearlmillet grain yield was recorded with pearlmillet (paired row) + soybean (2:1) followed by pearlmillet (uniform row) + soybean (2:1) followed by pearlmillet (uniform row) + soybean (1:1).

A field experiment was conducted by Tripathi *et al*. (2007) at JNKVV-Zonal Agricultural Research Station, Tikamgarh during rainy seasons of 2003, 2004 and 2005 under rainfed condition. On the basis of three years mean, results revealed that the highest sesame grain equivalent yield, net return and B:C ratio were recorded with sole sesame as compared to sole clusterbean and sole blackgram.

In intercropping system, clusterbean at 3:1 row ratio recorded higher sesame grain equivalent yield. The higher net returns and benefit cost ratio were also recorded with clusterbean at 3:1 row ratio intercropped with sesame. The intercropping of sesame + blackgram at 3:1 row ratio will remain in 2nd position in respect of sesame grain equivalent yield, net return & B. C. ratio.

Thakur *et al.* (2004) conducted a field experiment during 1994-95 and 1995-96 in Chhindwara. Madhya Pradesh, India, to select the most compatible intercrop with sunflower under varying row proportions for increased and economical productivity. The treatments comprised: 50 cm sole sunflower; 25 cm sole chickpea; 25 cm sole pea; 25 cm sole linseed; 25 cm sole niger; sunflower + chickpea (1:1 and 1:2); sunflower + pea (1:1 and 1:2); sunflower + linseed (1:1 and 1:2); sunflower + niger (1:1 and 1:2).

Sunflower + chickpea (1:1) gave the maximum plant height (100 cm) of wheat and land equivalent ratio (1.27). Sunflower + linseed (1:1) gave the highest head size (12.5 cm) and grain yield (1525 kg had) of sunflower. Sunflower + niger (1:1) had the highest number of seeds per head (279) and relative crowding coefficient (3.33). Sunflower + pea (1:1) and (1:2) and sunflower + linseed (1:2) gave the highest seed chaffiness (9.2%), sunflower equivalent yield (1101 kg $ha^{-1}$and stem girth (5.0 cm), respectively.

Guriqbal and Sekhon (2002) conducted a field experiment to study the intercropping of mungbean cv. SML 32 and spring-planted sunflower cv. MSFH 8. Five cropping systems were established: 1:4, 1:6 and 2:6 sunflower: mungbean row ratio and sole sunflower and mungbean. Sole crops of both species produced higher yields than intercrops. The land equivalent ratio was highest in 1:4 ratio in all the years. except in 1994. In terms of mungbean equivalent yield. 1:4 sunflower :mungbean ratio produced the highest, while sole mungbean the lowest.

A field experiment was carried out by Thanunathan *et al*. (2008) at Annamalai University Experimental Farm, Annamalainagar, Tamil Nadu during rabi and kharif season 2004 to find out the economically viable castor based intercropping system. Intercrops viz., blackgram, greengram, cowpea, sesame and soybean were grown between castor rows. Among the intercropping systems evaluated, castor + blackgram recorded higher castor seed yield and it was followed by castor + greengram intercropping system.

Alam (2015) reported that yield attributing characters of mustard and linseed were higher at 6:1 row intercropping than sole crops. The 6:2 row ratio of chickpea + mustard and chickpea + linseed recorded maximum grain and straw yields of linseed and mustard which were significantly higher over 6:1 row ratio in both the years.

Mahale *et al.* (2008) conducted a field experiment to study the performance of sesame + groundnut intercropping system. The results indicated that the treatment sesame + groundnut in 3:1 row ratio recorded significantly higher yield, that was at par with sesame + groundnut in 1:2 row ratio and sesame + groundnut in 1:3 row ratio.

Prajapat *et al*. (2011) observed that pods per plant and seeds per pod of sole mungbean, remaining at par with mungbean + sesame in 3:1 and 4:1 row ratios, significantly reduced when intercropped with sesame in 2:1 row ratio. The seed and straw yields of mungbean were also significantly reduced when it intercropped with sesame in all intercropping systems.

Goud and Andhalkar (2012) observed that pods per plant, seeds weight per plant and 100-seed weight of pigeon pea significantly increased when intercropped with soybean. Whereas, the seed yield of pigeonpea reduced significantly when intercropped with soybean.

Yadav (2012) at Jobner reported that pods per plant and seeds per pod of sole mothbean, remaining at par with mothbean + sesame 2:1 and 3:1 row ratios significantly reduced when intercropped with sesame in 2:1 paired row ratio. The seed and straw yields of mothbean were also significantly reduced when it intercropped with sesame in all intercropping systems.

Dhandayuthapani *et al.* (2015) observed that yield of pigeonpea were achieved higher in pigeonpea (120 x 30 cm) + greengram 1:3 row ratio than other planting geometry and row ratio.

Sahoo *et al.* (2006) conducted a field experiment to determine the suitable intercropping system of grain legumes with sunflower and worked out the economics of sole and intercropping systems during the rabi season in Andhra Pradesh, India. Treatments comprised: sole crop of sunflower (SF); sole crop of groundnut (ON); sole crop of' greengram (GO); sole crop of blackgram (BG): sole crop of cowpea (CP); sole crop of soybean (SB); SF + ON (at 100% + 50% population); SF + GG (at 100% + 50% population); SF + SB (at 100% + 50% population); SF + CP (at 100% + 50% population); SF + SB (at 100% + 50% population). Among the intercropping treatments.

SF + ON produced the highest sunflower seed yield and was found to be significantly superior to the rest of the treatments. Seed or pod yield of all intercrops decreased in intercropping than their respective sole crops. lntercropping resulted in higher land equivalent ratio (LER) than sole cropping. LER was maximum with the SF -F on intercropping system, indicating a 45% yield advantage over sole cropping, which however was at par with SF + BG intercropping system. Gross returns, net returns and B:C ratio were also highest with SF + ON, followed by SF + BG intercropping system.

Rashid *et al*. (2002) conducted an experiment to evaluate the economic efficiency of intercropping summer legumes, soybean, mungbean and mashbean with sunflower under rainfed conditions. Intercropping systems gave higher gross income, net income and benefit-cost ratio than the sole cropping of component crops. Among all. sunflower-mungbean intercropping gave the highest per hectare gross income (Rs/. 18431.04). net income (Rs/. 10723.04) and benefit-cost ratio (2.39), followed by the sunflower - soybean and sunflower - mashbean intercropping systems.

Rajvir (2002) conducted a field experiment to study the effect of' intercropping with mungbean on the performance of sunflower under various planting patterns. The treatments consisted of sole sunflower and mungbean. sunflower + mungbean at 1:1 and also at different paired row and skip row. Sunflower had the highest leaf area index (5.39) when planted as a sole crop. The skip row planting of sunflower resulted in the highest dry matter production (195.56 g per plant). The highest sunflower seed yields were obtained under sole sunflower (1651 kg ha^{-1}) and sunflower + mungbean at 1:1(1502 kg ha^{-1}). Mungbean had the highest dry matter content (12.8 g per plant), leaf area index (2.92) and seed yield (1324 kg/ha) when planted as a sole crop.

Maloy conducted an experiment to find out the yield optimization through sunflower based intercropping system. Sunflower. greengram, blackgram and sesame were planted singly and sunflower (paired row) was intercropped with greengram, blackgram 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 greengram or blackgram. Dry matter accumulation was higher in sunflower intercropped with greengrani or blackgram than with sesame. The highest total productivity in terms of sunflower equivalent yield has been recorded through two rows of sunflower intercropped with one row of greengram (27.6 q/ha), followed by sunflower intercropped with two rows of greengram (26.33 q ha^{-1}).

Shanwad *et al*. (2001) conducted an experiment, to study the integrated nutrient management in sunflower pigeonpea intercropping system. Combi nation of") organic sources (Farmyard manure, vermicompost and poultry manure) and 5 fertilizer levels (0, 25, 50, 75 and 100% of recommended dose) were used. Sunflower and pigeonpea were 30 cm x 60 cm spaced with 2:1 row proportions. Application of poultry manure + 100% of recommended dose of fertilizer (RDF) to sunflower and 50% RDF to pigeonpea, farmyard manure + 100% RDF to sunflower and 50% RDF to pigeonpea were found suitable combinations in intercropping system.

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 at ratios of 1:1, 1:2. 1:3. 3:1. 3:2 and 3:3 in the field. 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.

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 legumes. The sunflower seed yield equivalent, gross and net monetary returns and cost-benefit ratios were lowest with sole situations. 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.

Gouri *et al*. (1997) studied the effect of intercropping sunflower with legumes on yield and economics. In this experiment sunflower was grown alone or intercropped with pigeonpeas, cowpeas, soybean or blackgram with normal (4500 cm) or paired row (30/6000 cm) spacing of sunflowers. Each legume was also grown alone. Sunflower equivalent yield and economic returns were highest from pigeonpeas grown alone, followed by sunflowers (normal) + pigeonpeas and sunflowers (paired) + Pigeonpeas intercropping system.

Sarkar and Chakraborty (1995) conducted an experiment on the yield components and yield of sunflower, sesame and greengram 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 greengram were decreased by over 60%.

Oil content of groundnut spaced at 30 x 5 cm intercropped with one row of sunflower declined (Venkateswarulu *et al.,* 1980). Total oil and protein yield were found to be higher by inter cropping of sunflower with groundnut as compare to sole crops. (Nikamet *et al*., 1984). Intercropping increased the total oil content and protein yields of groundnut (Venkateshwarulu et al., 1980, Nikamet et al., 1984 and Bina, 1989).

Narwal and Malik (1986) working at Hissar, reported that intercropping increased the protein content but had no effect on percent oil content of sunflower when intercropped with legumes. Biradar et al. (1986) conducted an experiment at Dharwad (Karnataka) and reported that neither the intercrop row proportion nor plant Contrary to this Shafshak et al. (1986) found that sunflower seed oil content increased from 41.0 per cent in the pure stand to 44.5 percent for double rows of sunflower alternated with double row of soybean.

Kumar and Gautam (1992) worked at New delhi on biomass production and nutrient uptake studies in intercropping of castor and cowpea under rainfed conditions and observed that residual N was higher in the soil after harvest of the crop in intercropping of cowpea and castor. Kumar et al. (1993) observed increase in grain protein content in pearlmillet under castor + pearlmillet intercropping system.

Meena et al. (2008) reported that addition of 5 t FYM/ha along with 20 kg N/ha gave 8.5 and 9.8% higher uptake of N in clusterbean + sesame intercropping system in 2:1 row proportion than of 40 kg N/ha and the control respectively.

Abraham et al. (2010) carried out a field experiment during rabi seasons of 2005-06 and 2006-07 at Bulandshahr (U.P.). They reported that significantly higher uptake of N, P and S were recorded with chickpea + mustard (4:1) ascompared to sole crops.

Prajapat et al. (2011) reported that sole planting of mungbean and sesame significantly higher total uptake of nitrogen and sulphur as compared to different intercropping system.

Goud and Andhalkar (2012) reported that pigeonpea sole gave significantly higher total uptake of N and P as compared to pigeonpea + soybean (6:1).

Kumawat et al. (2012) carried out a field experiment during kharif season 2008-09 and 2009-10 to evaluate the response of pigeonpea [*Cajanus cajan (L.*) Millsp] + blackgram (*Vigna mungo L.)* intercropping system to integrated nutrient levels. Both the intercropping system gives significantly higher uptake of N,P and K when compared to sole pigeonpea.

Yadav (2012) at Jobner reported that sole planting of mothbean and sesame recorded significantly higher total uptake of nitrogen, phosphorus and sulphur and protein content in seed of mothbean as compared to different intercropping system.

Mandal et al. (2014) reported that highest nitrogen concentration in seed and straw, and protein contentin grains were obtained in maize + soybean (2:1) and maize + groundnut (3:4) treatment.

Ikramullah *et al.* (1996) reported that nitrogen uptake by sorghum crop was significantly more in sole sorghum (179 kg/ha) than intercropping system (157 kg/ha). While, Singh (1997) observed that the uptake of N and P2O5was significantly higher with intercropping than with sole cropping. Mishra *et al*. (1997) reported the highest crude protein yield in paired alternate rows of sorghum with cowpea (2:2) as compared with other sole and intercropping systems of fodder sorghum, cowpea and horse gram.

Kumar *et al.* (2005) observed that significantly higher total crude protein was recorded with maize + cowpea (2:2) indicating superiority of 35.5 and 68.9 per cent over sole stands of maize and cowpea, respectively. Further, total crude protein yield was equal in cowpea (sole), maize + cowpea (1:1 and 1:2) as well as with maize + cowpea (3:3 and 4:1).

Chapter 3

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during February 2018 to May 2018. This chapter deals with a brief description on experimental site, climate, soil, land preparation. layout. experimental design, intercultural operations, data recording and their analysis.

3.1 Location

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the rabi season of 2018. The experimental land was situated at the southwestern part of SAU Farm. It was located at 90°33' E longitudes and 23° 77' N latitude at an altitude 1 meter above the sea level. The land was medium high and well drained.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season (October-March). The weather data regarding temperature, rainfall, relative humidity and sunshine hour were collected from the weather station, Agargaon during the study period at the experimental site, which is presented in Appendix I.

3.3 Soil Properties

The experimental site had deep red brown terrace soil and belonged to Nodda cultivated series. The land was above the food level with sufficient sunshine during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The topsoil was silty clay loam in texture. Organic matter content was very low (0.62%) and soil pH varied from 5.97 - 5.43. Exchangeable K is about 0.43 rneq / 100 g soil (Appendix II).

3.4 Planting Materials

Two types of crops having dissimilar growth habits were used in the experiment. The crops were Sesame *(Sesamum indicum L.*) and Mungbean (*Vigna radiata L)*. Sesame was grown as main crop and Mungbean as companion crop.

3.5 Plant Characters and Variety:

3.5.1 Sesame

Two high yielding sesame varieties BARI Til-3 and BARI Til -4 were selected as a planting materials. Bangladesh Agricultural Research Institute (BARI) released BARI Til-3 and BARI Til-4 respectively in 2001 and 2009. It was found that BARI Til-3 variety complete its life cycle in 90-100 days and BARI Til-4 in 90-95 days. Their germination percentage was 84. The height of the variety BARI Til-3 is 100-110 cm and it has dark green leaf. Fruit is four chambered. Seed is deep red in color, and the yield is 1.20 -1.40 t/ha. The plant height of the variety BARI Til-4 is 90-120 cm with dark green leaf. Seed is deep red in color and its yield is 1.4- 1.5 t/ha which is 8-10% higher than BARI Til-3.

3.5.2 Mungbean

Mungbean belongs to the family Fabaceae and sub family Papilionaceae. Two high yielding mungbean varieties BARI Mung-5 and BARI Mung -6 was selected as planting materials. BARI Mung-5 released by BARI in 1997 and BARI Mung -6 was released by BARI in 2003. It was found that BARI Mung-5 completes its life cycle in 60-65 days and BARI Mung -6 in 55-58 days. BARI Mung-5 is a leaf spot and yellow mosaic virus resistant variety. Leaf, fruit and seeds are larger in size. 1000 seed weight is 40-42g. Around 70-80% fruit mature at the same time and the yield is 1200-1500kg/ha. The height of the variety BARI Mung-6 is 40-45 cm. Around 80% fruit mature at the same time. It has dark green leaf and fruit. Seeds are larger in size. Its also leaf spot and yellow mosaic virus resistant variety. 1000 seed weight is 51-52g ha^{-1} . Around 80% fruit mature at the same time and the yield is 1500-1600kg/ha.

3.6 Experimental Details

3.6.1 Treatments

The experiment consisted of the following treatments:

T_1= Sesame sole (BARI Til-3)

T_2= Sesame sole (BARI Til-4)

T_3=Mungbean sole (BARI Mung-5)

T_4= Mungbean sole (BARI Mung-6)

T_5=Intercropping (BARI Til-3+BARI Mung-5)

T_6= Intercropping (BARI Til-3+ BARI Mung-6)

T_7=Intercropping (BARI Til-4+BARI Mung-5)

T_8= Intercropping (BARI Til-4+ BARI Mung-6)

3.6.2 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from 0-15 cm soil depth. The samples were collected by means of an auger from different location, covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a 10 mm sieve and stored in a clean plastic container for physical and chemical analysis.

3.6.3 Land Preparation

The experimental field was first opened on February 3, 2018. The land was ploughed thoroughly with a power tiller and given laddering to obtain the desirable tilth. Weeds, stubbles and crop residues of the field were removed prior to sowing of seeds and the whole experimental area was divided into 24unit plots, maintaining the desired spacing. The field layout was done according to the experimental design. Then all basal doses of fertilizers as per treatment were incorporated into the soil and finally the plots were made ready for sowing.

3.6.4 Experimental design and layout

The experiment was laid out in a randomized complete block design with three replications. The size of each unit plot was 2.4 m x 2.5 m and each plot was separated by 0.5m wide space. The experimental field was divided into three blocks.

3.6.5 Fertilizer application

The experimental field was fertilized with Urea, TSP, MP, Gypsum, Boric acid, and $ZnSo_4$ at the rate of 165, 230, 80, 62.5, 22 and 3 kg ha^{-1} respectively. The whole amount of all other fertilizers and half of N were mixed with soil at the time of final land preparation. The remaining urea was applied after 25-30 days after sowing as top dressing. Fertilizer dose of sesame was followed in sole sunflower and all the intercropped plots, whereas in sole mungbean plots, that of Mungbean was followed.

3.6.6 Collection and sowing of seeds

The seeds of sesame were sown on February 3, 2018. Furrows were made with hand rakes for sowing. Seeds were sown continuously in line. The line to line distance was 30 cm. After sowing, seeds were covered with soil. The Mungbean seeds were sown when the land was at field capacity condition at the same days on February 3, 2018. Seeds were sown continuous with maintaining line to line distance 30 cm. After sowing, seeds were covered with soil and slightly pressed by hand.

3.6.7 Intercultural operation

3.6.7.1 Thinning and gap filling

After one week of direct seed sowing thinning was done to maintain the respective population number. Gap filling was also done as when necessary.

3.6.7.2 Weeding

Two hand weedings were done. First weeding was done at 20 days after sowing followed by second weeding at 15 days after first weeding.

3.6.7.3 Application of irrigation water

Irrigation water was added to each plot according to the needs. Two light irrigations were given at 30 and 60 days after sowing. Before ripening the field was kept dry for all the plots.

3.6.7.4 Plant protection measures

The sesame crop was infested by some insect - pest and diseases and Mungbean was also infested by insect pest. Therefore contact insecticide (Diathene m45 @ 22.2 mm per 10 litres of water. Sevin 85 WP @ 5 g / kg seed, for treating the seeds.

3.6.8. Harvesting and sampling

At full maturity, the sesame crop was harvested plot wise on May 6, 2018. Before harvesting, five plants of sesame from each plot was selected randomly and uprooted. Crop of each plot was harvested separately and marked with tags, brought to the threshing floor and sun dried for three days. After threshing, seeds were then weighed separately to record the seed yield which was converted to t ha^{-1}. The mungbean pods was harvested at three installments. At first Mungbean was harvested in April 8, 2018. The whole mungbean pod was harvested plot wise on April 24, 2018. Sample plants were processed in the similar way for data collection.

3.7. Recording of data

3.7.1 Sesame

1. Plant height (cm)
2. Leaf dry weight (g)
3. Stem dry weight (g)
4. No. of capsules plant^{-1}
5. No. of seeds capsule^{-1}
6. Length of capsule (cm)
7. Seed weight (g)
8. 1000 seed weight (g)
9. Stover yield (g)
10. Seed yield (kg ha^{-1})

3.7.2 Mungbean

1. Plant height (cm)
2. Leaf dry weight (g)
3. Stem dry weight (g)
4. No. of pods plant^{-1}
5. Pod length (cm)
6. No. of seeds pod^{-1}
7. Seed weight (g)
8. 1000 seed weight (g)
9. Stover yield
10. Seed yield (kg/ha)

3.8. Procedure of recording data

The details of data recording is given below:

A. Sesame

1. Plant height (cm)

The height of five plants were measured from the ground level to tip of the plants and averaged. It was taken at 30 days interval starting from 9th March 2018.

2. Leaf dry weight (g)

Leaves from five plants at 30 days interval starting from 9th March 2018 were collected and dried at 70° C for 48 hours. The dried samples were then weighed and averaged.

3. Stem dry weight (g)

Stem of five plants at 30 days interval starting from 9th March 2018 were collected and dried at 70° C for 48 hours. The dried samples were then weighed and averaged.

4. No. of capsules plant^{-1}

The no. of capsule from five plants were counted and then averaged.

5. No. of seeds capsule-^{1}

Seeds of 10 capsule were counted and then averaged.

6. Length of capsule

Length of 10 capsules were measured and then averaged.

7. Seed weight

Seeds from five plants were collected and weight of those seeds were measured in an digital electric balance and then averaged.

8. 1000 seed weight (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and was expressed in gram.

9. Stover yield

Five plants were uprooted during harvesting. Leaves and stems of these plants were dried in sun and oven. The dried samples then weighted and averaged.

10. Seed yield (kg ha^{-1})

The mature capsule from selected and sampled plants were collected. Seeds were threshed, dried, weighed and averaged for determining seed yield ha^{-1}. The seed yields were recorded at 12% moisture level.

B. Mungbean

1. Plant height (cm)

The height of five plants were measured from the ground level to tip of the plants and averaged. It was taken at 20 days interval starting from 23^{th} February 2018.

2. Leaf dry weight (g)

Leaves from five plants at 20 days interval starting from 23^{th} February 2018 were collected and dried at 70° C for 48 hours. The dried samples were then weighed and averaged.

3. Stem dry weight (g)

Stem of five plants at 20 days interval starting from 23^{th} February 2018 were dried at 70° C for

48 hours. The dried samples were then weighed and averaged.

4. No. of pods plant^{-1}

The no. of pod from five plants were counted and then averaged.

5 No. of seeds pod^{-1}

Seeds of 10 pod were counted and then averaged

6. Length of pod

Length of 10 pods were measured and then averaged.

7. Seed weight

Seeds from five plants were collected and weight of those seeds were measured in an digital electric balance and then averaged.

8. 1000 seed weight (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

9. Stover yield

Five plants were uprooted during harvesting. Leaves and stems of these plants were dried in the sun and oven. The dried samples were then weighted and averaged.

10. Seed yield (kg ha^{-1})

The mature pods from selected and sampled plants were collected. Seeds were threshed, dried, weighed and averaged for determining seed yield ha^{-1}. The seed yields were recorded at 12% moisture level.

3.9. Productivity performance

3.9.1 Harvest index

The efficiency of a crop to convert the dry matter into the economic yield is determined with the help of harvest index value. More the value of harvest index of a variety more is the efficiency of the variety to convert the dry matter into the economic part of the crop. The harvest index value was calculated using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.9.2 Sesame equivalent yield (SEY)

Sesame equivalent yield was calculated and it was computed by converting the yield of companion crop (mungbean) into the yield of sesame on the basis of prevailing market prices using the following formula (Anjaneyulu *et al*.. 1982).

$$\text{Sesame equivalent yield} = YS + \frac{Ym \times pm}{Ps}$$

Here, Ys = Seed yield of Sesame (intercrop) (t/ ha)

Ym = Seed yield of mungbean (intercrop)(t/ ha)

Ps = Market price of Sesame seed (Tk. 90/ kg)

Pm = Market price of seeds of mungbean (Tk. 85/ kg)

3.9.3 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of sesame and mungbean intercropping. All input cost include the cost for lease of land and miscellaneous were considered in computing the cost of production. The market price of sesame and mungbean was considered for estimating the cost and return. Economic analysis was done by calculating benefit cost ratio (BCR).

The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return (Tk ha}^{-1}\text{)}}{\text{Total cost of production (Tk ha}^{-1}\text{)}}$$

3.10 Statistical analysis

The data collected on different parameters were statistically analyzed using the MSTAT computer package program developed by Russel (1986). Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez,1984).

Chapter 4

Result and Discussions

RESULTS AND DISCUSSIONS

Results of the experiment have been presented in this chapter. A brief discussion has also been made while presenting the results of the individual parameters**.**

4.1Growth and yield contributing characters of sesame

4.1.1 Plant height

Significant difference was recorded for plant height of sesame at 30, 60 and 90 DAS due to different treatments (Table1). At 30, 60 and 90 DAS the longest plant (21.93, 92.25 and 109.20 cm) was obtained from T_6 (Intercropped sesame) and the shortest plant (14.67, 77.13 and 87.77 cm) respectively for same days was recorded from T8. Intercropping probably creates a competition between the plant species regarding light receiving and nutrient absorption that leads to the vegetative growth and the ultimate results is the longest plant.

Similar findings were also found by Meena et al. (2008) while conducting a field experiment during three kharif season at Bhuj (Gujrat) on cluster bean- sesame intercropping system and reported that among the different intercropping systems [sole cluster bean, sole sesame, clusterbean + sesame (1:2, 1:1 and 2:1 row ratio)], clusterbean + sesame (2:1) recorded significantly highest plant height of clusterbean and sesame over sole planting and other row ratios.

Table1. Plant height of sesame affected by intercropping with mungbean

Treatments	Plant height(cm) at		
	30 DAS	60 DAS	90 DAS
T_1	20.00c	87.70b	100.63bc
T_2	20.13c	89.67b	99.60c
T_5	21.10b	83.17c	102.12b
T_6	21.93a	92.25a	109.20a
T_7	21.57ab	81.63c	93.47d
T_8	14.67d	77.13d	87.77e
LSD $_{(0.05)}$	0.69	2.28	2.082
CV (%)	1.91	1.47	1.1

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability.

Here,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.1.2 Leaf dry Weight

Leaf dry weight was significantly influenced by intercropping. At 30 DAS the highest leaf dry weight (0.34g) was found in T_7 which is not significantly different from T_6 (0.32g) and the lowest from T_8 (0.18g). At 60 DAS the highest leaf dry weight was found in T_6 (3.70g) and lowest in T_5 (1.61g). At 90 DAS highest leaf dry weight was fond inT_7 (6.04g) which is not significantly different from T_6 (5.76g) and T8 (5.80g) and lowest from T_1(5.38g) which is not significantly different from T_2, T_5, T_6 and T_8.

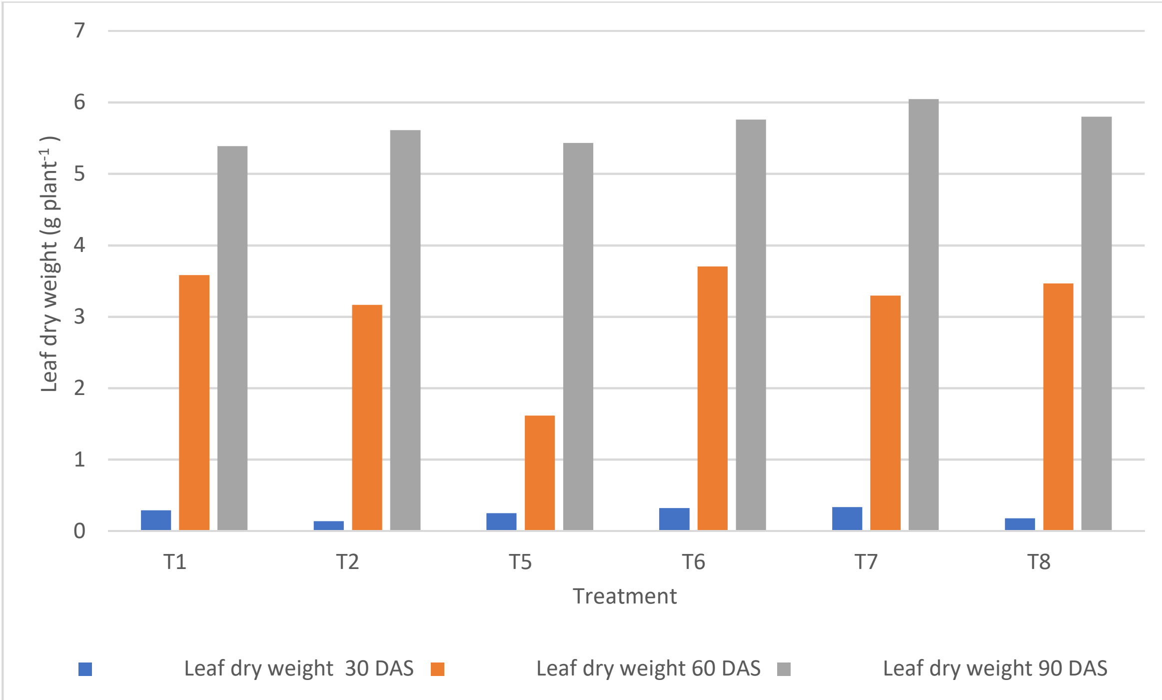

Figure1: Leaf dry weight of sesame affected by intercropping with Mungbean

$LSD_{(0.05)}$ =0.03, 0.15 and 0.59 at30, 60 and 90 Days after sowing

Here,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

Natrajan and Willey (1986) reported dry matter yield advantage due to intercropping as compared to sole cropping ranging from 0-19 percent for sorghum + groundnut system.

4.1.3 Stem dry weight

Stem dry weight of sesame was significantly varied at 30, 60 and 90 DAS due to different treatment. At 30 DAS maximum stem dry weight was recorded in Treatment T7(0.15g) which is statistically similar with T5(0.13g) and lowest from T8(0.08g) which is not significantly different from T2(0.07g) (sole sesame). At 60 and 90 DAS highest stem dry weight was recorded in T2 5.64 and 16.7 g (sole sesame) and lowest from T8(3.77g) and T1(7.58g). This may be due to BARI mung -6 influenced more than BARI Mung -5.

Bangali (1987) while working at Jobner observed that plant height, dry matter production and number of tillers per meter row length significantly increased under paired row planting of perlmillet intercropped with cowpea and mungbean over sole pearlmillet.

4.1.4 Number of capsules plant^{-1}

Intercropping has no significant effect on number of capsule plant^{-1} (Table 4). The highest number of capsule recorded from T_5 (67.667) (BARI Mung-5+ BARI Til-3) and lowest from T_1 (62) (sole sesame). Number of capsule plant^{-1} are statistically similar in both sole sesame and intercropped sesame.

4.1.5 Length of the capsule

Intercropping has no significant effect on length of the capsule (Table 4). Maximum length of the capsule was recorded in T_8 (2.67cm) and minimum in T_6 (2.42cm). Length of the capsule in both sole and intercropped sesame are statistically similar.

4.1.6 Number of seeds capsule $^{-1}$

Intercropping has significant effect on number of seed capsule^{-1} under different treatment (Table 4). The highest number of seed was recorded in T_5 (82.6) which is not significantly different from T_8 (80.5) and lowest number of seed was recorded inT_7 (69.66). This may be due to BARI Mung-5 influenced more on BARI Til-4 than BARI TIL-3.

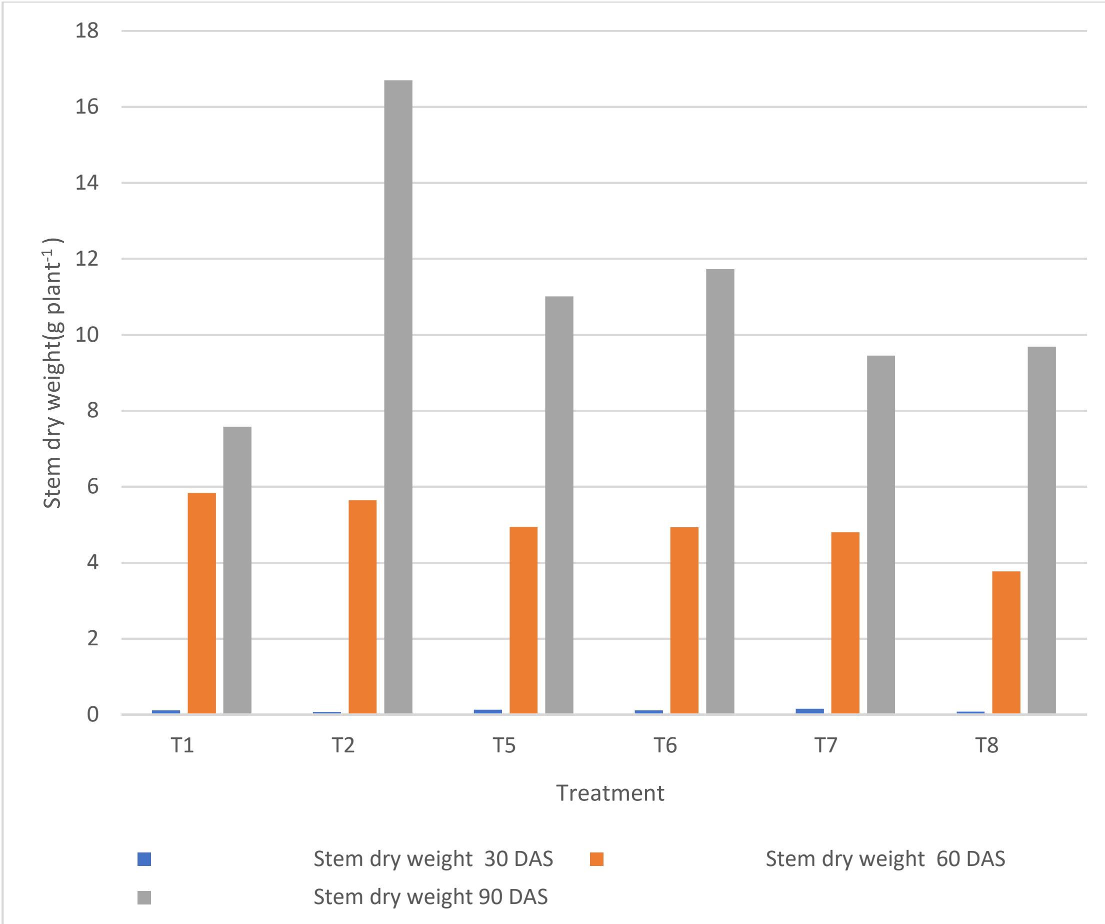

Figure 2: Stem dry weight of sesame affected by intercropping with Mungbean

$LSD_{(0.05)}$ =0.02, 0.49 and1.09 at 30, 60 and 90 Days after sowing

Here,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.1.7 Seed weight plant^{-1} (g)

Intercropping has significant effect on seed weight/plant under different treatment (Table 4). Maximum seed weight was recorded in T_7 (7.704g) and minimum in T_6 (2.94). In intercropping BARI Mung-6 influenced more on BARI Til-3.

4.1.8 1000 seed weight

Recorded data shows that Intercropping has less significant influence on 1000 seed weight of sesame (Table 4). Maximum seed weight of 1000 seed was obtained from T_8 (3.50g) which is not significantly different from T_7 (3.427g) and minimum was recorded in T_6 (3.09g) which is statistically similar with T_1, T_2 and T_5. In intercropping BARI Mung-6 influenced more on BARI Til-3 than BARI Til-4.

Similar findings were also found by Meena et al. (2008) while conducting a field experiment during three kharif season at Bhuj (Gujrat) on cluster bean- sesame intercropping system and reported that among the different intercropping systems [sole cluster bean, sole sesame, clusterbean + sesame (1:2, 1:1 and 2:1 row ratio)], clusterbean + sesame in 2:1 row ratio recorded significantly maximum number of pods per plant, 1000- seed weight, harvest index of clusterbean and sesame than sole cropping.

4.1.9 Stover yield

Intercropping has significant effect on stover yield of sesame. Maximum stover yield was recorded in T_2 (367.06g) and minimum stover yield was recorded in T_5 (112.32g). BARI Mung-5 has more influence on BARI til-3 than BARI Til-4.

4.1.10 Seed yield of Sesame

The seed yield of sunflower was significantly influenced by intercropping. The significantly highest seed yield (1.6 t ha^{-1}) was obtained from T_2 (sole sesame) (Table 4). This value was higher than other values obtained from the rest of the treatments.

The highest seed yield in sole sesame might have resulted from the less competition of sesame plant population as there was no competition for light, space, nutrients and moisture among the plants in this treatment. On the other hand, the lowest seed yield of sesame (0.66 t ha^{-1}) was obtained from T_5.

Sarkar et al. (2003) also found that the yield attributing characters of Sesame such as number of capsules per plant, seeds per capsule and 1000- seed weight reduced with all the intercropping systems.

Table 2. Yield and yield contributing parameters of sesame affected by intercropping with Mungbean

Treatments	Capsule $plant^{-1}$ (No.)	Length of capsule (cm)	Seeds $capsule^{-1}$ (No.)	Seed weight $plant^{-1}$ (g)	1000 seed weight (g)	Stover yield (g)	Harvest index (%)	Yield (t ha^{-1})
T_1	62.00a	2.56a	76.33bc	6.93b	3.10b	303.51b	0.33b	1.49b
T_2	65.00a	2.57a	77.00bc	6.85b	3.20b	367.06a	0.31b	1.67a
T_5	67.67a	2.54a	82.67a	6.48b	3.15b	112.32d	0.37a	0.66f
T_6	66.50a	2.42a	73.00cd	2.94d	3.09b	192.52c	0.40a	1.31c
T_7	67.00a	2.43a	69.67d	7.70a	3.43a	264.84b	0.31b	1.22d
T_8	65.67a	2.67a	80.50ab	5.01c	3.50a	163.60c	0.39a	1.04e
LSD(0.05)	11.02	0.30	5.293	0.555	0.189	41.41	0.04	5.8513
CV (%)	9.23	6.51	3.80	5.10	3.21	9.73	6.33	2.61

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability.

Here,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.2 Growth and yield contributing characters of Mungbean

4.3 l Plant height

The plant height of Mungbean was not significantly influenced by intercropping. The highest plant height of mungbean 8.53, 27.65 and 34.857 cm were recorded at 20, 40 and 60 DAS respectively in T3(sole Mungbean) which is statistically similar with T4 and T7 at 20 DAS. Lowest from T8 (7.4,25.9 and 26.47 cm) at 20 ,40 and 60 DAS which is statistically similar with T5 and T6 at 60 DAS. This may be due to competition between the plants in intercropping. BARI Til -4 influenced more on BARI Mung-6 than BARI Til-3.

Sharma (1997) reported that intercropping significantly enhanced plant height of mungbean at all the successive stages.

Table 3. plant height of mungbean affected by intercropping

Treatments	Plant height(cm) at		
	20 DAS	40 DAS	60 DAS
T_3	8.53a	27.65a	34.86a
T_4	7.93a	25.70ab	30.83ab
T_5	8.27a	26.40ab	28.09bc
T_6	8.08a	25.25b	28.9bc
T_7	8.03a	27.20ab	31.2ab
T_8	7.43a	25.90ab	26.47c
$LSD_{(0.05)}$	2.15	2.38	4.09
CV(%)	9.45	3.19	4.81

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability.

Here,

- T_3= Mungbean sole (BARI Til-3)
- T_4= Mungbean sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.2.2 Leaf dry weight

Intercropping has significant influence on leaf dry weight of mungbean. At 20 DAS maximum leaf dry weight recorded in T_3 (0.09g) sole mungbean which was statistically similar with all other treatments and lowest from T_8 (0.0643g). At 60 and90 DAS maximum leaf dry weight recorded in T_3 (sole mungbean) 0.97, 1.86 g which was not significantly different from T4 and lowest from T7(0.68 and 1.39g) which was statistically similar with T_5. Intercropping may be created higher competition between the plants. In intercropping BARI TIL-3 had more influence on BARI Mung -6 than BARI Mung-5.

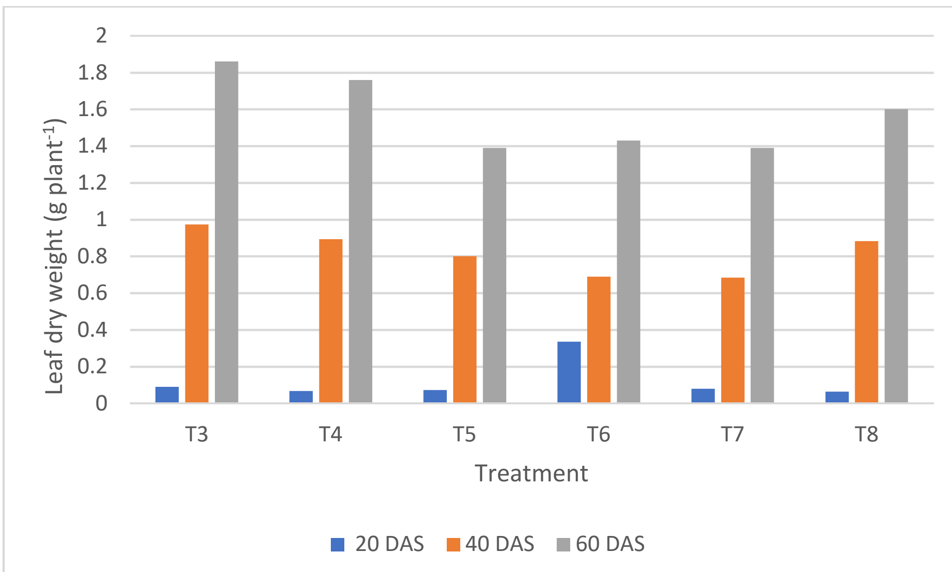

Figure 3: Leaf dry weight of mungbean affected by intercropping with sesame

$LSD_{(0.05)}$ =0.49, 0.26 and 0.19 at 20, 40 and 60 Days after sowing

Here,

- T_3= Mungbean sole (BARI Til-3)
- T_4= Mungbean sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.2.3 Stem dry weight

Intercropping has significant influence on Stem dry weight of mungbean. At 20 DAS maximum leaf dry weight was recorded in T_6 (0.074g) (intercropped mungben) which was statistically similar with T_4, T_5 and T_8 and minimum in T_3 (0.034) whereas at 40 and 60 DAS maximum leaf dry weight was recorded in T_3 (sole mungbean) 0.613, 2.23 g and minimum in T_5 (0.45g) and T_6 (0.91g). BARI Mung -5 showed better performance with BARI Til-4 than BARI Til-3.

Sharma (1997) reported that intercropping significantly enhanced dry matter accumulation of mungbean at all the successive stages.

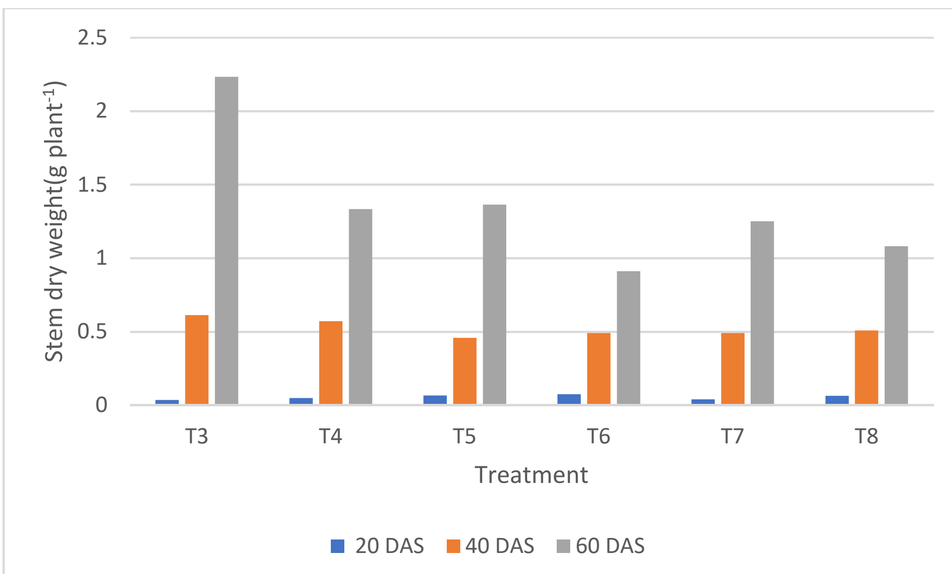

Figure 4: Stem dry weight of Mungbean affected by intercropping with sesame

$LSD_{(0.05)}$ =0.05, 0.22 and 0.19 at 20, 40 and 60 Days after sowing

Here,

- T_3= Mungbean sole (BARI Til-3)
- T_4= Mungbean sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.2.4 Number of pods plant^{-1}

Intercropping has significant influence on number of pod/plant (Table 8). Maximum number of pod was obtained from T_3(8.00) which was not significantly different from T_4 and minimum from T_6 (4.00) which was not significantly different from T_7 and T_8. The highest number of pods plant^{-1} of sole crop may be attributed to no or less competition for space, light, water and nutrients in these treatments. BARI Til-3 showed better performance than all other intercropped treatments.

Prajapat et al. (2011) observed that pods per plant significantly reduced when intercropped with sesame in 2:1 row ratio.

4.2.5 Length of pod (cm)

The pod length was not significantly affected by intercropping (Table 8). Maximum length of pod was obtained from T_8 and minimum from T_6 which was statistically similar with T_3, T_4, T_5, T_6 and T_7. In intercropping BARI Til-3 has more influence on BARI Mung-6 than BARI Til-4.

4.2.6 Number of seeds pod^{-1}

Number of seed pod-1 was not significantly affected by intercropping (Table 8). Highest number of seed was recorded in T3 which was not significantly different from T_4, T_6 and T_8. Lowest number of seed pod^{-1} was recorded in T_7 which was statistically similar with T_4, T_6, T_5 and T_8.

Prajapat et al. (2011) reported that seeds per pod of sole mungbean significantly reduced when intercropped with sesame in 2:1 row ratio.

4.2.7 Seed weight plant^{-1}

Intercropping has significant influence on seed weight/plant. Maximum weight of seed was obtained from T_3 (5.82) which is not significantly different from T_4

(5.53) and minimum from T_7 (2.66g) which is statistically similar with T_6 and T_5. BARI Mung-6 showed better performance with BARI Til-4 than BARI Til-3.

4.2.8 Weight of 1000 seed

Intercropping has significant influence on 1000seed weight of mungbean. Maximum seed weight of thousand seed was recorded in T_4 (87.09g) sole mungbean and minimum from T_3 (42.673) which was statistically similar with T_6. BARI Til-3 showed better performance with BARI Mung -6 than BARI TIl-4 with BARI Mung-6.

4.2.9 Stover yield

Intercropping has significant influence on stover yield of mungbean. Maximum yield of stover was recorded in T_3 (297.70g) sole mungbean and minimum from T_7(79.93g) which was not significantly different from T_5, T_6 and T_8 . BARI TIL-4 influenced more on BARI Mung-5 than BARI Til-3.

Prajapat et al. (2011) reported that straw yields of mungbean were also significantly reduced when it intercropped with sesame in all intercropping systems.

4.2.10 Seed yield

The Seed yield of mungbean was significantly affected by intercropping treatments (Table 8). The highest mungbean yield (1.25 t/ha) was recorded in T_3 (sole mungbean) which was significantly higher than those of other treatments. The lowest value (0.41t/ha) was obtained from the treatment T7 which was statistically similar with T5 (0.413t/ha). In intercropping BARI Til-3 show better performance with BARI Mung -6 than BARI Til-4.

Prajapat et al. (2011) reported that the seed yield of mungbean were also significantly reduced when it intercropped with sesame in all intercropping system.

Table 4. Yield and yield contributing parameter of Mungbean affected by intercropping with sesame

Treatments	No. of pods plant^{-1}	Length of pod (cm)	Seeds pod^{-1} (no.)	Seed weight (g plant^{-1})	1000 seed weight (g)	Stover yield (g m^{-2})	Yield (t ha^{-1})	HI (%)
T3	8.00a	6.81b	10.00a	5.82a	42.67c	297.70a	1.25a	0.2967 b
T4	6.33ab	6.65b	8.67ab	5.53a	87.09a	185.25b	0. 9b	0.3300 a
T5	6.00b	6.86b	8.00b	3.25c	49.90b	91.13c	0.41d	0.3200 a
T6	4.00c	6.48b	8.67ab	3.27c	47.58bc	138.19bc	0.68c	0.3333 a
T7	5.33bc	6.72b	8.00b	2.66c	52.88b	79.93c	0.41d	0.3467 a
T8	5.67bc	7.51a	9.67ab	4.37b	53.46b	137.80bc	0.62c	0.3100 ab
LSD$_{(0.05)}$	1.68	0.43	1.88	0.73	6.87	44.65	7.63	0.0715
CV (%)	15.71	3.47	11.69	9.61	6.80	6.25	15.83	12.18

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability.

Here,

- T_3= Mungbean sole (BARI Til-3)
- T_4= Mungbean sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

4.3. Productivity performance

4.3.1. Harvest index

The data depicting the harvest index of sesame is given in Table 2 which shows that intercropping has significant effect on the harvest index. Greater harvest index of 0.40 was obtained when sesame was intercropped with mungbean (BARI Til-3 +BARI Mung-6) T_6 which was statistically similar with T_5 and T_8. Lowest harvest index was recorded in T_2 (0.31) which was not significantly different from T_1 and T_7.

The data presented the harvest index of mungbean is given in Table 4 which shows that intercropping has less significant effect on the harvest index. Greater harvest index of 0.34 was obtained when was mungbean intercropped with sesame T_7(BARI Til-4+BARI Mung-5) which was statistically similar with T_4, T_5, T_6 and T_8. Lowest harvest index was recorded in T_3(0.296) which was not significantly different from T_8.

Bhatti (2005) however showed no effect of intercropping and row spacing on sesame harvest index.

4.3.2 Sesame equivalent yield (SEY)

Sesame equivalent yield of different intercropping of' sesame and mungbean at maturity stage have been shown in table 5. The sesame equivalent yield varied significantly in different row treatments. Among the treatments, the highest sesame equivalent yield (1.96) were obtained in $T_{6.}$ The second highest sesame equivalent yield (1.67) was obtainted from $T_{2.}$

Similar findings were also reported by Singh (2007). He opinioned that intercropping of sunflower + frenchbean under 2:2 row ratio recorded significantly higher sunflower equivalent yield (1231 kg/ha) than their sole stands.

4.3.2. Benefit-cost ratio

Benefit-cost ratio of different intercropping of sesame and mungbean have been shown in Table 5. The benefit-cost ratio varied significantly in different intercropping treatments. Among the treatments, the highest benefit: cost ratio was in T_6 (3.21). The next highest benefit: cost ratio was found in T_2 (2.73). The lowest benefit: cost ratio was obtained in T_4 (sole mungbean) and T_5 (1.47) in intercropping.

Table 5: Economical analysis of sesame and Mungbean

Treatment	Yield of mungbean (t ha^{-1})	yield of sesame (t ha^{-1})	Seasame equivalent yield (t ha^{-1})	Gross Return (Tk ha^{-1})	Net Return (TK ha^{-1})	Benefit cost ratio
T_1	0.00	1.49	1.49	134415	79415	2.44
T_2	0.00	1.67	1.67	150372	95372	2.73
T_3	1.25	0.00	1.18	106250	51250	1.93
T_4	0.95	0.00	0.90	80750	25750	1.47
T_5	0.41	0.66	1.05	94701.5	39701.5	1.72
T_6	0.69	1.31	1.96	176368	121368	3.21
T_7	0.41	1.22	1.61	144956	89956	2.64
T_8	0.62	1.04	1.63	146390	91390	2.66

Price: Sesame = 90 Tk kg^{-1}

Mungbean = 85 Tk kg^{-1}

Here,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_3= Mungbean sole (BARI Til-3)
- T_4= Mungbean sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

Chapter 5

Summary

SUMMARY

A study was carried out at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during February 2018 to May 2018 to evaluate the varietal performance of sesame and mungbean in sole and intercropping system over a cropping season. To meet the objectives, eleven treatments were used as,

- T_1= Sesame sole (BARI Til-3)
- T_2= Sesame sole (BARI Til-4)
- T_5=Intercropping (BARI Til-3+BARI Mung-5)
- T_6= Intercropping (BARI Til-3+ BARI Mung-6)
- T_7=Intercropping (BARI Til-4+BARI Mung-5)
- T_8= Intercropping (BARI Til-4+ BARI Mung-6)

All the physiological characters yield and yield contributing characters of sesame was significantly influenced by intercropping with mungbean. Plant height increased with the advancement of crop age. The highest plant height of 21.927,92.253and 109.20 cm were recorded respectively at 30, 60 and 90 DAS from T6 (intercropped sesame). The lowest plant height at all the stages was shown by T8.

Highest leaf dry weight was found in T_7 (0.336g and 6.043g) intercropped sesame at 30 and 90 DAS and lowest from T8(0.18g and 5.80 g at 30 and 90 DAS). Maximum stem weight was found in T_2(sole sesame) 5.64g and 16.7 g at 60 and 90 DAS and minimum in T_8(0.08g, 3.77g ,9.69g at 30, 60 and 90 DAS).

Highest number of capsule plant^{-1} were recorded from T_5 (67.67) {BARI Mung-5+ BARI Til-3}and lowest from T_1 (62) sole sesame. Maximum length of the capsule was recorded in T_8 (2.67 cm) and minimum in T_6 (2.42cm). The highest number of seed was recorded in T_5(82.67) and lowest number of seed was recorded inT_7(69.67). Maximum

seed weight was recorded in T_7 (3.42g) and minimum in T_6 (2.94g). Maximum 1000 seed weight obtained from T_8 (3.50g) minimum was recorded in T_6 (3.09g) Maximum stover yield was recorded in T_2 (367.60gm$^{-2)}$ and minimum stover yield was recorded in T_5(112.32 gm^{-2}).

The seed yield of sesame was significantly influenced by intercropping patterns with Mungbean. The significantly highest seed yield (1.6 t/ha) was obtained from T_2 (sole sesame). The lowest seed yield of sesame (0.66 t/ha) was obtained from T_5.

The plant height of mungbean was significantly influenced by different treatments in this study. The highest plant height of 8.533, 27.65 and 34.857 cm were recorded at 20, 40 and 60 DAS in T_3 (sole Mungbean) and lowest from T_8 (7.4, 25.9 and 26.47 cm) at 20 ,40 and 60 DAS.

At 20, 40 and 60 DAS maximum leaf dry weight recorded in T_3 (sole mungbean) 0.09, 0.97, 1.86 g and minimum from T_7 (0.68g, 1.39 g).

Maximum stem dry weight was recorded in T_3 (sole mungbean) at 40 and 60 DAS 0.613, 2.23 g and minimum from T_6 (0.91g) at 90 DAS.

Maximum number of pod was obtained from T_3 (8.00) and minimum from T_6 (4.00). Maximum length of pod was obtained from T_8 (7.50) and minimum from T_6(6.4cm).

Highest number of seed was recorded in T_3 and lowest number of seed/pod was recorded in T_7. Maximum weight of seed was obtained from T_3 (5.82g) and minimum from T_7 (2.66g). Maximum seed weight of 1000 seed was recorded in T_4 (87.09g) sole mungbean and minimum from T_3 (42.673g). Maximum yield of stover was recorded in T_3 (297.30g m^{-2}) sole mungbean and minimum from T_7 (79.93gm^{-2}) intercropped munngbean.

The highest mungbean yield (1.25 t/ha) was recorded in T_3 (sole mungbean) and the lowest value (0.41t/ha) was obtained from the treatment T_7.

Based on the above finalings it may be concluded that sole cultivation of sesame and mungbean yielded highest. In case of intercropping considerations, some intercropping treatments performs better than sole cultivation. It must be considered as less risky in case of crop failure.

By considering intercropping T6 was found best treatment for growth and yield parameters.

From the result of this experiment, it can be said that Mungbean can be successfully grown as intercrop with sesame without severe yield reduction. BARI Til-3 with BARI Mung -6 gave the highest yield and this intercropping pattern was found to be superior in terms of productivity and economic return.

From the present study it may be said that farmers should follow intercropping of sesame and mungbean instead of cultivating sole crops because it will bring more profit and will be the less risky as in the case of monocrop.

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APPENDICES

Appendix I. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from February to April 2018

Month	Year	Monthly average air temperature (°C)	Average relative humidity (%)	Total rainfall (mm)	Total sunshie (hours)
		Max.- Min.-Mean			
February	2018	28- 16 - 22	37	25	8
March	2018	32- 20- 26	38	65	7
April	2018	34- 24 - 29	42	155	6

Source: website

Appendix II. Physical characteristics and chemical compositions of soil of the experimental plot.

Soil Characteristics	Analytical result
Agroecological Zone	Madhupur Tract
P^H	5.97 - 6.43
Organic matter	0.86
Total N (%)	0.62
Available phosphorous	22 ppm
Exchangeable K	0.43 meq / 100 g

Source: Soil Resources Development Institute (SRDI)

Appendix III. Analysis of variance of the data on plant height of sesame at 30 days after sowing

Source of variation	DF	SS	MS	F- ratio	P Value
Replication	2	0.300	0.1500		
Treatment	5	107.332	21.4664	149.05	0.0000
Error	10	1.440	0.1440		
Total	17	109.072			

Appendix IV. Analysis of variance of the data on plant height of sesame at 60 days after sowing

Source of variation	DF	SS	MS	F- ratio	P Value
Replication	2	10.763	5.3814		
Treatment	5	473.624	94.7248	60.02	0.0000
Error	10	15.783	1.5783		
Total	17	500.170			

Appendix V. Analysis of variance of the data on plant height of sesame at 90 days after sowing

Source of variation	DF	SS	MS	F- ratio	P Value
Replication	2	6.209	3.104		
Treatment	5	820.021	164.004	125.21	0.0000
Error	10	13.098	1.310		
Total	17	839.327			

Appendix VI. Analysis of variance of the data on Leaf dry weight of sesame at 30 days after sowing

Source of variation	DF	SS	MS	F- ratio	P Value
Replication	2	0.00108	0.00054		
Treatment	5	0.09656	0.01931	49.24	0.0000
Error	10	0.00392	0.00039		
Total	17	0.10156			

Appendix VII. Analysis of variance of the data on Leaf dry weight of sesame at 60 days after sowing

Source of variation	DF	SS	MS	F	P
Replication	2	0.29188	0.14594		
Treatment	5	8.91996	1.78399	243.31	0.0000
Error	10	0.07332	0.00733		
Total	17	9.28516			

Appendix VIII. Analysis of variance of the data on Leaf dry weight of sesame at 90 days after sowing

Source of variation	DF	SS	MS	F	P
Replication	2	0.06194	0.03097		
Treatment	5	0.91271	0.18254	1.72	0.2181
Error	10	1.06286	0.10629		
Total	17	2.03751			

Appendix IX. Analysis of variance of the data on Stem dry weight of sesame at 30 days after sowing

Source of variation	DF	SS	MS	F	P
Replication	2	0.00008	3.889E-05		
Treatment	5	0.01436	2.872E-03	17.35	0.0001
Error	10	0.00166	1.656E-04		
Total	17	0.01609			

Appendix X. Analysis of variance of the data on Stem dry weight of sesame at 60 days after sowing

Source of variation	DF	SS	MS	F	P
Replication	2	0.46201	0.23101		
Treatment	5	7.99244	1.59849	22.01	0.0000
Error	10	0.72619	0.07262		
Total	17	9.18064			

Appendix XI. Analysis of variance of the data on Stem dry weight of sesame at 90 days after sowing

Source of variation	DF	SS	MS	F	P
Replication	2	0.296	0.1478		
Treatment	5	146.450	29.2899	80.93	0.0000
Error	10	3.619	0.3619		
Total	17	150.364			

Appendix XII. Analysis of variance of the data on Capsule no. plant-1 of sesame

Source of variation	**DF**	**SS**	**MS**	**F**	**P**
Replication	2	58.861	29.4306		
Treatment	5	61.069	12.2139	0.33	0.8818
Error	10	366.972	36.6972		
Total	17	486.903			

Appendix XIII. Analysis of variance of the data on seed no. capsule-1 of sesame

Source of variation	**DF**	**SS**	**MS**	**F**	**P**
Replication	2	29.861	14.9306		
Treatment	5	339.736	67.9472	8.03	0.0028
Error	10	84.639	8.4639		
Total	17	454.236			

Appendix XIV. Analysis of variance of the data on seed weight plant-1 of sesame

Source of variation	**DF**	**SS**	**MS**	**F**	**P**
Replication	2	0.8464	0.42319		
Treatment	5	45.2244	9.04487	97.05	0.0000
Error	10	0.9320	0.09320		
Total	17	47.0027			

Appendix XV. Analysis of variance of the data on 1000 seed weight of sesame

Source of variation	DF	SS	MS	F	P
Replication	2	0.08271	0.04136		
Treatment	5	0.45964	0.09193	8.49	0.0023
Error	10	0.10829	0.01083		
Total	17	0.65064			

Appendix XVI. Analysis of variance of the data on stover yield of sesame

Source of variation	DF	SS	MS	F	P
Replication	2	3.414E-04	1.707E-04		
Treatment	5	3.748E-03	7.497E-04	12.68	0.0005
Error	10	5.912E-04	5.912E-05		
Total	17	4.681E-03			

Appendix XVII. Analysis of variance of the data on yield of sesame

Source of variation	DF	SS	MS	F	P
Replication	2	3.6	1.80		
Treatment	5	18868.8	3773.76	364.81	0.0000
Error	10	103.4	10.34		
Total	17	18975.8			

Appendix XVIII. Analysis of variance of the data on plant height of Mungbean at 20 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.06948	0.03474		
Treatment	5	2.04864	0.40973	0.71	0.6304
Error	10	5.78052	0.57805		
Total	17	7.89864			

Appendix XIX. Analysis of variance of the data on plant height of Mungbean at 40 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.6908	0.34542		
Treatment	5	12.7500	2.55000	3.60	0.0401
Error	10	7.0792	0.70792		
Total	17	20.5200			

Appendix XX. Analysis of variance of the data on plant height of Mungbean at 60 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	1.091	0.5457		
Treatment	5	128.643	25.7285	12.31	0.0005
Error	10	20.898	2.0898		
Total	17	150.632			

Appendix XXI. Analysis of variance of the data on leaf dry weight of mungbean at 20 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.06597	0.03298		
Treatment	5	0.17050	0.03410	1.12	0.4078
Error	10	0.30364	0.03036		
Total	17	0.54011			

Appendix XXII. Analysis of variance of the data on leaf dry weight of mungbean at 40 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.05614	0.02807		
Treatment	5	0.20663	0.04133	4.59	0.0196
Error	10	0.09012	0.00901		
Total	17	0.35289			

Appendix XXIII. Analysis of variance of the data on leaf dry weight of mungbean at 60 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.01213	0.00607		
Treatment	5	0.61645	0.12329	25.03	0.0000
Error	10	0.04927	0.00493		
Total	17	0.67785			

Appendix XXIV. Analysis of variance of the data on stem dry weight of mungbean at 20 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	7.168E-04	3.584E-04		
Treatment	5	3.767E-03	7.534E-04	1.97	0.1698
Error	10	3.832E-03	3.832E-04		
Total	17	8.316E-03			

Appendix XXV. Analysis of variance of the data on stem dry weight of mungbean at 40 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.00968	0.00484		
Treatment	5	0.05158	0.01032	1.68	0.2275
Error	10	0.06152	0.00615		
Total	17	0.12278			

Appendix XXVI. Analysis of variance of the data on stem dry weight of mungbean at 60 days after sowing

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.01120	0.00560		
Treatment	5	3.16925	0.63385	135.44	0.0000
Error	10	0.04680	0.00468		
Total	17	3.22725			

Appendix XXVII. Analysis of variance of the data on No. of pod plant-1 of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	3.4444	1.72222		
Treatment	5	25.7778	5.15556	6.03	0.0080
Error	10	8.5556	0.85556		
Total	17	37.7778			

Appendix XXVIII. Analysis of variance of the data on length of the pod of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.27901	0.13951		
Treatment	5	1.89031	0.37806	6.71	0.0055
Error	10	0.56352	0.05635		
Total	17	2.73284			

Appendix XXIX. Analysis of variance of the data on Seed no. pod-1 of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	1.3333	0.66667		
Treatment	5	10.5000	2.10000	1.97	0.1693
Error	10	10.6667	1.06667		
Total	17	22.5000			

Appendix XXX. Analysis of variance of the data on seed weight plant-1 of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.6274	0.31371		
Treatment	5	25.6088	5.12177	32.20	0.0000
Error	10	1.5905	0.15905		
Total	17	27.8267			

Appendix XXXI. Analysis of variance of the data on 1000 seed weight of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	23.91	11.957		
Treatment	5	3803.04	760.607	53.19	0.0000
Error	10	143.00	14.300		
Total	17	3969.95			

Appendix XXXII. Analysis of variance of the data on stover yield of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	0.02668	0.01334		
Treatment	5	7.90984	1.58197	161.99	0.0000
Error	10	0.09766	0.00977		
Total	17	8.03418			

Appendix XXXIII. Analysis of variance of the data on yield of mungbean

Source of variation	DF	SS	MS	F ratio	P- value
Replication	2	43.4	21.68		
Treatment	5	15431.4	3086.28	175.55	0.0000
Error	10	175.8	17.58		
Total	17	15650.6			