

## LIGHT INTERCEPTION AND PRODUCTIVITY OF MAIZE INTERCROPPED WITH LEGUMES IN *KHARIF* SEASON

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(Received: 09 December 2021, Accepted: 19 December 2021)

**Keywords:** Light interception, maize legume intercropping, weed growth, productivity

### Abstract

The experiment was carried out at the Bangladesh Agricultural Research institute, Joydebpur, Gazipur during 2012 to evaluate the intercepted PAR in maize intercropped with legume in comparison to monoculture for better weed suppression, productivity and economic benefits in *kharif* season. There were 17 treatments in the experiment viz., T<sub>1</sub>= Sole maize (no weeding), T<sub>2</sub>= Maize + Mungbean (no weeding), T<sub>3</sub>= Maize + Mungbean (weeding at 20 DAE), T<sub>4</sub>= Maize + Mungbean (weeding at 40 DAE), T<sub>5</sub>= Maize + Mungbean (weeding at 20 and 40 DAE), T<sub>6</sub>= Maize + Soybean (no weeding), T<sub>7</sub>= Maize + Soybean (weeding at 20 DAE), T<sub>8</sub>= Maize + Soybean (weeding at 40 DAE), T<sub>9</sub>= Maize + Soybean (weeding at 20 and 40 DAE), T<sub>10</sub>= Maize + Blackgram (no weeding), T<sub>11</sub>= Maize + Blackgram (weeding at 20 DAE), T<sub>12</sub>= Maize + Blackgram (weeding at 40 DAE), T<sub>13</sub>= Maize + Blackgram (weeding at 20 and 40 DAE) T<sub>14</sub>= Sole maize (weed free), T<sub>15</sub>= Sole Mungbean (weed free), T<sub>16</sub>= Sole Soybean (weed free) and T<sub>17</sub>= Sole Blackgram (weed free). The results showed that PAR was significantly affected by cropping system, where it was higher in intercropping systems compared to sole crop. Regarding weed control, intercrops were more effective than sole crops and it was related to lower availability of PAR for weeds in intercropping systems. The highest grain yield (8.05 t ha<sup>-1</sup>) was obtained from weed free sole maize. Among all intercropping, maize + mungbean along with two hand weeding gave the highest yield (maize: 7.18 t ha<sup>-1</sup>; 572.6 kg ha<sup>-1</sup> mungbean), maize equivalent yield (MEY) = 12.49 t ha<sup>-1</sup> and BCR = 2.84). From the study it can be concluded that maize mungbean intercropping with two hand weeding at 20 and 40 DAE would be the best in reducing weed growth, producing maximum yield and net return in intercropping systems under *kharif* season.

### Introduction

Maize (*Zeamays* L.) is the third most important cereal next to rice and wheat, in the world as well in Bangladesh. Many factors are responsible for the low yields of maize in Bangladesh. The average yield of maize in Bangladesh is 3.0 t/ha (BBS, 2017) which is too low compared to many other countries. Weeds are one of the major constraints of maize production in our country. They cause yield losses worldwide with an average of 12.8 per cent despite weed control practices and 29.2% in case of unchecked weed growth (Dogan *et al.*, 2004). Although maize plant is vigorous and tall in nature, yet it is very sensitive to weed competition at early stages of growth. Hence, it is necessary that maize should be kept free of weeds for the first 30 days after crop emergence. Now-a-days, the labour force is diminishing in agriculture. Management of weeds in cropped field has become a real challenge to the farmers. The production and productivity of maize is reduced due to competition offered by weeds for growth resources viz., nutrients, moisture, sunlight and space during entire vegetative growth and early reproductive stage.

Intercropping is an agricultural practice which can be used for decreasing the dependency on chemical herbicides in weed control (Banik *et al.*, 2006). Intercropping generates beneficial biological inter-

actions between crops increasing grain yield and stability, more efficient using available resources and reducing weed pressure (Kadziulienė *et al.*, 2009). Many authors indicated the limiting effect of intercropping on the number and biomass of weeds (Gharineh and Moosavi, 2010). Weed suppression in intercropping through more efficient use of environmental resources by component crops has been reported (Poggio, 2005). Light interception and light use efficiency (LUE) of crops directly determine dry matter accumulation and yield formation, depending on canopy traits such as the distribution and photosynthetic capacity of the leaves (Gao *et al.*, 2010). Higher light interception or a higher LUE can result in greater productivity. Numerous studies reported that yield advantage in intercropping was mainly due to greater light interception and use efficiency. Katsaruware and Manyanhaire (2009) reported that maize-cowpea intercrops reduced weed biomass when compared to sole crops and it was as a result of limited availability of resources to weed species, where incoming PAR reaching the ground was reduced by maize-cowpea intercrop. Baumann *et al.* (2000) reported that intercropping increase light interception by the weakly competitive component and can, therefore, shorten the critical period for weed control and reduce growth and fecundity of late-emerging weeds. The tall maize C<sub>4</sub> plants canopy provides greater light penetration so that better light distribution is available over the leaves located in lower state. The under storey short stature C<sub>3</sub> legume crop is shaded but this is partially offset by its higher photosynthetic rates per unit radiant energy at a low light intensity and it may be compatible crop as intercrop with maize (Muoneke *et al.*, 2007). Among the intercrops, blackgram, greengram, soybean and cowpea were generally found to increase the yield of maize or gave similar yield along with an additional yield of intercrop (Li *et al.*, 2001). The aim of the present study was to quantify the effect of intercropping on weed suppression by evaluating the amount of photosynthetically active radiation (PAR) consumption.

## Materials and Methods

The experiment was conducted at the On-farm research field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *kharif* season of 2012. The experiment site was located at Chhiata Series under Agro-Ecological Zone-28. Before opening the land, the soil samples were taken and showed that the soil of the experimental field was loam in texture and low in organic matter (1.16%). The soil pH is 7.2 and contained very low amount of total nitrogen (0.061%), phosphorus (3 µg/g), sulphur (0.6 µg/g), zinc (3.54 µg/g), boron (0.44 µg/g) and potassium (0.13 meq./100g soil). During the crop growth period average monthly maximum temperature was recorded in the month of April (22.5° C). There were 17 treatments in the study viz., T<sub>1</sub>= Sole maize (no weeding), T<sub>2</sub>= Maize + Mungbean (no weeding), T<sub>3</sub>= Maize + Mungbean (weeding at 20 DAE), T<sub>4</sub>= Maize + Mungbean (weeding at 40 DAE), T<sub>5</sub>= Maize + Mungbean (weeding at 20 and 40 DAE), T<sub>6</sub>= Maize + Soybean (no weeding), T<sub>7</sub>= Maize + Soybean (weeding at 20 DAE), T<sub>8</sub>= Maize + Soybean (weeding at 40 DAE), T<sub>9</sub>= Maize + Soybean (weeding at 20 and 40 DAE), T<sub>10</sub>= Maize + Blackgram (no weeding), T<sub>11</sub>= Maize + Blackgram (weeding at 20 DAE), T<sub>12</sub>= Maize + Blackgram (weeding at 40 DAE), T<sub>13</sub>= Maize + Blackgram (weeding at 20 and 40 DAE) T<sub>14</sub>= Sole maize (weed free), T<sub>15</sub>= Sole Mungbean (weed free), T<sub>16</sub>= Sole Soybean (weed free) and T<sub>17</sub>= Sole Blackgram (weed free) were studied. Maize was sown in 75 cm × 20 cm spacing both in sole and intercrop system. Planting arrangement in intercrop treatments, two rows of legumes accommodated between one row of maize. The trial was laid out in a randomized complete block design with three replications. The plot size was 5.0m × 4.5m. Maize var. BARI Hybrid Maize-7, mungbean var. BARI Mung-5, blackgram var. BARI Mash-3 and soybean var. BARI Soybean-5 were used as test crops. Fertilizer was applied for maize at the rate of 250-50-100-44-5-2 kg of N, P, K, S, Zn and B ha<sup>-1</sup>, respectively, from urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half amount of N and full dose of other fertilizers were incorporated into the soil at the time of final land preparation. The remaining urea was top dressed in two equal installments as top dressing at 8-10 leaf stage (30-35 DAS) and at tasseling stage (55 DAS) followed by irrigation. Fertilizers were applied for sole mungbean, blackgram and soybean at the rate of 21-17-18 and 23-18-18 kg of N, P, K ha<sup>-1</sup>, respectively from Urea, TSP, MoP, respectively. Half

amount of urea and full amount of other fertilizers were applied at the time of final land preparation. Additional fertilizers were not applied for legumes in intercrop situation. Urea was top dressed as band placement in maize rows only. Sowing of both maize and legumes were done on 15 March 2012. Weed management was done as per treatment specification. Mature mungbean and blackgram were harvested at 65 DAE while soybean was harvested at 100 DAE. Maize was harvested at 120 DAS. Legume equivalent yield and maize equivalent yield were computed using the formula of Bandyopadhyaya (1984).

$$\text{Maize equivalent yield} = Y_{im} + (Y_{il} \times P_l) / P_m$$

Where,

- Y<sub>il</sub> = Yield of intercrop legume (t ha<sup>-1</sup>)
- Y<sub>im</sub> = Yield of intercrop maize (t ha<sup>-1</sup>)
- P<sub>m</sub> = Selling price of maize
- P<sub>l</sub> = Selling price of legume

Weed control efficiency (WCE) was calculated using the following formula (Curz *et al.*, 1986).

$$\text{WCE} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

DWC = Dry weight of weeds in the weedy check

DWT = Dry weight of weeds in the weeding treatment

The portion of intercepted PAR (PAR<sub>int</sub>) was calculated using the following equation and expressed in percentage (Ahmed *et al.*, 2010).

$$\text{PAR}_{int} (\%) = \frac{\text{PAR}_{inc} - \text{PART}}{\text{PAR}_{inc}} \times 100$$

Where, PAR<sub>int</sub> = Intercepted PAR, PAR<sub>inc</sub> = incident PAR and PART = transmitted PAR

The collected data were statistically analyzed by using MSTAT programme and the means were adjudged by using LSD. Economic analysis was also done.

## Results and Discussion

Weed density, weed dry weight and weed control efficiency (WCE) as affected by different intercropping systems and weeding regime are presented in Table 1. Intercropping systems significantly reduced the weed population and weed dry biomass than sole cropping of maize under unweeded situation. *Cynodon dactylon*, *Eleusine indica*, *Echinochloa crus-galli*, *Paspalum conjugatum*, *Cyperus rotundus* L. and *Physalis heterophyll* were the common and dominant weeds in the maize field. Maximum weed density (363.3 m<sup>-2</sup> at 20 DAE and 426 m<sup>-2</sup> at 40 DAE) and weed dry weight (216.8 g at 20 DAE and 284.4 g at 40 DAE) were recorded in unweeded monoculture maize crop. Among the three different intercropping systems, T<sub>5</sub> (Maize + Mungbean with two hand weeding at 20 and 40 DAE) treatment provided the lowest weed density (275.3 m<sup>-2</sup> at 20 DAE and 53.33 m<sup>-2</sup> at 40 DAE) and weed dry weight (184.3 g at 20 DAE and 14.07 g at 40 DAE) and it was followed by maize + soybean and maize + blackgram systems. The reduction in weed population and weed dry biomass in intercropping systems might be attributed to shading effect and competition stress created by canopy of more number of crop plants in a unit area having suppressing effect on associated weeds thus preventing the weeds to attain full growth. Similar results were reported by Dwivedi and Shrivastava (2011). At 20 DAE, the weed control efficiency (WCE) in all the treatments was almost same while at 40 DAE the WCE varied significantly in all treatments. Weed control efficiency of different treatments varied from 14.8-25.3% at 20 DAE and 17.9-87.53% at 40 DAE. Among the weed control treatments, two hand weeding at 20 and 40 DAE in maize + mungbean caused the highest weed control efficiency (24.0-87.5%) while it

was (19.55-85.46%) in maize + soybean and (19.82-80.09%) in maize + blackgram treatments. Pandey and Prakash (2002) reported that maize and legume intercropped either as paired rows + two rows of legume or one row of legume in between two rows of maize adversely affected the weed growth and caused 22.4 and 31.9% weed growth suppression as compared with sole maize, respectively. Among the intercropping systems, Maize + Soybean unweeded plot gave lower WCE (18.83-22.34%).

Table 1. Weed density, weed dry weight and weed control efficiency in different maize +legumes intercropping systems during the *Kharif* season of 2012

Treatments	Weed density (no. m <sup>-2</sup> )		Weed dry weight (g m <sup>-2</sup> )		Weed control efficiency (%)	
	20 DAE	40 DAE	20 DAE	40 DAE	20 DAE	40 DAE
T <sub>1</sub>	363.3 a	426.0 a	216.8 a	284.4 a	-	-
T <sub>2</sub>	284.7 cd	324.3 c	190.5 cde	178.0 b	21.32 abc	23.84 e
T <sub>3</sub>	283.0 cd	113.0 d	189.1 cde	25.61 e	21.82 abc	73.40 d
T <sub>4</sub>	270.7 d	326.3 c	181.2 e	157.9 c	25.25 a	23.27 e
T <sub>5</sub>	275.3 cd	53.33 g	184.3 de	14.07 f	24.05 ab	87.53 a
T <sub>6</sub>	293.3 bc	330.7 bc	196.3 bc	182.6 b	18.83 cd	22.34 e
T <sub>7</sub>	286.0 cd	85.67 ef	192.2 cde	35.17 d	21.12 abc	79.82 bc
T <sub>8</sub>	289.3 cd	333.3 bc	193.7 cd	163.9 c	20.13 bc	21.65 e
T <sub>9</sub>	291.0 bcd	62.00 g	194.8 cd	17.50 ef	19.55 bc	85.46 ab
T <sub>10</sub>	310.0 b	330.3 bc	207.5 ab	181.2 b	14.13 d	22.38 e
T <sub>11</sub>	280.7 cd	64.00 fg	187.8 cde	17.67 ef	22.42 abc	84.96 ab
T <sub>12</sub>	277.3 cd	349.3 b	185.6 cde	179.6 b	23.46 abc	17.87 e
T <sub>13</sub>	290.3 bcd	99.33 de	190.3 cde	38.50 d	19.82 bc	76.71 cd
CV (%)	4.48	6.49	8.32	3.10	13.99	6.91

T<sub>1</sub>= Sole maize (no weeding), T<sub>2</sub>= Maize + Mungbean (no weeding), T<sub>3</sub>= Maize + Mungbean (weeding at 20 DAE), T<sub>4</sub>= Maize + Mungbean (weeding at 40 DAE), T<sub>5</sub>= Maize + Mungbean (weeding at 20 and 40 DAE), T<sub>6</sub>= Maize + Soybean (no weeding), T<sub>7</sub>= Maize + Soybean (weeding at 20 DAE), T<sub>8</sub>= Maize + Soybean (weeding at 40 DAE), T<sub>9</sub>= Maize + Soybean (weeding at 20 and 40 DAE), T<sub>10</sub>= Maize + Blackgram (no weeding), T<sub>11</sub>= Maize + Blackgram (weeding at 20 DAE), T<sub>12</sub>= Maize + Blackgram (weeding at 40 DAE), T<sub>13</sub>= Maize + Blackgram (weeding at 20 and 40 DAE)

### Photosynthetically active radiation (PAR) interception

Light/ solar radiation is the energy that drives crop productivity by the process of photosynthesis (Keating and Cerberry, 1993). It is an important resource essential for crop production. The plants use this resource to produce biomass and part of biomass is converted to economic yield (Trenbath, 1986). Percent radiation interceptions in different intercropping systems with varying weeding regimes in *Kharif* season are presented in Fig. 1. Among the intercropping systems, maize + mungbean intercropping intercepted more light than maize + soybean and maize + blackgram systems at all growth stages. Maize + mungbean with two hand weeding at 20 and 40 DAE received more light (95%) at 50 DAE which was followed by one hand weeding (90%) and no weeding (88%) treatments. Same trend was observed in soybean and blackgram intercropping combinations. Percent PAR interception was lower in earlier growth stages but it increased gradually up to 50 DAE in mungbean and blackgram in maize + blackgram association with the increase of foliage coverage of maize and legumes. Significantly the higher mean of PAR interception was recorded in intercrop treatments and sole cropped legume than that of sole cropmaize (Eskandari, 2012). Among the legume crops, the intensity and the quality of solar radiation intercepted by the canopy are important determinants of yield components and therefore yield of soybean since it is sensitive to shading (Liu *et al.*, 2010).

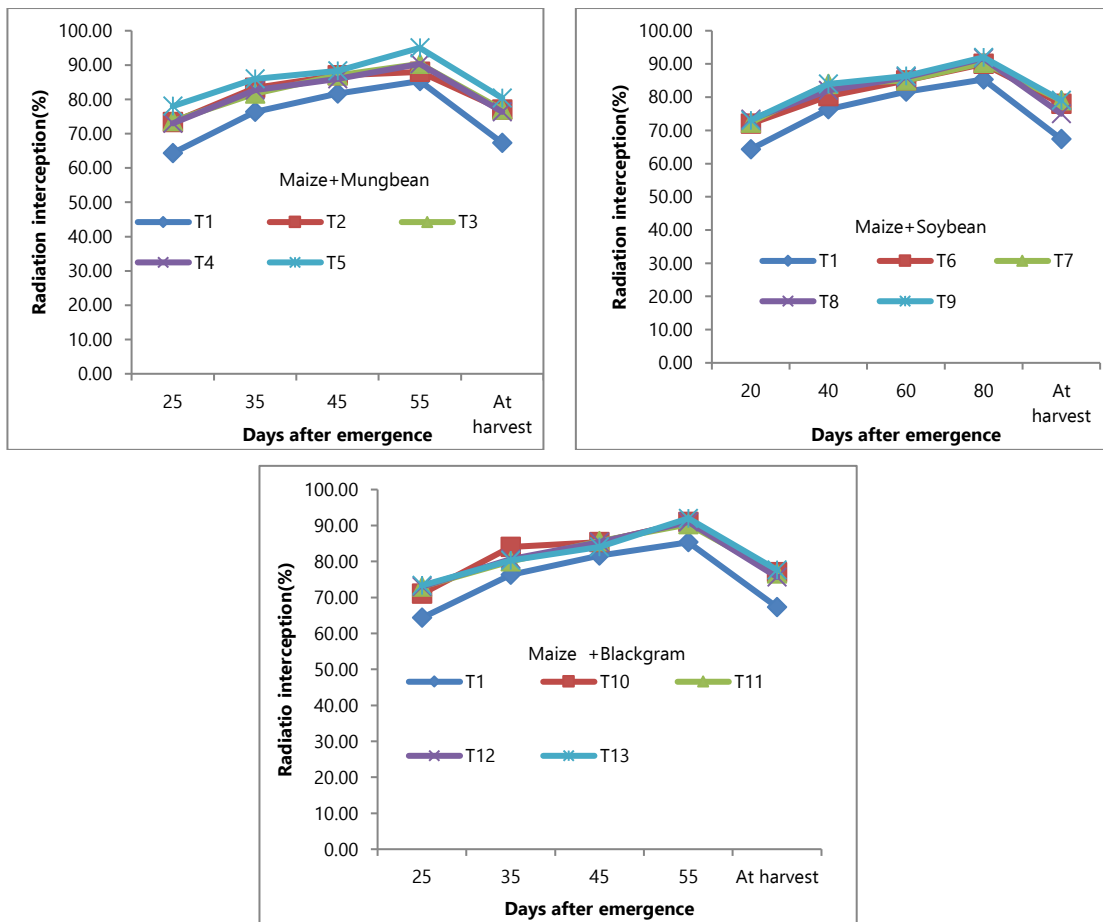


Fig.1. Photosynthetically active radiation interception of maize + legumes intercropping systems during the *Kharif* season of 2012.

Light levels during the late flowering to mid pod formation stages of growth have been found to be more critical than during vegetative and late reproductive periods (Liu *et al.*, 2010). Differences in varietal arrangement of foliage and canopy architecture of intercrop components may lead to more PAR interception by intercropping compared with sole crops (Keating and Carberry, 1993).

**Total dry matter**

Total dry matter (TDM) production of maize was significantly influenced by different legume intercropping systems and weeding regimes (Fig. 2). Dry matter accumulation of maize increased slowly and attained plateau at around 80 DAE and then the pattern of curves remained similar until harvest. The highest dry matter accumulation of maize (2065 g m<sup>-2</sup>) was obtained in monoculture. It might be due to utilized solar radiation and CO<sub>2</sub> as the plants were spaced planted with better nitrogen uptake and less weed infestation. Similar results were reported by Talukder *et al.* (2003). Among the intercropping systems in maize + mungbean with two hand weeding at 20 and 40 DAE (T<sub>5</sub>) gave higher TDM than maize + soybean and maize + blackgram association at all the growth stages. The lowest dry matter accumulation was recorded in no weeding in all intercropped situation.

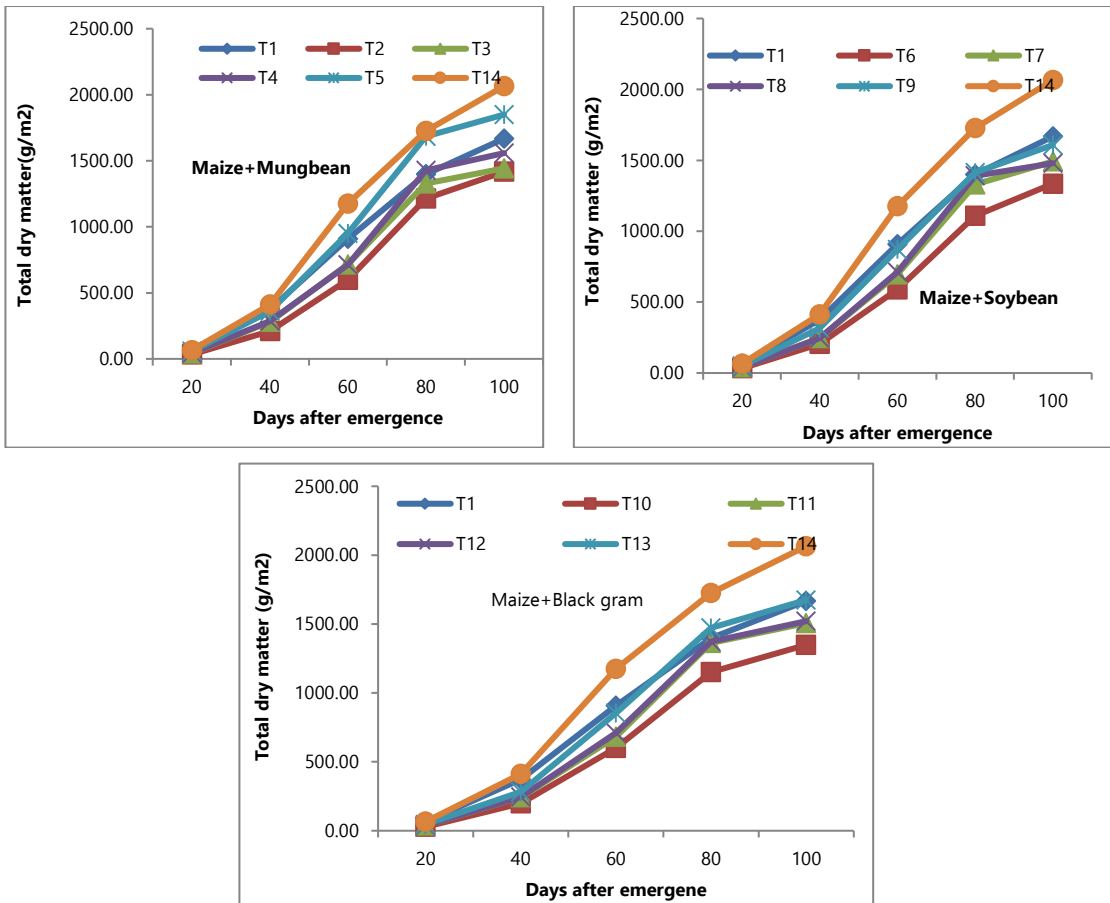
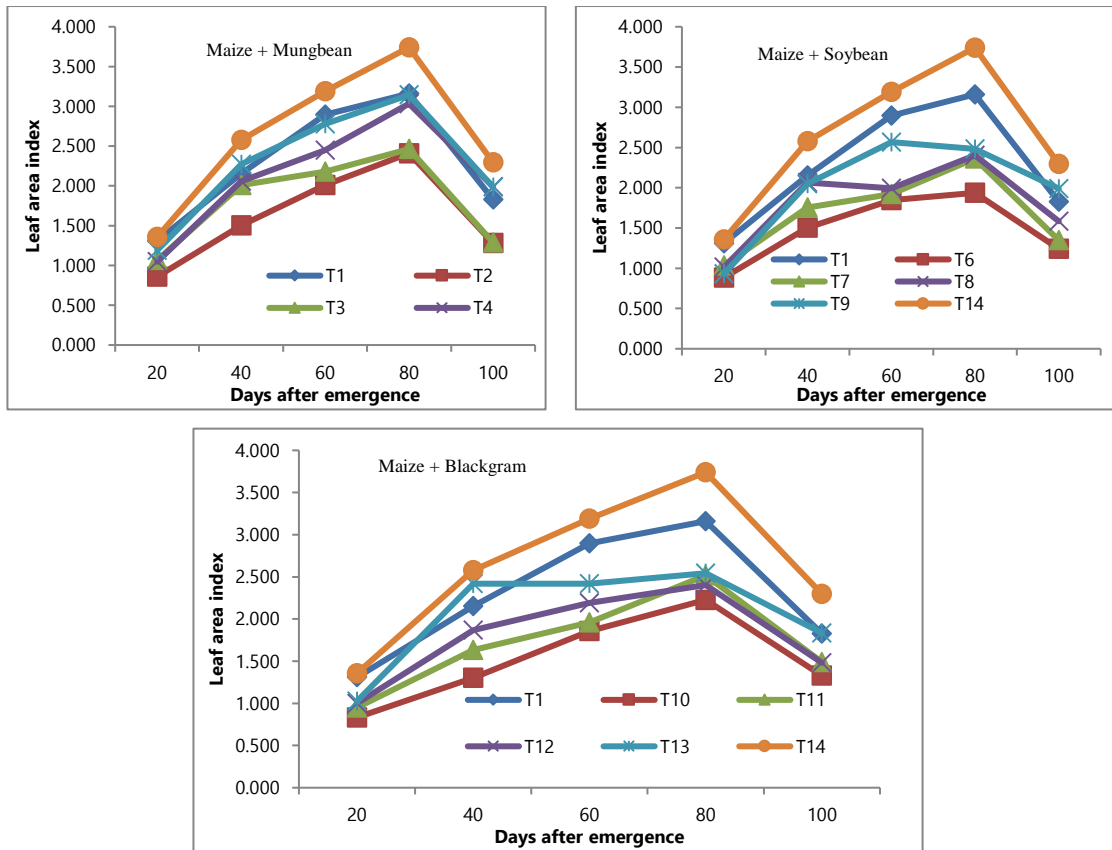


Fig. 2. Total dry matter of maize under various maize + legumes intercropping systems at different days after emergence during the *Kharif* season of 2012.

Intercrop legumes with lower density faced different levels of shading from different planting geometry of maize and subsequently accumulated lower dry matter (Kephart *et al.*, 1992). The highest dry matter accumulation was observed in sole legumes than intercropped. Among all the intercropping systems mungbean gave higher dry matter accumulation than soybean and blackgram at all the growth stages.

**Leaf area index**

Leaf area index (LAI) of maize was significantly influenced by different legumes intercropping systems and weeding regimes at different days after emergence (Fig. 3). It was measured at 25, 35, 45, 55 DAE and at harvest of mungbean, blackgram and at 20, 40, 60, 80 DAE and at harvest of soybean. LAI of maize reached to maximum at 80 DAE and then decreased due to leaf senescence. Sole maize (T<sub>1</sub>) produced significantly higher(3.74) LAI as compared to all intercropping treatments.



T<sub>1</sub>= Sole maize (no weeding), T<sub>2</sub>= Maize + Mungbean (no weeding), T<sub>3</sub>= Maize + Mungbean (weeding at 20 DAE), T<sub>4</sub>= Maize + Mungbean (weeding at 40 DAE), T<sub>5</sub>= Maize + Mungbean (weeding at 20 and 40 DAE), T<sub>6</sub>= Maize + Soybean (no weeding), T<sub>7</sub>= Maize + Soybean (weeding at 20 DAE), T<sub>8</sub>= Maize + Soybean (weeding at 40 DAE), T<sub>9</sub>= Maize + Soybean (weeding at 20 and 40 DAE), T<sub>10</sub>= Maize + Blackgram (no weeding), T<sub>11</sub>= Maize + Blackgram( weeding at 20 DAE), T<sub>12</sub>= Maize + Blackgram( weeding at 40 DAE), T<sub>13</sub>= Maize + Blackgram (weeding at 20 and 40 DAE), T<sub>14</sub>=Sole maize (weed free)

Fig. 3. Leaf area index of maize under various maize + legumes intercropping systems at different days after emergence during the *Kharif* season of 2012.

Similar results had been reported by Oljaca *et al.* (2000) who reported that sole maize produced higher LAI values than any other mixtures. LAI of maize was higher when it was intercropped with mungbean with two hand weeding (T<sub>5</sub>) in all the growth stages. It ranged from 1.19 to 3.14 which was followed by maize + soybean (0.93 to 2.56) and maize + blackgram (1.02 to 2.54) intercropping systems. Leaf area index was lowest in no weeding intercropping treatment at 20 DAE in maize under mungbean, soybean and blackgram combination which were statistically similar than that of other growth stages (Fig. 3). Thobatsi (2009) also found maize intercropped with cowpea long duration cultivar had significantly higher LAI.

**Yield and yield attributes of maize**

Yield and yield contributing characters were influenced significantly by different intercropping systems and weeding regimes (Table 2). Maximum cob length of maize was found in sole maize (16.8 cm) and maize + mungbean intercropping T<sub>5</sub> (16.7 cm). The lowest cob length was obtained from no weeding maize + soybean (15.07 cm) which was as par with T<sub>6</sub> (15.13 cm), treatment. Higher number of grains cob<sup>-1</sup> was recorded from weed free sole maize (554) while lower number in no weeding maize +

soybean (432) and maize + blackgram (436) intercropping system. Among the intercropping systems, maize + mungbean with two hand weedings gave higher grains  $\text{cob}^{-1}$  (501) than maize + blackgram and maize + soybean intercropping systems. Significant influence was observed in 1000-grain weight by the treatments. The maximum 1000-grain weight was recorded from maize + mungbean with two hand weedings intercropping system (277.5g) which was statistically at par with weed free sole maize (276.9 g), no weeding sole maize (273.7 g), one hand weeding at 20 DAE maize + mungbean intercropping plot (272.4g) and maize + blackgram two hand weedings (272 g) treatments. Among the intercropping systems, maize + mungbean obtained higher grains weight than maize + blackgram and maize + soybean association. The highest grain yield was obtained from weed free sole maize ( $8.05 \text{ t ha}^{-1}$ ) than unweeded sole maize ( $6.48 \text{ t ha}^{-1}$ ) treatment (Fig. 4).

Table 2. Yield attributes of maize in maize + legumes intercropping system during the *Kharif* season of 2012

Treatments	Cob length (cm)	Grains $\text{cob}^{-1}$ (no.)	1000-grain wt. (g)
T <sub>1</sub>	16.80 ab	486.3 b	273.7 ab
T <sub>2</sub>	15.53 bcd	459.0 bcde	260.5 f
T <sub>3</sub>	15.48 cd	473.0 bcde	272.4 abc
T <sub>4</sub>	15.95 bcd	484.0 bc	268.3 bcde
T <sub>5</sub>	16.67abc	501.0 b	277.5 a
T <sub>6</sub>	15.13 d	432.0 e	263.2 ef
T <sub>7</sub>	15.73 bcd	440.7 cde	269.7 bcd
T <sub>8</sub>	15.97 bcd	473.0 bcde	267.9 bcde
T <sub>9</sub>	15.83 bcd	474.7 bcde	267.1 cde
T <sub>10</sub>	15.07 d	436.0 de	264.4 def
T <sub>11</sub>	15.50 cd	440.0 cde	265.8 def
T <sub>12</sub>	15.92 bcd	471.7 bcde	269.1 bcde
T <sub>13</sub>	15.90 bcd	478.7 bcd	272.0 abc
T <sub>14</sub>	17.70 a	554.0 a	276.9 a
CV (%)	4.10	4.88	5.45

The lowest yield was found in unweeded maize plot in all intercropped situation. Among the intercropping situation, maize + mungbean with two hand weedings treatment marked higher grain yield ( $7.18 \text{ t ha}^{-1}$ ) than maize + blackgram ( $6.55 \text{ t ha}^{-1}$ ) and maize + soybean ( $6.25 \text{ t ha}^{-1}$ ) intercropping systems. Higher yield of maize observed in monoculture compared to their respective intercropped might be due to no intercrop competition for light, nutrients, moisture and space. This corroborates with the findings of Uddin *et al.* (2003) who reported that maize yield was found to be highest from sole crop when intercropped with legume. The reduction of maize yield was probably due to intercrop competition between crops and weeds. Lower crop-weed competition under two hand weedings might have led to better yield components and thus resulted in higher yield (Mundra *et al.*, 2003).



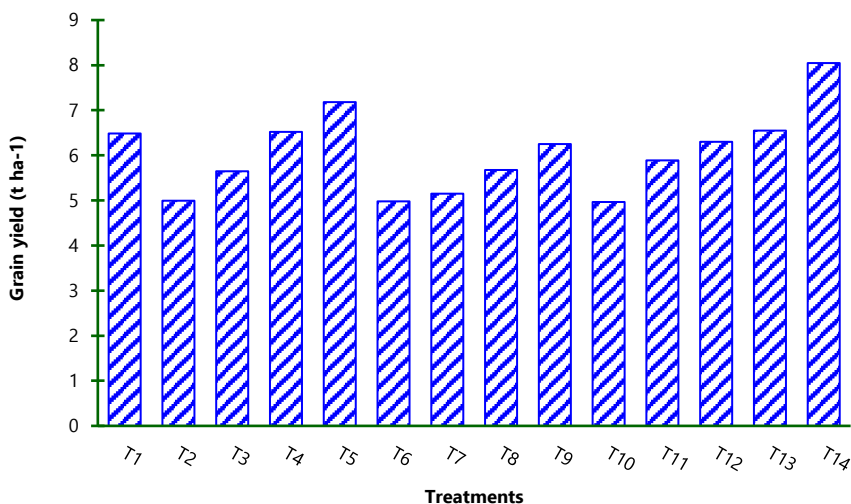


Fig. 4. Grain yield of maize in maize + legumes intercropping system in *Kharif* season.

**Yield and yield attributes of legumes**

All the yield characters of legumes were significantly influenced by the treatments of maize + legumes intercropping systems and the results are presented in Table 3. Higher number of pods plant<sup>-1</sup> was recorded in intercropped soybean (80) which was statistically identical with sole soybean (78) and the lowest one was in intercropped mungbean (16.4) that was similar with others mungbean treatments. Among the legumes intercropping systems, maize + soybean was found in higher number of pods /plant with varying weeding regime. Akhteruzzaman and Quayyum (1991) also reported that number of pods plant<sup>-1</sup> of legumes were reduced by intercropping in *Kharif* season. The highest seeds pod<sup>-1</sup> was obtained in sole legumes, except mungbean. Among the intercropping systems maize + mungbean intercropping in mungbean gave higher number of seeds pod<sup>-1</sup> than other maize + soybean and maize + blackgram intercropping (Table 4). Maximum 1000-seed weight was observed in soybean mono cropping systems which was followed by soybean two hand weedings in intercropping treatments. The lowest 1000-seed weight was observed in blackgram intercropping treatments. Seed yield of legumes were influenced by the treatments in *Kharif* season (Fig. 5). Sole legumes produced the highest seed yield then it reduced significantly when it was grown in association with maize as intercrop. The higher seed yield produced from maize + mungbean intercropping with two hand weedings (572.6 kg ha<sup>-1</sup>) which was followed by maize + blackgram (510.8 kg ha<sup>-1</sup>) and maize + soybean (502.9 kg ha<sup>-1</sup>) intercropping systems. The lowest yield was obtained by mungbean no weeding treatment (302.4 kg ha<sup>-1</sup>) which was statistically similar with maize + blackgram no weeding (316.6 kg /ha) and maize + soybean no weeding (333.7 kg ha<sup>-1</sup>) treatments. Besides, legumes yield was poor due to less availability of light and nutrient in intercropping situation and also shading effect of maize. These findings are in accordance to those of Torofderet *al.* (2006). It also might be due two hand weedings intercropping systems favoured of intercropped mungbean and judicious use of growth resources compared to other intercropped combinations.

Table 3. Yield attributes of legumes in maize + legumes intercropping system during the *Kharif* season of 2012

Treatments	Pods plant <sup>-1</sup> (no.)	Seeds pod <sup>-1</sup> (no.)	1000-seed weight (g)
T <sub>2</sub>	16.57 f	12.17 a	36.30 de

T <sub>3</sub>	16.43 f	13.33 a	37.13 cde
T <sub>4</sub>	16.77 f	13.13 a	38.40 cde
T <sub>5</sub>	18.83 f	13.53 a	39.63 bcde
T <sub>6</sub>	52.67 c	2.467 c	31.33 f
T <sub>7</sub>	70.67 b	2.433 c	41.00 bc
T <sub>8</sub>	70.33 b	2.467 c	37.33 cde
T <sub>9</sub>	79.67 a	2.500 c	43.33 ab
T <sub>10</sub>	26.00 e	5.667 b	35.17 ef
T <sub>11</sub>	37.67d	5.667 b	35.27 ef
T <sub>12</sub>	35.43 d	6.000 b	36.07de
T <sub>13</sub>	38.57 d	6.333 b	36.63 cde
T <sub>15</sub>	18.83 f	12.33 a	40.57 bcd
T <sub>16</sub>	78.33 a	2.933 c	46.00 a
T <sub>17</sub>	47.67 c	6.667 b	39.27 bcde
CV (%)	8.97	10.47	6.16

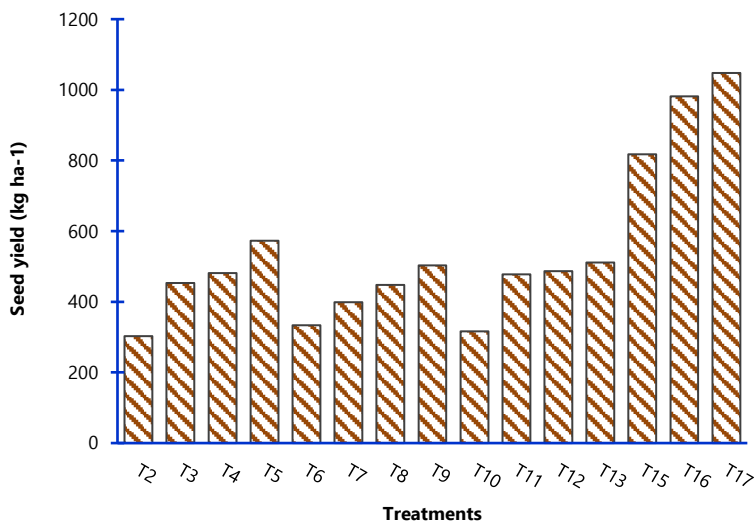


Fig. 5. Seed yield of legumes in maize legumes intercropping system in *Kharif* season.

#### Evaluation of intercrop productivity

Intercrop productivity was evaluated by equivalent yield and monetary advantage (Table 4). The maximum maize equivalent yield ( $12.49 \text{ t ha}^{-1}$ ) was obtained from T<sub>5</sub> treatment in both intercrop and sole situation. The lowest maize equivalent yield ( $6.48 \text{ t ha}^{-1}$ ) was obtained from no weeding regime of sole maize. Patra et al. (2000) also reported similar observations in different intercropping systems. The results showed that the total gross return was higher in all the intercropping systems compared to their respective sole crop. The highest total gross return of Tk. 124900  $\text{ha}^{-1}$  was obtained from maize + mungbean intercropping with two hand weeding situations. On the other hand, the lowest gross return of Tk. 50643  $\text{ha}^{-1}$  was found from sole situation in mungbean treatment. The cost of cultivation increased in the intercropping systems compared with the respective sole crop of maize and legumes. It might be due to increased seed requirement and additional cultural practices for legumes in the intercropping systems. Similar results were also reported by Patel and Rajagopal (2001) under cereal + legume intercropping system. The highest cost of cultivation was observed in maize + soybean (Tk. 45035  $\text{ha}^{-1}$ ) intercropping systems. The lowest cost of cultivation was Tk. 30515  $\text{ha}^{-1}$  from sole

mungbean. The cost of cultivation increased in the intercropping system over the respective sole crops of legumes due to addition of another crop in this system. The highest BCR (benefit cost ratio) was observed from same treatment of the maize + mungbean with two hand weeding situation (2.84). Sole maize with no weeding treatment gave lower BCR than other intercropping systems (1.60).

Table 4. Equivalent yield and economic analysis of maize + legume intercropping systems at different weeding regimes during the *Kharif* season of 2012

Treatments	Maize equivalent yield (t ha <sup>-1</sup> )	Gross return (Tk. ha <sup>-1</sup> )	Cost of cultivation (Tk. ha <sup>-1</sup> )	BCR
T <sub>1</sub>	6.48	64800	40515	1.60
T <sub>2</sub>	7.93	79300	41715	1.90
T <sub>3</sub>	9.77	97700	43215	2.26
T <sub>4</sub>	9.98	99800	43215	2.31
T <sub>5</sub>	12.49	124900	44000	2.84
T <sub>6</sub>	8.14	81400	41034	1.98
T <sub>7</sub>	8.80	88000	42535	2.07
T <sub>8</sub>	9.76	97600	42535	2.29
T <sub>9</sub>	10.81	108100	45035	2.40
T <sub>10</sub>	8.00	80000	41115	1.95
T <sub>11</sub>	10.21	102100	42615	2.40
T <sub>12</sub>	10.76	107600	42615	2.52
T <sub>13</sub>	10.22	102200	43015	2.38
T <sub>14</sub>	8.05	82308	44675	1.84
T <sub>15</sub>	0.818	50643	30515	1.66
T <sub>16</sub>	0.982	65669	32785	2.00
T <sub>17</sub>	1.05	64322	30555	2.11

T<sub>1</sub>= Sole maize (no weeding), T<sub>2</sub>= Maize + Mungbean (no weeding), T<sub>3</sub>= Maize + Mungbean (weeding at 20 DAE), T<sub>4</sub>= Maize + Mungbean (weeding at 40 DAE), T<sub>5</sub>= Maize + Mungbean (weeding at 20 and 40 DAE), T<sub>6</sub>= Maize + Soybean (no weeding), T<sub>7</sub>= Maize + Soybean (weeding at 20 DAE), T<sub>8</sub>= Maize + Soybean (weeding at 40 DAE), T<sub>9</sub>= Maize + Soybean (weeding at 20 and 40 DAE), T<sub>10</sub>= Maize + Blackgram (no weeding), T<sub>11</sub>= Maize + Blackgram (weeding at 20 DAE), T<sub>12</sub>= Maize + Blackgram (weeding at 40 DAE), T<sub>13</sub>= Maize + Blackgram (weeding at 20 and 40 DAE), T<sub>14</sub>= Sole maize (weed free), T<sub>15</sub>= Sole Mungbean (weed free), T<sub>16</sub>= Sole Soybean (weed free) and T<sub>17</sub>= Sole Blackgram (weed free)

## Conclusion

The results revealed that intercropping of two rows of mungbean in between two rows of maize with two hand weeding at 20 and 40 DAE appeared as a profitable practice for good yield advantages, optimum use of PAR, weed control efficiencies, and monetary values.

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