GROWTH AND YIELD PERFORMANCE OF GRASSPEA UNDER DIFFERENT METHODS OF SOWING AND PRE-EMERGENCE IRRIGATION

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This is to certify that the thesis entitled "**Growth and Yield Performance of Grasspea under Different Methods of Sowing and Pre-emergence Irrigation**" 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** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Bulbul Ahmed**, Registration number: **00963** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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GROWTH AND YIELD PERFORMANCE OF GRASSPEA UNDER DIFFERENT METHODS OF SOWING AND PRE EMERGENCE IRRIGATION

ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2007 to March 2008 to study the growth and yield performance of grasspea under different methods of sowing and pre-emergence irrigation. The variety BARI Khesari-2 was used as the test crop. The treatments of the experiment were T_1: Broadcast sowing without irrigation; T_2: Furrow sowing without irrigation; T_3: Furrow sowing with furrow irrigation; T_4: Broadcast sowing with primed seeds; T_5: Furrow sowing with primed seeds; T_6: Broadcast sowing with sprinkler irrigation at evening; T_7: Broadcast sowing with sprinkler irrigation at evening and morning; T_8: Furrow sowing with sprinkler irrigation at morning and T_9: Broadcast sowing with post sowing flood irrigation. Parameters were studied at 15, 25, 35, 45 and 55 days after sowing. The highest seedling emergence (4.80, 19.65, 26.20, 54.20 and 71.50) was recorded in T_7 treatment whereas the lowest (2.40, 5.10, 18.20, 44.60 and 45.23) in T_1 treatment. The tallest plant (15.11 cm, 34.91 cm, 42.79 cm, 59.41 cm and 71.92) at 15, 25, 35, 45 and 55 DAS was recorded in T_7 treatment and the shortest (10.94 cm, 25.76 cm, 31.07 cm, 46.55 cm and 56.98 cm) in T_1 treatment. The highest number of leaves, number of branches, number of flowers and dry matter were recorded from T_7 treatment and whereas, the lowest in T_1 treatment. The highest pod number, pod length, number of seeds pod^{-1}, weight of 1000 seeds were recorded from T_7 treatment and the lowest in T_1 treatment. The highest seed yield (1.75 t ha^{-1}) and stover yield (3.91 t ha^{-1}) were recorded in T_7 treatment and the lowest seed yield (1.29 t ha^{-1}) and stover yield (3.39 t ha^{-1}) in T_8 treatment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

In Bangladesh, various types of pulse crops are grown. Among them lentil, blackgram, mungbean, chickpea, grasspea and cowpea are very important. Pulse crop is an important food crop since it provides a cheap source of easily digestible dietary protein. According to FAO (1999), a minimum intake of pulse by a human should be 80 g $head^{-1}$ day^{-1}, whereas it is only 14.19 g in Bangladesh (BBS, 2006). Grasspea (*Lathyrus sativus* L.) is an important pulse crop of Bangladesh and is commonly known as khesari. It belongs to the family Leguminosae and sub-family Papilionaceae. The genus *Lathyrus* is also important pulse crop in India, Nepal, Pakistan, China, Middle East, Myanmar, Srilanka, Southern Europe and part of Africa and South America (Tadesse, 1977).

The crop is potentially useful in improving cropping pattern. Grasspea can fix atmospheric nitrogen through the symbiotic relationship between the host grasspea roots and a soil bacterium *Rhizobium* and improves soil fertility. It is the most important pulse crop not in terms of area (65,341 ha) and production (56,672 ton) but also for its high consumption as a common pulse in Bangladesh (BBS, 2006).

Grasspea is cultivated with minimum land preparation and without fertilizer application and insect, diseases or weed control. All these factors are responsible for low yield. The average yield of grasspea is 0.69 t ha^{-1} (BBS, 2006), which is very poor in comparison to that of other grasspea growing countries in the world. There are many reasons of low yield of grasspea. Irrigation is the important one that greatly affects the growth, development and yield of this crop.

The farmers of Bangladesh generally grow grasspea by one ploughing and almost without irrigation. There is an ample scope of increasing the yield of grasspea with improved management practices and by using irrigation with following optimum time and methods of irrigation application. The farmers of our country hardly use irrigation due to their poor socio-economic condition; as a result the yield becomes low although it has great potential to increase yield. Adequate supply of irrigation, water among with chemical fertilizer is essential for normal growth and yield of a crop (Ayallew and Tabbada, 1987; Kumar *et al.*, 1995).

Grasspea is a temperate crop and it is cultivated in the cold winter months in the Indian sub-continent (Gowda and Kaul, 1982). The usual time of grasspea sowing ranges from last week of October to middle December when the soil contains little moisture. Traditionally, grasspea is being grown following diversified methods of cultivation (Sarwar *et al.*, 1995). It is generally broadcasted in the low lying areas, immediately after aman rice harvest as a rainfed crop. Drought tolerance could be considered to be its most important attribute, rendering it's suitability for country wide cultivation in the rainfed areas in dry winter months. Grasspea is cultivated on residual soil moisture and is often subjected to soil water deficit. The lower yield of grasspea is normally associated with many factors and soil moisture is one of the most important factors that reduce crop yield in many areas of Bangladesh.

Water deficiency had adverse effects on plant growth, average yield and crude protein in legume crops. The flowering stage is the most vulnerable stage for water stress (Golakiya and Patel, 1992). As the grasspea plants use the residual soil moisture for its early vegetative growth, the subsequent growth is suffered in most cases. Amelioration of drought environment through management practices like limited irrigation and deeper sowing is needed for the proper germination, emergence, establishment and subsequent satisfactory yield of grasspea.

Hence, the present study was done to maximize the seed yield of grasspea with different methods of sowing and irrigation. Considering the above circumstances, the present investigation has been undertaken with the following objectives:

i. to study the effect of limited pre-emergence irrigation on the growth, yield contributing characters and yield of grasspea.

ii. to determine the optimum method of sowing for attaining the highest growth and yield of grasspea.

CHAPTER 2

REVIEW OF LITERATURE

Grasspea is an important pulse crop in Bangladesh and in many countries of the world. The crop has conventional less concentration by the researchers on various aspects because normally it grows without less care or management practices. For that a very few studies related to growth, yield and development of grasspea have been carried out in our country. So the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the methods of sowing and pre-emergence irrigation on yield contributing characters and yield so far been done at home and abroad on this crop and other pulse crops have been reviewed in this chapter under the following headings-

2.1. Effect of sowing methods on pulse crop

Tickoo *et al.* (2006) carried out an experiment on mungbean and cultivars Pusa 105 and Pusa Vishal, which were sown in broadcast and furrow method with 36-46 and 58-46 kg NP ha^{-1} in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105 with furrow sowing. Row spacing at 22.5 cm resulted in higher grain yields in furrow sowing.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) and methods of sowing on the growth and yield of mungbean cv. AEM 96 in

Tandojam, Pakistan, during the spring season of 2004. The methods of seed sowing significantly affected the crop parameters. The 10-30-30 kg of NPK ha^{-1} was the best treatment, recording plant height of 56.25 cm, germination of 90.50%, satisfactory plant population of 162.00, prolonged days taken to maturity of 55.50, long pods of 5.02 cm, seed weight per plant of 10.53 g, seed index of 3.52 g and the highest seed yield of 1205.2 kg ha^{-1} with line sowing than the broadcast.

Mahboob and Asghar (2002) studied the effect of seed sowing methods at different nitrogen levels on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000-grain weight was affected significantly with 50-50-0 NPK kg ha^{-1} applied in line sowing. Again they revealed that seed sowing in line was more effective than the broadcasting and line sowing exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Thakur *et al.* (1996) conducted an experiment with green gram (*Vigna radiata*) grown in kharif [monsoon] 1995 at Akola, Maharashtra, which was given 0, 25, 50 or 75 kg P_2O_5 ha^{-1} as single superphosphate or diammonium phosphate in different methods of seed sowing. Seed and straw yields were not significantly affected by line sowing.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P ha^{-1} increased mungbean yield sowing in line. Results from the experiments of mungbean showed that the application of N with P and line sowing gave higher seed yield.

A field experiment was conducted by Patro and Sahoo (1994) during the winter season of 1991 at Berhampur, Orissa, with mungbean cv. Dhauli and PDM 54 applying 0, 15, 30, 45 or 60 kg P_2O_5 ha^{-1}. They observed that line sowing gave seed yields of 706, 974, 1049, 1234 and 1254 kg ha^{-1}, respectively with the treatments. There was significant difference between the yields of cultivars.

2.2. Effect of irrigation on pulse crop

2.2.1. Seedling emergence

Singh *et al*. (2005) conducted 2-year field experiment on a Typic Ustochrept to find out the effects of P fertilizer (0, 30, and 60 kg P_2O_5 ha^{-1}), PSB (inoculation and without-inoculation) and moisture regimens (rain-fed and irrigated condition) on soil moisture depletion, seedling emergence of lentil (*Lens culinaris*) were examined. They reported that irrigation has a significant role in emergence of seedling than the control.

A field experiment was carried out by Ramasamy *et al*. (1999) during summer 1996 and 1997 at Vamban to study the productivity of irrigated groundnut (*Arachis hypogaea* L.) as influenced by land management using organic amendments under varying irrigation regimes. Adopting land management of ridges and furrows and providing irrigation at 0.8 IW/CPE gave the highest germination of groundnut.

Rajput *et al*. (1995) conducted a field trial in rabi (winter) 1987/88 at Morena, Madhya Pradesh, the soil moisture depletion pattern was determined from gram (*Cicer arietinum*), peas, mustard (*Brassica juncea*), safflower and a fallow plot and reported that soil moisture influenced the germination of all the test crops.

2.2.2. Plant height

Myburgh and Walt (2005) reported that water content during the dormant period by applying overhead irrigation, and thereby increasing yield, was investigated under semi-arid conditions. A field trial was conducted with Sultanina grapevines in the Lower Orange River region in South Africa over two seasons. Due to the lack of winter rain, all treatments received normal, under-vine irrigation in winter to avoid severe water deficits. Cane water content measured before bud break, i.e. early September, but also increased yield. The other overhead irrigation treatments did not affect cane water content or yield.

Hutami and Achlan (1992) conducted an experiment with different water stress condition in mungbean field and reported that plant height of mungbean reduced significantly due to water stress condition but the application of irrigation ensure highest plant height compare to stress condition. In another experiment with mungbean, Villegas (1981) found that under greenhouse conditions moisture stress significantly reduced plant height.

Jackson (1979) investigated the response of peas to water logging under glasshouse conditions. He found that symptoms of injury arising from excessive soil moisture condition included extensive desiccation and lower rates of transpiration, stem extension and growth of shoots.

Parjol *et al.* (1971) from a field experiment concluded that water deficit induced plant height reduction at vegetative phase and also exerted detrimental effect in other growth phases of plant's life.

2.2.3. Number of branches

Swaraj *et al.* (1995) carried out a field experiment with applying water stress condition in mungbean and reported that with increasing severity and duration of water stress, the number of branches decreased. Seth and Chaudhury (1989) emphasized importance of increasing the number of branches in good yielding cultivars of mungbean that could be ensured with the application of irrigation.

Murari and Pandey (1985) studied the influence of soil moisture levels on yield attributing characters of lentil and observed that irrigation increased number of branches. They also reported that straw yields were also increased significantly from non-irrigation to irrigation.

2.2.4. Leaf number

Islam *et al.* (1994) conducted an experiment on mungbean with different water stress condition in Japan and reported that plants produced lower leaf number under drought conditions. Arjunan *et al.* (1992) observed higher number of functional leaves in tolerant genotypes of groundnut under moisture deficit condition at harvest, which ensured plants a continued supply of photosynthesis to the sink until maturity. This means stress susceptible plants lost functioning of leaves that unable them to continue photo-assimilation and grain filling. In another experiment reduced leaf numbers were recorded for moisture stressed conditions in groundnut.

Hutami *et al.* (1991) have conducted an experiment on the water stress of mungbean. They observed that leaf area reduced in water stress conditions. Leaf growth is extremely sensitive to water stress condition and the reduction in leaf area due to moisture stress has been reported by many workers in many different crops. The total number of leaf of a plant may be changed due to either in leaf numbers or leaf sizes. (Turk and Hall, 1980; Babu *et al.,* 1984; Pandey *et al.*, 1984, Patel *et al.,* 1983).

Hughes *et al.* (1981) observed a reduction of leaf area in response to water stress condition. Wien *et al.* (1979) reported substantially less number of leaves when field-grown cowpea was exposed to moderate drought stress. Reduced number of leaves could be due to the inhibition of initiation and differentiation of leaf primodia.

This report supports the previous work of Kramer (1963) who reported reduced leaf area with increased thickness when plants were exposed to moisture stress. Furthermore, rapid leaf senescence was associated with stressed plant causing reduction in total functional leaf area.

Mehrotra *et al.* (1963) carried out a field experiment in mungbean and noted high negative correlation between leaf area and soil moisture tension and they also reported that leaf area was progressively reduced with the progressive increase in stress levels.

2.2.5. Dry matter content

Islam *et al.* (1996) conducted an experiment to identify the effect of moisture stress on the growth and yield of groundnut and observed that the total dry matter showed a gradual decrease with the increase stress levels. Decreased water application resulted in reduced total dry matter production and that resulted from declines in conservation of the intercepting radiation and thereby photo assimilation (Collinson *et al*,. 1996). Miah *et al* (1996) suggested that in adequate soil moisture condition plant produced higher photosynthesis and dry matter in mungbean.

Islam *et al.* (1994) conducted an experiment on mungbean in Japan. Growth, canopy structure and seed yield of mungbean was evaluated under water stress conditions. Water logging, optimum moisture and drought conditions had constituted the treatments. The distribution patter of the dry matter was more or less similar in all the treatments. In an experiment with mungbean, Islam *et al.* (1994) observed that drought conditions reduced total dry matter of plants.

In another experiment, Ludlow *et al.* (1990) had the opinion that in dry soil condition lower shoot dry weight could result from the higher partitioning of dry matter to roots at the expense of shoots. The maximum reduction in yield due to moisture occurs during grain filling stage drastic yield reduction was also reported in mungbean due to water stress (Hamid *et al.*, 1990a). The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production.

Ludlow and Muchow (1990) argued that reduced shoot dry weight under moisture stress partitioned more biomass to roots at the expense of shoot growth.

Al-Karaki (1988) tested lentil cultivars at different moisture stress and observed that cultivars were affected by moisture stresses. The results revealed that increase in moisture tension caused reduction in shoot weight.

Earing (1984) conducted an experiment in peanut and observed that root volume and root dry weight increased under water stress condition. Pandey *et al.* (1984) reported progressively reduced shoot dry weight with progressive increase in moisture stress, in groundnut.

In another experiment with cowpea Turk and Hall (1980) observed less shoot dry matter in increasing levels of drought stress, at all stages of growth. Wien *et al.* (1979) reported slightly less shoot dry matter production with moderate drought stress cowpeas grown under field condition. El-Nadi (1969) reported from his wheat experiment under water stress condition that the drier the soil, deeper the root development.

2.2.6. Yield and yield components

The effects of irrigation regimes (irrigation at 0.04 MPa at 15, 20 and 25cm depth) and P rate on the yield and water use efficiency of French bean (*Phaseolus vulgaris* cv. Contender) were studied by Pal (2007) in Nadia, West Bengal, India, during the winter season from 2002-03 to 2004-05. Among the irrigation regimes, irrigation at 15-cm depth recorded the highest mean grain yield (1895 kg ha^{-1}). Irrigation at 25-cm depth resulted in the lowest level of water use (157.43 mm, on average) and greatest water use efficiency (11.39 kg ha^{-1} mm^{-1}).

A field experiment was conducted by Patel *et al.* (2005) during the summer seasons of 2001, 2002 and 2003, in Sardarkrushinagar, Gujarat, India, to study the effects of irrigation scheduling (0.4, 0.6 and 0.8 IW:CPE ratios) and fertilizer doses (10 N kg + 20 kg P ha^{-1}, 20 kg N + 40 kg P ha^{-1}, and 30 kg N + 60 kg P ha^{-1}) on the yield of summer clusterbean. Irrigation at 0.8 and 0.6 IW:CPE ratio recorded almost similar seed yield (1238 and 1219 kg ha^{-1}, respectively), which was higher than that at 0.4 IW:CPE ratio. The highest straw yield (2848 kg ha^{-1}) was obtained when irrigation was applied at 0.8 IW:CPE ratio.

Biswas (2001) reported that irrigation frequency exerted a remarkable impact on yield of field bean. Application of 3 irrigations increased vegetable pod yield about 19% and 13% and seed yield about 53% and 30% over 1 and 2 irrigation respectively. He also reported that higher number of pods/plant, seeds/pod and pod length, with higher frequency of irrigation.

Craufurd and Wheeler (1999) examined that total dry matter, seed yield and other physiological traits of cowpea at two locations in Nigeria. They obtained 50% reduction in seed yield under drought in both location, attended by the reduced radiation use efficiency and TDM. In grasspea Sanaullah and Bano (1999) conducted an experiment and observed that drought stress significantly reduced the number of pods, seeds, and 1000-seed weight. Joseph *et al.* (1999) reported that water stress during pod filling stages significantly reduced pod initiation and pod growth rates and thereby reduced harvest Index (HI).

Nandan and Prasad (1998) reported that grain yield and net returns were higher with 3 irrigations than with 1 and 2 irrigations in French bean.

Collinson *et al.* (1996) observed that decreasing soil moisture levels resulted in a decline in total dry matter production and harvest index (HI). They also observed that a reduction in pod yield from 4.12 to 4.04 t/ha under stress condition. In a field experiment with lentil, Kumar *et al.* (1995) found that non-irrigated plot gave lower seed yield than in the irrigated ones.

Salam and Islam (1994) conducted a pot experiment in the glass house with some advanced mutant lentil lines (*Lens culinaris)* under different soil moisture regimes. Under stress they found that the mutant lines had greater filled pods, yield per plant and harvest indices (HI) than local cultivars. They also found that the mutant lines had higher biomass yield.

Islam *et al.* (1994) observed significantly higher seed yield of mungbean in optimum soil moisture condition followed by drought stress and water logging. Seed per plant and pod per plant contributed more to the seed yield per plant than the other yield contributing components. It was evident from this study that mungbean growth, canopy structure and seed yields were more susceptible to water logging than drought stress.

Karim *et al.* (1993) stated that soil and atmospheric water stress control plant growth directly of soybean. In a field experiment with mungbean, Hutami and Achlan (1992) observed that water stress condition significantly reduced number of pods per plant and number of seeds/plant. Majumdar and Roy (1992) reported that the higher grain yield and positive effect on yield components due to irrigation application in summer sesame.

Greco and Cacagnari (1991) conducted a pot experiment in lentil under drought condition and found that seed yield was significantly reduced by drought. Decreased grain yield due to water stress was also reported in chickpea (Provakar and Suraf, 1991), Soybean (Rajput *et al.*, 1991). Viera *et al.* (1991) reported a yield reeducation of 35 to 40% when drought stress was imposed during seed filling but found no effect on germination or vigour in soybean.

Erskine and Saena (1990) conducted an experiment and observed that moisture stress affected yield of lentil. They further noted that lentil production was limited by moisture stress.

Singh and Saxena (1990) conducted an experiment and observed that moisture stress reduced yield of lentil. They also found that lentil production was limited by moisture stress.

Hamid *et al.* (1990a) observed that, over watering and slight and severe water stress imposed at pre-flowering, flowering or pod development stages, reduced seed yield/plant, photosynthetic rate, water use efficiency and number of pods/plant in mungbean. Slight and severe water stress of pod development gave higher individual 1000-seed weight than unstressed control treatment (29.8, 28.5 and 24.1 g, respectively). Slight water stress at flowering gives the seed weight of 30.0 g compared with 25.06 g than the control. At pod development, control seed weight has been 24.4 g whereas neither water stress treatment has produced seeds. Khade *et al.* (1990) found the highest number of pods (8.28) plant^{-1}, seeds (16.43) pod^{-1} and seed yield (1.03 t ha^{-1}) with 3 irrigations in *Vicia fcrbcr*.

Hamid *et al.* (1990b) reported a drastic yield reduction in mungbean due to water stress. The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production.

Petersen (1989) reported that water stress reduced pods per plant and mean seed weight in *Phaseolus vulgaris* and pods per plant and seed per pod in *P. acutifolius.*

In a pot experiment with pea seeds, Matos *et al.* (1988) observed that pod production of peas were significant reduced by the least soil moisture level (30% FC). Janamath *et al.* (1988) conducted an experiment in groundnut under stress condition and found that total number of pods was significantly reduced by drought. Sadasivam *et al.* (1988) reported that stress during vegetative phase reduced grain yield through reducing plant size, limiting root growth and number of pods and harvest index in mungbean.

Pannu and Singh (1988) demonstrated the total dry matter as well as grain yields were affected by moisture stress in mungbean. Higher number of dry pods per plant, increased seed weight and seed yield per hectare was found when irrigation was done weekly (Haque, 1988).

Talukder (1987) reported that seed yield and harvest index were the most responsive parameters to water stress treatments imposed at flowering and pod development stages of mungbean. In mungbean, Ayallew and Tabbada (1987) observed that soil moisture stress reduced growth and seed yield.

Frick and Pinolato (1987) found that the deleterious effects of drought stress imposed at flowering were reduced numbers of filled spike lets per panicle and reduced photosynthetic leaf area, that effect directly on the grain of chickpea.

Water stress affected canopy development (Kridemann, 1986) and overall growth process but there were varietal differences in stress tolerance. In an experiment with groundnut, exposed to field capacity, half field capacity and drought condition, Mehrotra *et al.* (1986) observed that the yield of mature pods, seeds per pod and 1000-seed weight were the least under drought conditions. Irrigation increased pigeonpea yield by 97% but drought during the reproductive phase was the major yield-limiting factor (ICISAT, 1986).

Pandey *et al.* (1984) reported that mungbean was more susceptible to water deficits than many grain legumes. Hasan and Mahhady (1983) reported that interactions between soil salinity and available soil water induced significant effects on dry matter content, grain yield, grain number and 1000-grain weight of wheat. The stress conditions caused by high soil salinity and limited soil moisture progressively decreased the dry matter content of the wheat plant and triticale.

Lawlor *et al.* (1981) observed that yields, total dry matter production and harvest index of barley were decreased by water stress. The grain growth in non-irrigated crop was decreased. This was probably due to insufficient supply of current assimilate to fill the grain as because the plant had little photosynthates.

Turk *et al.* (1990) demonstrated the response of cowpea to different intensities of drought at different stages of growth and reported that yields were not reduced by drought imposed during the vegetative stage, while drought occurs during the flowering stage substantial yields reduction was obvious. Variation in yields resulted from variation in number of pods/m^2 and small seed size. Cselotel (1980) reported that a regular water supply particularly during flowering and pod formation was necessary for high yield and good quality of snap beans.

Eck and Musick (1979) opined from the result of an experiment that yield reduction from stress was initiated at early boot stage resulted from both reduced seed size and seed numbers of mungbean.

Lewis *et al.* (1974) reported that sorghum grain yields were reduced to 17.34% and 10% from control when water deficit occurs late vegetative to booting stage respectively. Vitkov *et al.* (1972) found that sprinkler irrigation wetting up to 60 cm depth of soil increased the seed yield up to 950 kg per hectare of French bean.

Dubtez and Mahalle (1969) found that water stress reduced yield of bush bean by 53%, 71% and 35% when the stress occurred during pre-flowering, flowering and pod formation periods respectively.

Salter and Good (1967) stated that the extent of yield reduction from water deficits depended not only on the magnitude of the deficit but also on the stage of growth of bush bean. Yield and dry matter production were reduced in all growth stages by water deficits. They further reported that when the deficit was removed the growth rate did not immediately return to normal but required several days to recover.

Denmead and Shaw (1960) in their studies with corn stated that plant growth, grain yield and dry matter production were reduced in all growth stages by water deficits. They further reported that when the deficit was removed the growth rate did not immediately retire to normal but required several days to recover.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2007 to March 2008 to study the growth and yield performance of grasspea under different methods of sowing and irrigation. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1. Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989).

3.2. Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the post-monsoon or the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment were collected from the Bangladesh Meteorological Department, Sher-e-Bangla Nagar and presented in Appendix I.

3.3. Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters (Appendix II).

3.4. Planting material

The variety BARI Khesari 2 was used as the test crop. The seeds BARI Khesari 2 were collected from the Research Centre of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. It grows both in kharif and rabi season. Life cycle of this variety ranges from 65 to 70 days. Maximum seed yield is 1.1-1.4 t ha^{-1}.

3.5. Land preparation

The land was irrigated before ploughing. After having zoe condition the land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing was done on 19 March 2007 and the final land preparation was done on 30 March 2007. Experimental land was divided into unit plots following the design of experiment.

3.6. Treatments of the experiment

The treatments of the experiment were as follows:

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

3.7. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each block was divided into 9 plots where 9 treatments were allotted at random. There were 27 unit plots altogether in the experiment. The size of the each unit plot was 2.5 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.8. Sowing of seeds in the field

The seeds of grasspea were sown on 15 December, 2007. Seeds were treated with Bavistin before sowing to control the seed borne diseases. The seeds were sown as per treatment maintaining a depth of 2-3 cm.

3.9. Intercultural operations

3.9.1. Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times to maintain proper plant population in each plot; first thinning was done at 8 days after sowing and second at 15 days after sowing.

3.9.2. Irrigation and weeding

Irrigation was done as per treatments. The crop field was weeded twice; first weeding was done at 15 DAS and the second at 30 DAS.

3.9.3. Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) attacked the young plants and at latter stage of growth pod borer (*Maruca testulalis*) attacked the plants. Dimacron 50EC was sprayed at the rate of 1litre ha^{-1}.

3.10. Harvest and post-harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand-picking from a pre-demarcated area of three line at the center of each plot.

3.11. Data collection

The following data were recorded

i. Emergence of plant (%)

ii. Soil moisture (%)

iii. Plant height (cm)

iv. Number of branches plant^{-1}

v. Number of leaves plant^{-1}

vi. Dry weight plant^{-1}

vii. Number of flowers plant^{-1}

viii. Number of pods plant^{-1}

ix. Pod length (cm)

x. Number of seeds per pod

xi. 1000-seed weight (g)

xii. Seed yield (t ha^{-1})

xiii. Stover yield (t ha^{-1})

xiv. Biological yield (t ha^{-1})

xv. Harvest index

3.12. Procedure of data collection

3.12.1. Emergence of plant

The emergence of seedlings in the experimental plots was recorded starting from 6 days after sowing (DAS) and continued upto 10 DAS.

3.12.2. Soil moisture

The fresh soil was collected from each unit of experimental plot. Total 100 g soil was measured from the collected sample immediately after harvest and it was the initial soil sample. After recording the fresh weight of the soil it was dried well in sun. The sun-dried soils were then dried in an oven at 70^0C for 72 hours, until constant weight was achieved. The recorded weight, after oven drying, was the dry weight of soil. Soil moisture was calculated following the formula-

$$\text{Soil moisture (\%)} = \frac{\text{Initial weight} - \text{Oven dry weight}}{\text{Oven dry weight}} \times 100$$

3.12.3. Plant height (cm)

The height of plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot started from 15 DAS and continued upto 55 DAS with 10 days interval.

3.12.4. Number of branches plant^{-1}

Number of branches of selected plants from each plot was counted and the mean number was expressed on per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot started from 15 DAS and continued upto 55 DAS with 10 days interval.

3.12.5. Number of leaves plant^{-1}

The leaves (trifoliate) were counted from selected plants. The average number of leaves per plant was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot started from 15 DAS and continued upto 55 DAS with 10 days interval.

3.12.6. Dry weight plant^{-1}

The fresh weight of plant at 15, 25, 35, 45 and 55 DAS was recorded as the average of 10 plants selected at random from each unit plot. The weight of the plants was recorded immediately after harvest. After recording the fresh weight of the plant, the plant were chopped and dried well in sun. The sun-dried plants were then dried in an oven at 70^0C for 72 hours, until constant weight was achieved. The recorded weight, after oven drying, was the dry weight plant^{-1}.

3.12.7. Number of flowers plant^{-1}

Number of total flowers of selected plants from each plot was counted and the mean number was expressed on per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.12.8. Number of pods plant^{-1}

Numbers of total pods of selected plants from each plot were counted and the mean number was expressed on per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.12.9. Pod length

Pod length of selected plants from each plot was measured and the mean length was expressed on per pod basis. Data were recorded as the average of 10 pods selected at random from the inner rows plant of each plot.

3.12.10. Number of seeds pods^{-1}

The number of seeds in each pod was also recorded from randomly selected pods at the harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.12.11. Weight of 1000-seed

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g). Data were recorded as the average of 10 plants selected at random from the inner rows.

3.12.12. Seed yield

The seeds collected from 5.0 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.12.13. Stover yield

The stover collected from 5.0 m^2 of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.12.14. Biological yield

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + stover yield.

3.12.15. Harvest index

Harvest index (HI) was calculated from the seed and stover yield of grasspea for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.13. Statistical analyses

The data recorded for different parameters were statistically analyzed to find out whether there are the significant differences among the different treatment effects on yield and yield contributing characters of grasspea using MSTAT software. The mean values of all the characters were calculated and analyses of variance were performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

To determine the growth and yield performance of grasspea under different methods of sowing and irrigation the present study was conducted. Data on different yield contributing characters and yield were recorded to find out the effect of treatments. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-X. The findings have been presented and possible interpretations given under the following headings:

4.1. Emergence of seedling

Emergence of grasspea seedling at different days after sowing (DAS) varied significantly due to the different treatments (Table 1). The highest emergence of seedlings (4.80, 19.65, 26.20, 54.20 and 71.50) was recorded from T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) at 6, 7, 8, 9 and 10 DAS, which was statistically similar to T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning), respectively. Whereas the lowest emergence (2.40, 5.10, 18.20, 44.60 and 45.23) was recorded from T_1 (Broadcast sowing without irrigation), which was statistically similar to that from T_2 (Furrow sowing without irrigation) and T_9 (Broadcast sowing with post sowing flood irrigation), respectively (Table 2). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on emergence by ensuring moisture considering the other treatments.

Table 1. Effect of different methods of sowing and irrigation on emergence of seedlings of grasspea

Treatment	Plants plot^{-1} at				
	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS
T_1	2.40 f	5.10 f	18.20 d	44.60 d	45.23 g
T_2	3.00 e	6.32 f	20.00 cd	47.40 cd	49.32 f
T_3	3.80 cd	10.47 cd	24.40 ab	51.80 ab	57.20 cd
T_4	3.60 cd	9.32 de	23.80 ab	51.00 abc	54.25 de
T_5	3.40 de	10.97 cd	22.60 bc	50.53 abc	51.98 e
T_6	4.40 ab	15.01 b	25.00 ab	53.60 a	65.83 b
T_7	4.80 a	19.65 a	26.20 a	54.20 a	71.50 a
T_8	4.00 bc	12.47 bc	25.40 ab	53.40 a	60.40 c
T_9	3.00 e	7.46 ef	22.20 bc	48.80 bc	49.73 f
$S\bar{x}$	0.024	0.141	0.365	0.768	0.645
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	7.52	14.00	7.44	3.91	4.88

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

Broadcast sowing with sprinkler irrigation at evening, and both at evening and morning was more effective for the emergence of plant. This trend was similar or followed by the combination of furrow and sprinkler irrigation. Irrigation created congenial environment for the germination of seeds for that emergence rate was higher for irrigated field compare to non-irrigated plot.

4.2. Soil moisture

Soil moisture varied significantly due to different treatments (Figure 1). The maximum soil moisture (32.35%, 33.14%, 32.91%, 33.24% and 34.08%) was recorded in T_9 (Broadcast sowing with post sowing flood irrigation) at 2, 4, 6, 8 and 10 DAS which was statistically similar to that of T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) and T_8 (Furrow sowing with sprinkler irrigation at morning) and the minimum (18.81%, 18.27%, 18.67%, 18.71% and 18.74%) was recorded in T_1 (Broadcast sowing without irrigation), which was statistically similar with T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds), T_5 (Furrow sowing with primed seeds) and T_6 (Broadcast sowing with sprinkler irrigation at evening) showed the moderate influence on plant height considering the other treatments.

Among the different treatment combinations, broadcast sowing with sprinkler irrigation retained the maximum soil moisture. This trend was similar or followed by the combination of furrow sowing with sprinkler irrigation.

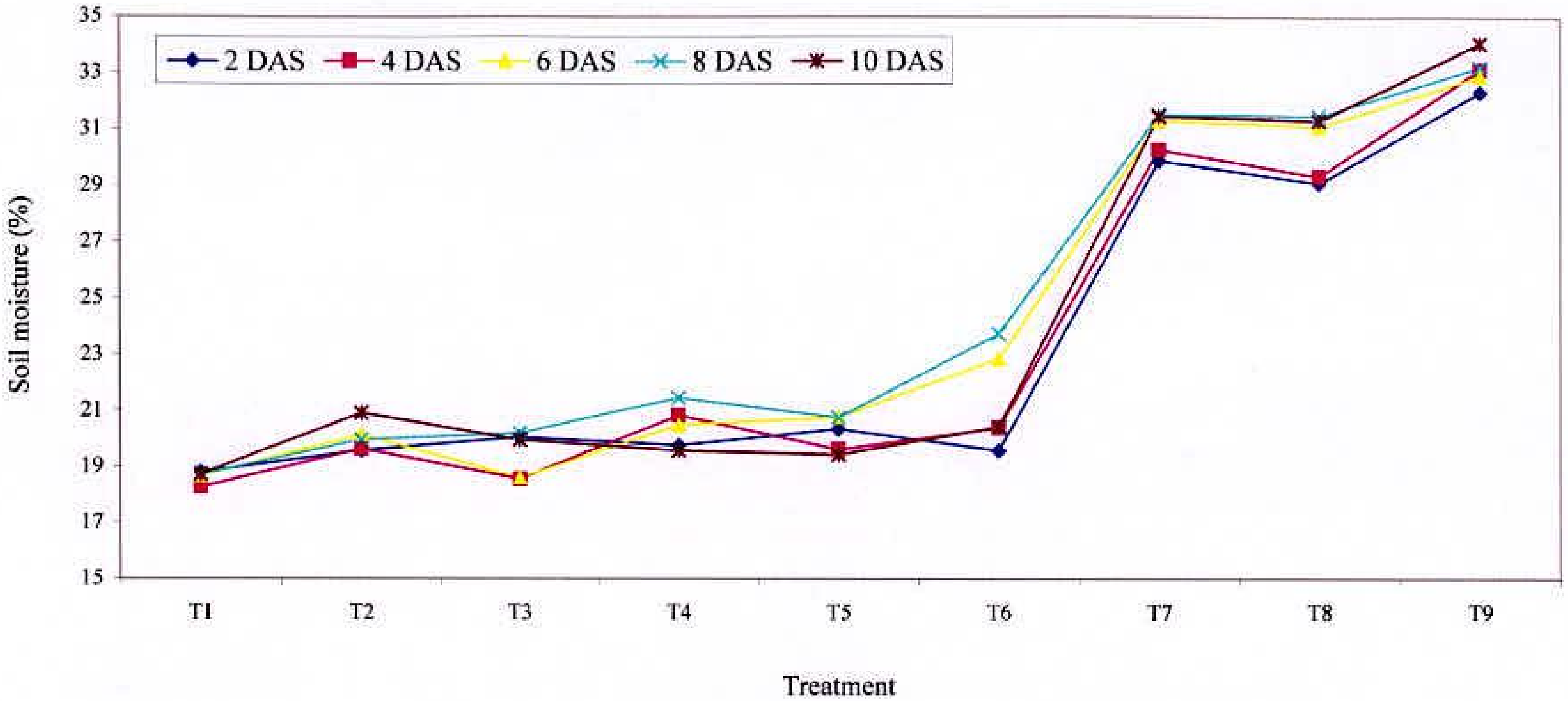

Figure 1. Effect of different methods of sowing and irrigation on soil moisture of grasspea field

T_1: Broadcast sowing without irrigation
T_2: Furrow sowing without irrigation
T_3: Furrow sowing with furrow irrigation
T_4: Broadcast sowing with primed seeds
T_5: Furrow sowing with primed seeds
T_6: Broadcast sowing with sprinkler irrigation at evening
T_7: Broadcast sowing with sprinkler irrigation at evening and morning
T_8: Furrow sowing with sprinkler irrigation at morning
T_9: Broadcast sowing with post sowing flood irrigation

4.3. Plant height

Statistically significant variation was recorded for plant height of grasspea at different days after sowing (DAS) due to the different treatments under the trial (Table 2). The tallest plant (15.11 cm, 34.91 cm, 42.79 cm, 59.41 cm and 71.92) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) treatment at 15, 25, 35, 45 and 55 DAS, which was statistically similar with T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The shortest plant (10.94 cm, 25.76 cm, 31.07 cm, 46.55 cm and 56.98 cm) was found in T_1 (Broadcast sowing without irrigation), which was statistically similar to T_2 (Furrow sowing without irrigation) and T_9 (Broadcast sowing with post sowing flood irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on plant height.

Among the different treatment combinations, broadcast sowing with sprinkler irrigation at evening, and both at evening and morning was more effective for the vegetative growth of grasspea as found in highest plant height. This trend was similar or followed by the combination of furrow sowing with sprinkler irrigation at morning. Earlier Greco and Cacagnari (1991) conducted a pot experiment under drought condition and found that plant height was significantly reduced by drought.

Table 2. Effect of different methods of sowing and irrigation on plant height of grasspea

Treatment	Plant height (cm)				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T_1	10.94 b	25.76 c	31.07 d	46.55 c	56.98 b
T_2	11.37 b	26.06 c	32.13 cd	47.52 bc	58.56 b
T_3	12.89 ab	33.64 a	39.96 a	55.69 a	68.01 a
T_4	12.63 ab	30.91 ab	38.80 ab	54.96 ab	68.95 a
T_5	12.64 ab	28.40 bc	35.60 bc	54.42 ab	65.17 ab
T_6	14.36 a	33.02 ab	40.19 a	56.43 a	67.46 a
T_7	15.11 a	34.91 a	42.79 a	59.41 a	71.91 a
T_8	14.68 a	34.38 a	41.55 a	59.09 a	70.77 a
T_9	13.10 ab	33.58 a	40.17 a	56.00 a	68.24 a
$S\bar{x}$	0.765	1.501	1.208	2.494	2.791
Level of significance	0.05	0.01	0.01	0.05	0.05
CV(%)	10.13	8.34	5.50	7.93	7.30

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.4. Number of branches plant^{-1}

Number of branches plant^{-1} in different treatments varied significantly over time (Table 3). The highest number of branches plant^{-1} (6.10, 10.27, 12.97, 24.27 and 30.13) was obtained from T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) at 15, 25, 35, 45 and 55 DAS, which was statistically similar to T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The lowest number of branches plant^{-1} (3.13, 6.10, 10.00, 15.30 and 16.73) was recorded in T_1 (Broadcast sowing without irrigation), which was statistically similar with T_2 (Furrow sowing without irrigation) and T_9 (Broadcast sowing with post sowing flood irrigation), respectively. Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on number of branches plant^{-1}.

Among the different combinations broadcast sowing with sprinkler irrigation at evening, and both at evening and morning was more effective for the vegetative growth of grasspea that leads to produce the tallest plant with maximum number of branches plant^{-1}. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

Table 3. Effect of different methods of sowing and irrigation on number of branches plant^{-1} of grasspea

Treatment	Number of branches plant^{-1}				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T_1	3.13 d	6.10 c	10.00 b	15.30 c	16.73 b
T_2	3.23 d	6.37 c	10.30 b	15.67 c	17.67 b
T_3	5.33 ab	8.83 ab	11.93 ab	22.97 ab	27.20 a
T_4	4.67 bc	8.77 ab	11.77 ab	19.47 abc	25.80 a
T_5	3.97 cd	7.60 bc	11.77 ab	18.00 bc	21.07 b
T_6	5.23 ab	8.80 ab	11.73 ab	22.07 ab	27.37 a
T_7	6.10 a	10.27 a	12.97 a	24.27 a	30.13 a
T_8	5.60 ab	9.97 a	12.70 a	24.17 a	29.40 a
T_9	5.47 ab	9.20 ab	11.87 ab	21.70 ab	26.67 a
$S\bar{x}$	0.313	0.584	0.652	1.545	1.438
Level of significance	0.01	0.01	0.05	0.01	0.01
CV(%)	11.41	11.98	9.68	13.12	10.09

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.5. Number of leaves plant^{-1}

Number of leaves plant^{-1} of grasspea at different days after sowing (DAS) varied significantly due to the different treatments (Table 4). The highest number of leaves plant^{-1} (17.00, 47.07, 59.80, 89.45 and 64.60) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) at 15, 25, 35, 45 and 55 DAS which was statistically similar with T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The lowest number of branches plant^{-1} (10.40, 16.70, 37.60, 67.50 and 48.47) was recorded in T_1 (Broadcast sowing without irrigation), which was statistically similar with T_2 (Furrow sowing without irrigation) and T_9 (Broadcast sowing with post sowing flood irrigation), respectively. Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on number of leaves plant^{-1}.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both evening and morning was more effective for the vegetative growth of grasspea as found in highest number of leaves plant^{-1}. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning under the trial which produced maximum number of leaves plant^{-1}.

Table 4. Effect of different methods of sowing and irrigation on number of leaves plant^{-1} of grasspea

Treatment	Numbers of leaves plant^{-1}				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T_1	10.40 d	16.70 f	37.60 f	67.50 e	48.40 e
T_2	12.40 c	20.00 ef	43.60 e	75.08 d	53.00 d
T_3	14.20 bc	30.22 cd	52.00 bc	84.00 abc	59.00 bc
T_4	14.00 bc	30.07 cd	51.00 c	83.07 bc	58.40 bc
T_5	13.00 c	23.40 def	49.40 cd	80.55 cd	57.20 cd
T_6	16.20 a	40.37 ab	56.20 ab	88.00 ab	62.00 ab
T_7	17.00 a	47.07 a	59.80 a	89.75 a	64.60 a
T_8	15.80 ab	33.65 bc	55.60 ab	87.45 ab	61.80 ab
T_9	13.40 c	26.83 cde	46.60 de	79.00 cd	55.00 cd
$S\bar{x}$	0.368	0.981	1.034	1.231	1.652
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	7.45	14.79	4.79	3.78	4.11

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.6. Dry matter plant^{-1}

Dry matter plant^{-1} of grasspea over time varied significantly due to the different treatments (Table 5). The highest dry matter plant^{-1} (3.20 g, 4.80 g, 9.97 g, 10.80 g and 14.60%) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) at 15, 25, 35, 45 and 55 DAS which was statistically similar with T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The lowest dry matter plant^{-1} (1.40 g, 2.40 g, 6.63 g, 4.80 g and 10.00 g) was recorded from T_1 (Broadcast sowing without irrigation), which was statistically similar with T_2 (Furrow sowing without irrigation) and T_9 (Broadcast sowing with post sowing flood irrigation). Treatment T_3 (Furrow sowing and furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on dry matter plant^{-1}.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to production of highest dry matter plant^{-1}. This trend was similar or followed by the combination of furrow and sprinkler irrigation and was also effective for the plant growth under the trial which produced maximum dry weight plant^{-1}. Collinson *et al.* (1996) observed that decreasing soil moisture levels resulted in a decline in total dry matter production.

Table 5. Effect of different methods of sowing and irrigation on dry matter content plant^{-1} of grasspea

Treatment	Dry matter plant^{-1} (g)				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T_1	1.40 f	2.40 f	6.63 d	4.80 f	10.00 c
T_2	1.60 ef	3.00 e	7.21 cd	5.80 e	11.20 bc
T_3	2.20 bcd	3.80 cd	9.02 ab	7.80 cd	12.60 ab
T_4	2.00 cde	3.60 cd	8.83 ab	7.40 d	12.40 ab
T_5	2.00 cde	3.40 de	8.23 bc	7.00 d	12.00 bc
T_6	2.60 b	4.40 ab	9.63 a	9.40 b	13.20 ab
T_7	3.20 a	4.80 a	9.97 a	10.80 a	14.60 a
T_8	2.40 bc	4.00 bc	9.55 a	8.40 c	13.20 ab
T_9	1.80 def	3.00 e	7.84 bc	6.20 e	11.40 bc
$S\bar{x}$	0.065	0.086	0.291	0.194	0.521
Level of significance	12.40	7.52	7.58	6.07	9.63
CV(%)	6.55	7.08	10.44	5.87	7.22

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.7. Number of flowers plant^{-1}

Number of flowers plant^{-1} of grasspea varied significantly due to the different treatments (Figure 2). The maximum number of flowers plant^{-1} (77.57) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) which was statistically similar (74.70 and 75.83) with T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning), respectively. On the other hand the minimum number of flowers plant^{-1} (59.67) was recorded from T_1 (Broadcast sowing without irrigation), which was statistically similar (64.27) with T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on number of flowers plant^{-1} considering the other treatments.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning. Greco and Cacagnari (1991) conducted a pot experiment under drought condition and found that number of flowers was significantly reduced by drought.

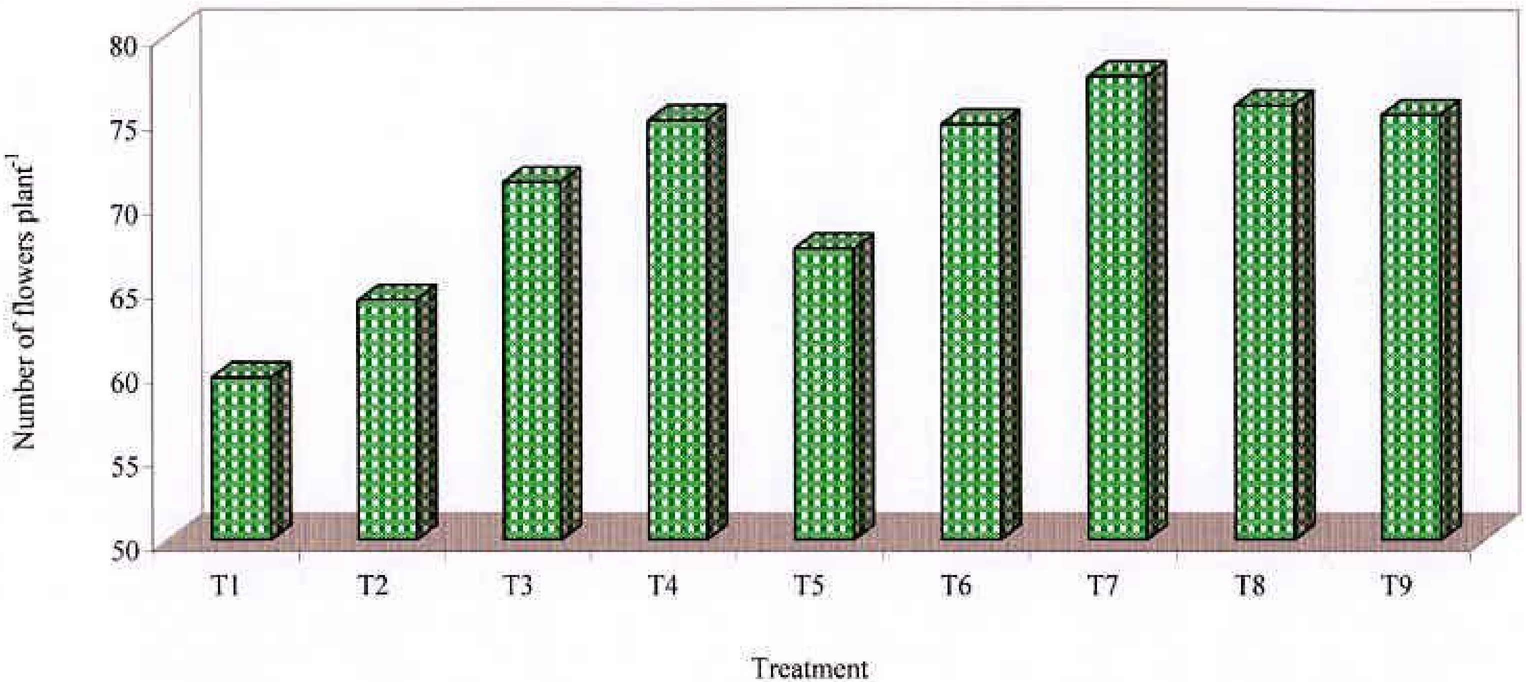

Figure 2. Effect of different methods of sowing and irrigation on number of flowers plant^{-1} of grasspea

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.8. Number of pods plant^{-1}

Number of pods plant^{-1} of grasspea varied significantly due to the different treatments (Table 6). The maximum number of pods plant^{-1} (50.27) was recorded from T_7 (Broadcast sowing with sprinkler irrigation at evening and morning), which was statistically similar (47.33 and 49.63) to that of T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The minimum number of pods plant^{-1} (43.50) was recorded in T_1 (Broadcast sowing without irrigation), which was statistically similar (44.77) to that of T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on number of pods considering the other treatments. Turk *et al.* (1990) demonstrated the response of cowpea to different intensities of drought at different stages of growth and reported that yields were not reduced by drought imposed during the vegetative stage, while drought occurs during the flowering stage substantial yield reduction was of obvious. Variation in yields resulted from variation in number of pods/m^2 and small seed size.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth with maximum number of pods plant^{-1}. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

Table 6. Effect of different methods of sowing and irrigation on yield contributing characters of grasspea

Treatment	Number of pods $plant^{-1}$	Pod length (cm)	Number of seeds pod^{-1}	Weight of 1000 seeds (g)
T_1	43.50 d	3.03 c	3.27 c	34.58
T_2	44.77 cd	3.03 c	3.37 bc	34.78
T_3	47.93 abc	3.43 ab	3.87 ab	37.86
T_4	47.17 abc	3.27 abc	3.67 abc	37.77
T_5	46.50 bcd	3.17 bc	3.60 abc	36.07
T_6	47.33 abc	3.33 abc	3.87 ab	37.88
T_7	50.27 a	3.53 a	4.07 a	39.52
T_8	49.63 ab	3.33 abc	3.87 ab	38.34
T_9	48.83 ab	3.50 a	3.93 a	38.04
$S\bar{x}$	1.087	0.092	0.153	1.280
Level of significance	0.01	0.01	0.05	NS
CV(%)	7.98	6.83	7.10	5.96

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.9. Pod length

Pod length of grasspea varied significantly due to the different treatments (Table 6). The highest pod length (3.53 cm) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning), which was statistically identical (3.33 cm) to T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The lowest pod length (3.03 cm) was recorded from T_1 (Broadcast sowing without irrigation), and T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on pod length.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth with longest pod length. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

4.10. Number of seeds pod^{-1}

Number of seeds pod^{-1} of grasspea varied significantly due to the different treatments (Table 6). The highest number of seeds pod^{-1} (4.07) was recorded from T_7 (Broadcast sowing with sprinkler irrigation at evening and morning), which was statistically identical (3.87) to T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning), respectively. On the other hand the lowest number of seeds pod^{-1} (3.27) was recorded in T_1 (Broadcast sowing without irrigation), and (3.37) with T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on number of seeds pod^{-1}. Hasan and Mahhady (1983) reported that available soil water induced significant effects on seed number.

Among the different combinations broadcast sowing and sprinkler irrigation at evening and both at evening and morning and also individually was more effective for the vegetative growth of grasspea that leads to highest reproductive growth with highest number of pod. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

4.11. Weight of 1000 seeds

Weight of 1000 seeds of grasspea varied non-significantly due to the different treatments (Table 6). The highest weight of 1000 seeds (39.52 g) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) and the lowest weight of 1000 seeds (34.58 g) was recorded in T_1 (Broadcast sowing without irrigation). Hasan and Mahhady (1983) reported that available soil water induced significant effects on 1000-grain weight

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth with filled grain. This trend was similar or followed by the combination of others treatment.

4.12. Seed yield (t ha^{-1})

Seed yield of grasspea varied significantly due to the different treatments (Table 7). The highest seed yield (1.75 t ha^{-1}) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning), which was statistically identical (1.67 t ha^{-1} and 1.66 t ha^{-1} to that of T_6 (Broadcast sowing with sprinkler irrigation at evening) and T_8 (Furrow sowing with sprinkler irrigation at morning). The lowest seeds yield (1.29 t ha^{-1}) was recorded from T_1 (Broadcast sowing without irrigation), and (1.31 t ha^{-1}) T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation) and T_4 (Broadcast sowing with primed seeds) showed the moderate influence on seed yield. The grain growth in un-irrigated crop was decreased. This was probably due to insufficient supply of current assimilate to fill the grain as because the plant had little photosynthates. Erskine and Saxena (1990) conducted an experiment and observed that moisture stress affected yield

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth and highest seed yield. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

Table 7. Effect of different methods of sowing and irrigation on yield of grasspea

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
T_1	1.29 b	3.76	5.20	24.95 c
T_2	1.31 b	3.62	4.92	26.61 c
T_3	1.69 a	3.64	5.32	31.86 ab
T_4	1.64 a	3.63	5.26	31.13 ab
T_5	1.43 b	3.63	5.07	28.26 bc
T_6	1.67 a	3.72	5.38	31.02 ab
T_7	1.75 a	3.91	5.66	32.68 a
T_8	1.66 a	3.39	5.04	32.91 a
T_9	1.68 a	3.60	5.28	32.14 ab
$S\bar{x}$	0.052	0.221	0.241	1.290
Level of significance	0.01	NS	NS	0.01
CV(%)	5.72	10.52	8.00	7.40

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly

T_1: Broadcast sowing without irrigation

T_2: Furrow sowing without irrigation

T_3: Furrow sowing with furrow irrigation

T_4: Broadcast sowing with primed seeds

T_5: Furrow sowing with primed seeds

T_6: Broadcast sowing with sprinkler irrigation at evening

T_7: Broadcast sowing with sprinkler irrigation at evening and morning

T_8: Furrow sowing with sprinkler irrigation at morning

T_9: Broadcast sowing with post sowing flood irrigation

4.13. Stover yield (t ha^{-1})

Stover yield of grasspea varied non-significantly due to the different treatments (Table 7). The higher stover yield (3.91 t ha^{-1}) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) and the lower (3.39 t ha^{-1}) was recorded in T_8 (Furrow sowing with sprinkler irrigation at morning). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate stover yield.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth and highest stover yield. This trend was similar or followed by the combination of others treatment.

4.14. Biological yield (t ha^{-1})

Biological yield of grasspea varied non-significantly due to the different treatments (Table 7). The highest biological yield (5.66 t ha^{-1}) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning) and the lowest biological yield (4.92 t ha^{-1}) was recorded in T_2 (Furrow sowing without irrigation). Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on biological yield.

Among the different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth and highest biological yield. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning.

4.15. Harvest index (%)

Harvest index of grasspea showed non significant variation due to the different treatments (Table 7). The higher harvest index (32.68%) was recorded in T_7 (Broadcast sowing with sprinkler irrigation at evening and morning), whereas the lower harvest index (24.95%) was recorded in T_1 (Broadcast sowing without irrigation. Treatment T_3 (Furrow sowing with furrow irrigation), T_4 (Broadcast sowing with primed seeds) and T_5 (Furrow sowing with primed seeds) showed the moderate influence on harvest index.

From different combinations broadcast sowing with sprinkler irrigation at evening and both at evening and morning was more effective for the vegetative growth of grasspea that leads to highest reproductive growth and highest seed yield. Similar trend was followed by the combination of furrow sowing with sprinkler irrigation at morning. Collinson *et al.* (1996) observed that decreasing soil moisture levels resulted in a decline in harvest index.

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2007 to March 2008 to study the growth and yield performance of grasspea under different methods of sowing and pre-emergence irrigation. The variety BARI Khesari-2 was used as the test crop. The treatments of the experiment were T_1: Broadcast sowing without irrigation; T_2: Furrow sowing without irrigation; T_3: Furrow sowing with furrow irrigation; T_4: Broadcast sowing with primed seeds; T_5: Furrow sowing with primed seeds; T_6: Broadcast sowing with sprinkler irrigation at evening; T_7: Broadcast sowing with sprinkler irrigation at evening and morning; T_8: Furrow sowing with sprinkler irrigation at morning and T_9: Broadcast sowing with post sowing flood irrigation.

The highest emergence of plant over time (4.80, 19.65, 26.20, 54.20 and 71.50) were recorded in T_7 treatment whereas the lowest (2.40, 5.10, 18.20, 44.60 and 45.23) in T_1 treatment. The maximum soil moisture over time (32.35%, 33.14%, 32.91%, 33.24% and 34.08%) was recorded in T_9 and the minimum (18.81%, 18.27%, 18.67%, 18.71% and 18.74%) in T_1 treatment. The tallest plant over time (15.11 cm, 34.91 cm, 42.79 cm, 59.41 cm and 71.92) were recorded in T_7 treatment and the shortest (10.94 cm, 25.76 cm, 31.07 cm, 46.55 cm and 56.98 cm) in T_1 treatment.

The highest number of branches $plant^{-1}$ over time (6.10, 10.27, 12.97, 24.27 and 30.13) were recorded in T_7 treatment and the lowest (3.13, 6.10, 10.00, 15.30 and 16.73) in T_1 treatment. The highest number of leaves $plant^{-1}$ over time (17.00, 47.07, 59.80, 89.45 and 64.60) were recorded in T_7 treatment and the lowest (10.40, 16.70, 37.60, 67.50 and 48.47) in T_1 treatment. The highest dry matter $plant^{-1}$ over time (3.20 g, 4.80 g, 9.97 g, 10.80 g and 14.60%) was recorded from T_7 and the lowest dry matter $plant^{-1}$ (1.40 g, 2.40 g, 6.63 g, 4.80 g and 10.00 g) was recorded from T_1.

The maximum number of flowers $plant^{-1}$ (77.57) was recorded in T_7 treatment and the minimum (59.67) in T_1 treatment. The maximum number of pods $plant^{-1}$ (50.27) was recorded in T_7 treatment and the minimum (43.50) in T_1 treatment. The highest pod length (3.53 cm) was recorded from T_7 treatment and the lowest (3.03 cm) in T_1 treatment. The highest number of seeds pod^{-1} (4.07) was recorded in T_7 treatment and the lowest (3.27) in T_1 treatment. The highest weight of 1000 seeds (39.52 g) was recorded in T_7 treatment and the lowest (34.58 g) was in T_1 treatment.

The highest seed yield (1.75 t ha^{-1}) was recorded in T_7 treatment and the lowest (1.29 t ha^{-1}) in T_1 treatment. The highest stover yield (3.91 t ha^{-1}) was recorded in T_7 treatment whereas the lowest (3.39 t ha^{-1}) in T_8 treatment. The highest biological yield (5.66 t ha^{-1}) was recorded in T_7 treatment and the lowest (4.92 t ha^{-1}) in T_2 treatment. The highest harvest index (32.68%) was recorded in T_7 treatment while the lowest (24.95%) in T_1 treatment.

Considering the results of the present experiment, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Other management practices may be included for further study.

REFERENCES

Al-Karaki, G. H. (1988). Response of ten lentil genotypes to simulate drought conditions. *Aleandria Agric. Res.* (Egypt), **33**(3): 135-139.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Arjunan, A., Monoharan, V. and Tangavelu, S. (1992). Field screening for drought resistance in groundnut. *Int. Arachis Newsl.* 12 Nov. 1992. p. 11-12.

Arya, M. P. S. and Kalra, G. S. (1988). Effect of sowing time and phosphorus doses on growth, yield and quality of summer mungbean (*Vigna radiata*). *Indian J. Agric. Res.* **22**(1):23-30.

Ayallew, D. and Tabbada, R. A. (1987). Influence of soil moisture levels on the growth and development of the mungbean plant (*Vigna radiate L.). Natural and Applied Science Bull.* **39**(4): 273-280.

Babu, V. R., Murty, P. S. S., Reddi, G. S. S. and Reddy, T. Y. (1984). Leaflet angle and radiation effect of mungbean. *Hort. Sci.*, **23**(2): 23-26.

BBS. (Bangladesh Bureau of Statistics). (2006). Monthly Statistical Bulletin. Statistics Division. Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka. P. 46.

Biwas, D. C. (2001). Effect of irrigation and population density on growth and productivity of field bean *(Phaseolus vulgaris)*. MS Thesis. Bangabandhu Shiekh Mujibur Rahman Agric. Univ. Gajipur-1706.

Collinson, S. T., Chuula, S. N. and Hodsin, D. A. (1996). Growth, development and yield of bambara (*Vigna subterranea)* in response to soil moisture. *J. Agric. Sci.* **126**(3): 307-318.

Craufurd, P. Q. and Wheeler, T. R. (1999). Effect of drought and plant density on radiation interception radiation use efficiency and partitioning of dry matter to seeds in cowpea. *Expt. Agric*, **35**(3): 309-325.

Cselotel, G. (1980). Planting patterns and soybean yields. *Crop Sci.* **26**(3): 584-588.

Denmead, O. T. and Shaw, R. H. (1960). The effects of soil moisture stress at different stages of growth on the yield of corn. *Agron. J.* **52**: 272-274.

Dubtez, S. and Mahalle, P. S. (1969). Effect of soil water stress in bush beans (*Phaseolus vulgaris L.)* at three stages of growth. *J. Am. Soc. Hort. Sci.* **94**(5): 479-481.

Earing, P. K. (1984). Performance of wheat and triticate cultivars subjected to soil salinity and soil moisture stress conditions. Wheat information Service, Kihara Institute for Biological Research Yokohama, Japan. **34**: 43-49.

Eck, H. V. and Musick, J. T. (1979). Plant water stress on irrigated grain sorghum. I. Effects on yield. *Crop. Sci.* **19**: 589-592.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

El-Nadi, A. A. (1969). Efficiency of water use by irrigated wheat in the Sudan soil and fertilizers. In: *Field Crop Abst.* **33**(1): 75.

Erskine, W. and Saxena, M. C. (1990). Problems and prospect of stress resistance breeding in lentil (*Lens culinaris*). *Lens Newsl.*, **17**(1): 7-9.

FAO (Food and Agricultural Organization). (1999). FAO Production Yearbook. Basic Data Unit. Statistic Division, FAO. Rome, Italy.

Frick, H. and Pinolato, T. D. (1987). Adaptive value of the xylem discontinuity in partition of photoassimilate to the grain. Bull. Torrey Bot. Club **114**:252-259.

Golakiya, D. and Patel, P. K. (1992). Effect of water stress on growth and yield of two mungbean varieties (*Vigna radiata L.),* Balai Penelitian Tanaman Pangan, Bogor (Indonesia). Balittan, **12**(1): 111-119.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). *Int. Rice Res. Inst., A Willey Int. Sci*., Pub., pp. 28-192.

Gowda, J. S. and Kaul, P. P. (1982). Growth morphology, assimilates partitioning and dry matter production of bean *(Phaseolus vulgaris L;)* plant under three light levels and two water regimes. *Hort Abst.* **23**(10): 733.

Greco, S. A. and Cacagnari, J. B. (1991). Influence of drought at different growth stages on yield of lentils. *Lens Newsl.* **18**(1): 27-29.

Hamid, A. Kubota, F. Agata, W. and Morokuma, M. (1990a). Photosynthesis, transpircation, dry matter accumulation and yield performance of mungbean plant in response to water stress, *J. Fac. Agr. Kyushu Univ*. **35**: 81-92.

Hamid, A., Agata. W. and Kawamitsu, Y. (1990b). Photosynthesis, transpiration and water use efficiency in four cultivars of mungbean [*Vigna radiata* (L) Wilczek]. *Photosynthetica*, **24**: 96-101.

Haque, A. M. M. (1988). Growth, yield and seed quality of two snap bean *(Phaseolus vulgaris L.)* varieties as affected by irrigation frequency and fertilizer materials. Ph. D. Dissertation, Benguit State Universit, Benguit, Philippines.

Hasan, I. S. and Mahhady, A. S. (1983). Performance of wheat and triticale cultivars subjected to soil salinity and soil moisture stress conditions. Wheat information Service, Kihara Institute for Biological Research, Yokohama, Japan. **56**: 28-33.

Hsiao, T. C. and Acevedo, F. (1974). Plant response to water deficits, water use efficiency and drought resistance. *Agric. Meterotol.* **14**: 69-84.

Hughes, G., Keating, J. D. H. and Scott, S. P. (1981). Planting density effect on the dry season productivity of short duration pigeonpea in the West Indies. Growth and development, p. 235-240. Proceedings of the international workshop on pigeonpeas, 15-19. Dec. 1980. ICRISAT, India.

Hutami, S. and Achlan, M. (1992). Response of mungbean varieties and lines to water stress. *Balai Penelitian Tanaman Pangan, Bogor(Indonesia), Balittan,* **68**(2): 540-547.

Hutami, S., Achan M., Nunung, Z. and Hastuti, R. D. (1991). Effect of water stress on growth and yield of two mungbean varieties (*Vigna radiata L.),* Balai Penelitian Tanaman Pangan, Bogor (Indonesia). *Balittan*, **14**(2): 117-229.

ICISAT. (1986). Growth and development of pulse. p. 211-233. Proceedings of the international workshop on pigeonpeas, 11-14. Dec. 1986.

Islam, M. T., Hamid, M. A., Salam, M. A. and Dutta, R. K. (1996). Identification of groundnut mutants tolerant to moisture stress. *Bangladesh J. Nuclear Agric.*, **12**: 1-9.

Islam, M. T., Kubata, F. and Agata, W. (1994). Growth canopy structure and seed yield of mungbean (*Vigna radiata*) as influenced by water stress. *J. Fac. Agric. Kyushu University*, **38**(3-4): 213-224.

Jackson, M. B. (1979). Rapid injury to peas by soil water logging. *J. Sci. Food and Agric*. 30: 143-152.

Janamath, V. S., Sashidhar, V. R. and Prasad, T. G. (1988). Effect of cycles of moisture stress on flower production, gynophore length and their relationship to pod yield in breach types of groundnut. In: *Field Crop Abst.* **41**(10): 828.

Joseph, K. D. S. M., Costa, W. A. J. M. and Shanmugathasan, K. N. (1999). Physiology of yield determination of mungbean (*Vigna radiata L.)* under various irrigation regimes in the dry and late zones of Srilanka. *Field Crop Res*, **61**(1): 1-12.

Karim, M. A., Nawata, E. and Shingnaga, S. (1993). Effect of salinity and water stress on the growth, yield and physiological characteristics in hexaploid triticale. *Jpn. UJ. Trop. Agr.* **37**: 46-52.

Khade, V. N., Patil, Talathi, P. G. and Khanvilkar, S. A. (1990). Response of field bean to irrigation at critical growth stages. *Hort. J.* **5**(1): 712.

Kramer, P. J. (1963). Water stress and plant growth. *Agron J.* **55**:31-35.

Kridemann, P. K. (1986). Influence of soil moisture regimes, straw mulching and kaolin spray on yield attributing characters and correlation between yield and yield attributes in lentils. *Lens Newsl.* **11**(1): 34-38.

Kumar, S., Singh B. R. T and Tyagi. R. C. (1995). Effect of irrigation on growth parameters of lentil (*Lens culinaris L.*) In: *Field Crop Abst*, **48**(5): 428-29.

Lawlor, D. W. Day, W. Johnston, A. E., Legg, B. J. and Parkinson, K. J. (1981). Growth of spring burley under drought. Crop development, photosynthesis, dry matter accumulation and nutrient content. *J. Agric. Sci.* **96**:167-186.

Lewis, J. K., Lopes, N. F. Oliva, M. A. Gomes, M. M. Souza, V. P. and Cardoso, M. J. (1974). Growth morphology, assimilates partitioning and dry matter production of bean *(Phaseolus vulgaris L;)* plant under three light levels and two water regimes. *Hort. Abst.* **32**(10): 733.

Ludlow, M. M. and Muchow, R. C. (1990). A critical evaluation of traits for improving crop yields in water limited environments. *Adv. Agron.* **43**: 107-153.

Mahboob, A. and Asghar, M. (2002). Effect of seed sowing and different nitrogen levels on the grain yield of mungbean. *Asian J. Plant Sci.* **1**(4): 314-315.

Majumdar , D. K. and Roy, S. K. (1992). Response of summer sesame *(Sesamum indicum)* to irrigation, row spacing and plant population. *Indian J. Agron.* **37**(4): 758-762.

Matos, A. T., Guedes, A. C. and Ferreira, P. E. (1988). Effect of different irrigation levels on the production of pea seeds. In: *Field Crop Abst.*, **41**(7): 564.

Mehrotra, C. N., Mothur, R. K. Ali, S. H. A. and Pathok, J. (1963). Soil moisture stress and growth and yield of hybrid maize. *Indian J. Plant Physiol.* **63**:95-102.

Mehrotra, O. N., Gang, R. C. and Ali, S. H. A. (1986). Influence of soil moisture on growth, yield and quality of groundnut. *Indian J. pl. physiol.* **11**(2): 158-163.

Miah, M. G., Hirota, O. and Chikushi, J. (1996). Influence of water status, photosynthesis rate and plant growth under different temperatures and water regimes during pod formation phase of mungbean (*Vigna radiata*). *J. Fac. Agric. Kyushu Univ.* **41**(1-2): 17-28.

Murari, K. and Pandey, S. L. (1985). Influence of soil moisture regimes, straw mulching and kaolin spray on yield attributing characters and correlation between yield and yield attributes in lentils. *Lens Newsl.* **12**(1): 18-20.

Myburgh, P. A. and Walt, L. D. (2005). Cane water content and yield responses of Vitis vinifera L. cv. Sultanina to overhead irrigation during the dormant period. *South African J. Eno. Viti.*, **26**(1): 1-5

Nandan, R. and Prasad, V. K. (1998). Effect of irrigation and nitrogen on growth, yield, nitrogen uptake and water-use efficiency of French bean (*Phaseolus vulgaris). Indian. J. Agril. Sci.* **67**(11): 75-80.

Oad, F. C. and Buriro, U. A. (2005). Influence of different NPK levels and methods of seed sowing on the growth and yield of mungbean. *Indian J. Plant Sci.*, **4**(4): 474-478.

Pal, S. K. (2007). Grain yield and water use efficiency of French bean under varying irrigation regimes and phosphorus levels. *J. Food Legumes*. **20**(1): 111-112

Pandey, R. K., Herrera, W. A. T., Villegas, A. N. and Pendleton, J. W. (1984). Drought response of grain legumes under irrigation gradient. *Agron. J.* **76**:557-560.

Pannu, D. and Singh, P. C. (1988) Resistance of sunflowers to drought at various stages and growth. Aralele institute cerecal Fundulea, 37: 191-208. In: *Field crop Abst*., **26**(10): 538.

Parjol, S. K., Susanta, P. B. and Mayer, S. K. (1971). Detrimental effect of water stress mungbean. *Agron. J.* 34: 18-22.

Patel, C. L., Padalia, M. R. and Babarin, N. B. (1983). Growth and plant water relation in groundnut grown under different soil moisture stress. *Indian J. Agric. Sci*., **53**(5): 340-345.

Patel, M. M., Patel, I. C., Patel, B. S. and Tikka, S. B. S. (2005). Response of summer clusterbean [*Cyamopsis tetragonoloba* (L.) (Taub.)] to irrigation and fertilizer doses on yield and economics under north Gujarat agro-climatic conditions. *J. Arid Legumes*. **2**(2): 262-264

Patro, H. and Sahoo, P. N. (1994). Response of mungbean genotypes to methods of sowing and phosphorus. *Indian J. Pulses Res*., 7(2): 191-192.

Petersen, A. C. J. (1989). Effect of water stress on *Phaseolus Valgaris L.* and *acutifolius* Phaseolus var *latifolius*. *Hort. Abst*. **59**(4): 333.

Provakar, M. and Suraf, G. S. (1991). Influence of irrigation and phosphorus in growth, yield and water use efficiency of chickpea (*Cicer arientinum* genotypes. *India J. Agrion*. **36**(3): 357-362.

Rahman, M. H., Khaliq, Q. A., Hamid, A., Miah, M. N. I and Haque, M. M. (2000). Irrigation and planting density effects on dry, matter production and yield in edible podded pea. *Bangladesh J. Agril. Res.* **25**(1): 161-167.

Rajput, R. L., Kausshik, G. P. and Verma, O. P. (1991). Yield and nutrient uptake in soybean (*Glycine max*) as affected by irrigation, phosphorus. *Indian J. Agron,* **36**(4): 549-552.

Rajput, R. L., Shrivastava, U. K. and Verma, O. P. (1995). Studies on soil moisture extraction pattern in pulses and oilseeds under rainfed conditions. *Agricultural Science Digest Karnal*. **15**(1/2): 61-63.

Ramasamy, M., Srinivasan, K. and Vairavan, K. (1999). Effect of land management, irrigation schedule and organic amendments on productivity of irrigated groundnut. *Madras Agril. J.* **86**(4/6): 298-300.

Sadasivam, R. N. Natarajaratnam, R. Chandra, B. Muralidharan, V. and Sree Rangasamy, S. R. (1988). Response of mungbean cultivars to soil moisture stress at different growth phases. In: Proceeding of the second international symposium, Mungbean. Pp. 260-262.

Salam, M. A. and Islam, M. T. (1994). Growth, yield and leaf water attributes of some advanced mutant of lentil under different soil moisture regimes. *Lens Newsl*. **24**(2): 31-39.

Salter, P. J. and Good, J. E. (1967). Crop response to water at different stages of growth. Common Agric. Bur. Farham Roel. Backs. England: 246.

Sanaullah, M. and Bano, A. (1999). Effect of plant growth regulators on the accumulation of a neurotoxin and yield of *Lathyrus sativus L. Bangladesh J. Bot.* **28**(2): 139-144.

Sankar, R. K. (1992). Response of summer greengram (*Phaseolus radiatus)* to irrigation and phosphorus application. *Indian J. Agron.* **37**(1): 123-125.

Sarwar, G. A., Siowit, N. and Kramer, P. J. (1995). Effect of water stress during different stages of growth of soybean. *Agron. J.* **69**: 274-278.

Seth, S. and Chaudhury, B. D. (1989). Irradiation for branching in mungbean *(Vigna radiata). J. Agric. & Crop Sci,* **168**(2): 128-132.

Singh, K. B. and Saxena, M. C. (1990). Problems and prospects of stress resistance breeding in lentil *(Lens culinaris)*. ICARDA, Syria. p.7.

Singh, K. K., Srinivasarao, C. and Masood, A. (2005). Root growth, nodulation, grain yield, and phosphorus use efficiency of lentil as influenced by phosphorus, irrigation, and inoculation. *Comm. Soil Sci. and Plant Analysis*. **36**(13/14): 1919-1929.

Swaraj, K., Babber, S., Ahlawat, S., Nandwal, A. S. and Nainawati, H. S. (1995). Effect of water stress on functioning and structure of chickpea (*Cicer arietinum)* nodules. *Biologia*., **37**(4): 613-619.

Tadesse, S. L. (1977). Response of mungbean cultivars to soil moisture stress at different growth phases. In: Proceeding of the first international symposium, Mungbean. Pp. 122-127.

Talukder, M. S. U. (1987). Growth and development of wheat as affected by soil moisture stress. *Idian. J. Agric. Sci.* **57**: 559-564.

Thakur, V. R., Giri D. G. and Deshmukh, J. P. (1996). Influence of different methods of seed sowing and levels of phosphorus on yield and uptake of greengram (*Vigna radiata* L.). *Ann. Plant Physiol.,* **10**(2): 145-147.

Tickoo, J. L., Naresh, C., Gangaiah, B., and Dikshit, H. K. (2006). Performance of mungbean (*Vigna radiata*) varieties at different row spacings, methods of sowing and nitrogen-phosphorus fertilizer levels. *Indian J. . Agril. Sci.,* **76**(9): 564-565.

Turk, K. J., Holl, A. E. and Asbell, C. W. (1990). Drought adaptation of cowpea. I. Influence of drought on seed yield. *Agron, J.* **72**: 413-420.

Turk, K. J. and Hall, A. E. (1980). Drought adaptation of cowpea. II. Influence of drought on plant growth and water relations with seed yield. *Agron. J.* 72: 428-433.

Viera, R. D., Turony, D. M. and Egli, D. B. (1991). Effect of drought stress on soybean seed germination and vigour. *J. Seed Technol.* **16**: 12-21.

Villegas, R. J. A. (1981). Effect of moisture stress on the growth and yield of mungbean *(Vigna radiata L.)*. Los. Banos, Launa, (Philippines). Nov. p. 136.

Vitkov, T. S., Tripurari, P. and Yadav, D. S. (1972). Effect of irrigation and planting density on yield attributes and yield of green gram and black gram. *Indian J. Agron.* **15**(1): 39-41.

Wien, H. C., Litteton, E. J. and Ayanaba, A. (1979). Drought stress of cowpea and soybean under tropical conditions. p. 283-301. In Mussel, H. and Staples, R. C. (ed). Stress Physiology in Crop Plants. Wiley Inter science, New York.

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and Sunshine of the experimental site during the period from December 2007 to March 2008

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
December, 2007	22.4	13.5	74	00	6.3
January, 2008	24.5	12.4	68	00	5.7
February, 2008	27.1	16.7	67	30	6.7
March, 2008	31.4	19.6	54	11	8.2

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Characteristics of Agronomy Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data on emergence of grasspea seedlings as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Total germinated plant plot^{-1}				
		6 DAS	7 DAS	8 DAS	9 DAS	10 DAS
Replication	2	0.281	1.385	0.583	2.561	1.338
Treatment	8	2.762**	6.721**	13.552**	33.879**	19.093**
Error	16	0.371	1.982	4.023	4.093	5.392

**: Significant at 0.01 level of probability:

Appendix IV. Analysis of variance of the data on soil moisture of grasspea field as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Soil moisture (%)				
		2 DAS	4 DAS	6 DAS	8 DAS	9 DAS
Replication	2	1.218	0.943	2.512	1.228	0.231
Treatment	8	5.905**	7.921**	12.908**	11.908**	5.095**
Error	16	0.734	1.562	1.657	3.782	0.529

**: Significant at 0.01 level of probability:

Appendix V. Analysis of variance of the data on plant height of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm)				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	1.485	4.881	4.422	22.346	5.590
Treatment	8	6.103*	38.555**	51.698**	61.740*	80.456*
Error	16	1.755	6.758	4.380	18.660	23.368

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of branches plant^{-1} of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Number of branches plant^{-1}				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.117	0.404	0.278	1.174	2.867
Treatment	8	3.438**	6.418**	2.827*	35.715**	73.567**
Error	16	0.293	1.022	1.275	7.161	6.200

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data number of leaves plant^{-1} of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Leaves numbers plant^{-1}				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.912	0.034	1.876	2.610	0.034
Treatment	8	2.987*	5.094**	12.151**	19.903**	26.095**
Error	16	0.902	1.903	3.073	2.781	2.908

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on dry matter content plant^{-1} of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Dry matter plant^{-1} (g)				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.005	0.419	0.891	0.043	0.178
Treatment	8	0.412**	2.148*	4.213**	1.562**	3.228**
Error	16	0.059	0.529	0.152	0.129	0.381

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on yield contributing characters of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square				
		Number of flowers plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Weight of 1000 seeds (g)
Replication	2	11.016	3.593	0.005	0.028	1.095
Treatment	8	113.089**	14.441**	0.103**	0.217*	8.476
Error	16	12.172	3.543	0.025	0.070	4.914

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data on yield of grasspea as influenced by different methods of sowing and irrigation

Source of variation	Degrees of freedom	Mean square			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.005	0.191	0.235	4.017
Treatment	8	0.093**	0.054	0.078	24.66**
Error	16	0.008	0.146	0.174	4.991

**: Significant at 0.01 level of probability: