RESPONSE OF GRASSPEA (*Lathyrus sativus* L.) VARIETIES TO DIFFERENT NITROGEN MANAGEMENTS

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CERTIFICATE

This is to certify that the thesis entitled "RESPONSE OF GRASSPEA (*Lathyrus sativus* L.) VARIETIES TO DIFFERENT NITROGEN MANAGEMENTS" submitted to the department of agronomy, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in agronomy, embodies the results of a piece of *bona fide* research work carried out by NUSRAT KABIR , Registration. No. 10-04231 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

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

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DECLARATION

I do hereby declare that this thesis entitled *"**Response of grasspea (Lathyrus sativus L.) Varieties to different nitrogen managements**"* has been written and composed by myself with my own investigated research data.

I further declare that this thesis has not been submitted anywhere in any form for any academic degree.

December 2012 **(Nusrat Kabir)**

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RESPONSE OF GRASSPEA (*Lathyrus sativus* L.) VARIETIES TO DIFFERENT NITROGEN MANAGEMENTS

ABSTRACT

An experiment was conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November to March 2011 to study the response of grasspea varieties to different nitrogen managements using RCBD (Randomized Complete Block Design) with three replications. During the experiment, three varieties of grasspea (V_1= BARI khesari-1, V_2=BARI khesari-2 and V_3= Local khesari) and six nitrogen management treatments (N_0= Control, N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage and N_5=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage) were used as treatments. In most of the growth stages the tallest plants, highest number of branches $plant^{-1}$, plant dry weight, nodule number $plant^{-1}$, nodule dry weight and pod number $plant^{-1}$, seed number pod^{-1}, maximum 1000-seed weight, grain yield, stover yield and harvest index was found from BARI khesari-2, which was followed by BARI khesari-1.In case of nitrogen management, distinct variations were observed between initial and later stages. Though N_2 (basal application with 40 kg N ha^{-1}) gave higher results for growth parameters initially, it was found that N_3(basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) was better at later stages than the previously mentioned treatment. Yield parameters like pod number $plant^{-1}$, seed number pod^{-1}, maximum1000-seed weight, grain yield, stover yield and harvest index were also highest in N_3 followed by N_2.On the other hand, for different nitrogen management techniques, the lowest results were recorded from N_0. For combination effect of variety and nitrogen management it was observed that initial growth was better in V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) and V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) while later growth and yield parameters were better in V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage) closely followed byV_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage).

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LIST OF ABBREVIATIONS

Abbreviation

AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh institute of Nuclear Agriculture
C.V	Coefficient Variation
cv.	Cultiver
DAS	Days after sowing
DM	Dry matter
DMRT	Duncan’s Multiple Range Test
et al.	And Others
FAO	Food and Agriculture Organization
HYV	High yielding variety
RCBD	Randomized Complete Block Design
SAU	Sher- e- Bangla Agricultural University

Units

%	Percent
g	gram
t/ha	Ton per Hectare
m	meter
kg	kilogram

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Grasspea (*Lathyrus sativus* L.) is traditional food stuff in many cultures of the world including Bangladesh. It is an important pulse crop of Bangladesh and is commonly known as khesari. Among all the pulses grown in Bangladesh, grasspea occupies the second highest position in terms of both acreage (89,474 ha) and production (83,000 ton) (BBS, 2011). According to FAO (1999), per-capita intake of pulse should be 80 g day^{-1}, where as it is only 12 g in Bangladesh (BBS, 2008).

In Bangladesh grasspea is cultivated for human food and fodder for livestock. It has a prostrate growth habit, with thin grass like foliage and red brown, blue or white colored flowers. It is an annual legume, well adapted to low rainfall, but it is also fairly tolerant to water-logging (Rahman *et al*., 1995). It is often the last crop to stand in case of extreme conditions. Though grass pea seeds contain neurotoxic compound ODAP (β -N-Oxalyl - L- α, β -diaminopropionic acid) potentially causing lathyrism (irreversible paralysis of lower limbs) in human beings, it is widely cultivated because of its wide adaptability and little requirement for inputs. *L. sativus* (grasspea) is also important pulse crop in India, China, Pakistan and Nepal (Campbell *et al.*, 1994; Yadav and Mehta, 1995).

Grasspea performs well under adverse agricultural conditions, and its many cultivars possess different attributes including the ability to resist both drought and flooding, and have the ability to grow in cool climate and at high altitude (Tiwari and Campbell, 1996). Grasspea also has the ability to adapt to saline, alkaline, clay or otherwise poor soils, and is hardy and easy to cultivate (Sinha *et al.,* 1983). In addition to nutritional benefits, grasspea has an important role as a legume crop in crop rotations, reportedly adding around 67 kg ha^{-1} of nitrogen to the soil in a single season and conferring yield and protein benefits on the subsequent nonlegume crop (Wang *et al,*. 2000). Grasspea is grown primarily as a winter pulse crop and is known as the 'poor men's diet' in our country. This crop is cultivated only as a fodder crop in Australia, Europe and North America, and is recommended for low quality soils of southwestern Australia (Siddique *et al.,* 1999). Grasspea is valued as a nutritious staple food and fodder crop primarily due to its relatively high protein content 18–34% dry weight in seeds, 17% in mature leaves) and its high lysine content (Siddique *et al.,* 1996).

The grain yield of grasspea is very low (500 kg ha^{-1}) as compared to other countries of the world. The reason behind low yield may be due to the absence of HYV in the farmer's field. Local variety is being cultivated with low management practices. BARI has developed some HYV of grasspea that can be cultivated in farmers' field for higher yield.

Nutrients play a vital role in increasing the seed yield in pulses. In legume, nitrogen (N) is more useful because it is the main component of amino acid as well as protein. Mineral nitrogen fertilizers are costly and detrimental to the environment. Grasspea can obtain nitrogen (N) by atmospheric fixation in their root nodules in symbiosis with soil *Rhizobia* and thus has a potential to yield well in nitrogen deficit soils. There are many reasons of lower yield of grasspea. The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers becomes helpful in increasing the yield (Ardeshna *et al.,* 1993). Bachchhav *et al.* (1994) observed that root nodule weight per plant was highest with 30 kg N ha^{-1}. Satyanarayanamma *et al.* (1996) reported that application of urea at flowering and pod development stage produced the highest seed yield. Grasspea as a legume crop responds well to added nitrogen to overcome its lag phase and it influences nutrient uptake by promoting root growth and nodulation (Sing and Sing, 1999).

Nitrogen enhances the uptake of other nutrients including nitrogen content in the crop which in turn increases the protein content of grasspea.

The nitrogen is applied to grasspea as basal to support its initial growth. It is thought that nodulation may support crop for its nitrogen requirement in the whole life cycle. Still there is question whether the reproductive stage is optionally supported with adequate nitrogen for its maximum flowering and pod setting. Scientists opined that in this stage plant partitioned its dry matter towards reproductive units rather than nourishing bacteria, thus nitrogen fixation in plant becomes lower which is not adequate for proper flowering and pod setting. In this connection nitrogen used as basal will not be available to the plant during this important stage. Subsequently the yield becomes limited in pulse crop. Understanding this situation, the spilt application of nitrogen could be an important management option to overcome this deficiency which did not get attention in our country. Hence this experiment was undertaken with following objectives –

a) to study the varietal performance of grasspea;
b) to ascertain the nitrogen requirement of plant responding towards splitting nitrogen dose.
c) to study the responsive variety towards nitrogen application for its greater growth, development and yield.

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

In this chapter, relevant literatures from home and abroad have been reviewed to gather knowledge on different varieties and managements of nitrogen fertilizer in pulse crops under the following heads.

1. Effect of variety/genotype on growth and yield
2. Effect of nitrogen application on growth and yield.

Effect of variety/genotype on growth and yield

Purushotham *et al.* (2001) studied different cultivars UPC-921, UPC-952, UPC-953, IFC-9502, IFC-9503, UPC-5286 and Bund lobia (control), and found the highest mean dry matter in IFC-9503 (18.1 q/ha).

Kalpana (2000) reported that the cowpea genotypes belonging to different growth habit indicated that the determinate genotypes had higher values of photosynthetic rate, transpiration rate, stomatal conductance, as compared to the indeterminate genotypes. The genotypes KM-5 and KM-4 among the determinate and C-44 and C-22 among indeterminate had higher seed yield and also recorded higher values for photosynthetic rate and transpiration rate.

Gracy *et al.* (1998) in Kerala reported that Cv. GC-3 and GC-8968 of cowpea were high yielding, short duration cultivars and are suitable for summer rice fallows.

Jadhav *et al.* (1995) found that cowpea genotype V-240 was found to be superior in terms of plant height, number of branches plant^{-1}, pod number and plant dry weight over PS-16 cowpea genotype.

At Port Blair, India, Ram *et al.* (1994) evaluated twenty-seven *Vigna unguiculata* varieties during 1985 and 1986. Highest seed yields were recorded for Cov Y2 (1.16 t/ha), RC-48 (1.25 t/ha), and C-152 (1.2 t/ha).

Birari *et al.* (1993) at Dapoli, India observed that among seven promising genotypes of cowpea, the high yielding genotypes were V-16 (9.39 g/plant) and ACCC-210 (8.17 g/plant). ACCC-210 showed a high degree of predictability for pods per plant, pod length, 100-grain weight and harvest index and was rated as the most stable genotype.

Wien and Ackah (1978) compared different cowpea genotypes for variation in pod development period and its influence on seed weight and seed number per pod. The study indicated that genotypes with more pod development period having higher seed growth would be desirable character for maintaining higher yield.

Effect of Nitrogen application on growth and yield

Amanullah (2004) conducted an experiment during 2000-01 in Peshawar, Pakistan to investigate the effect of various levels of N (0 and 20 kg ha^{-1} and P (0, 30, 60 and 90 kg ha^{-1}) on the growth and yield components of lentil cultivars Masur-85, Masur-93 and Manshera-89 under rainfed conditions. P application had significantly affected the number of pods $plant^{-1}$, 1000-seed weight and dry matter yield. Lower number of pods $plant^{-1}$ (81), seeds pod^{-1} (1.5), 1000-seed weight (14.2 g) and grain yield (550 kg ha^{-1}) were recorded without P application. P applied at 60 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$ (84), number of seeds pod^{-1} (1.6), 1000-seed weight (14.8 g), dry matter yield (2875 kg ha^{-1}) and grain yield (595 kg ha^{-1}) but had no significant effect on nodule numbers.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM - 98 to seed inoculation and different levels of fertilizer (0 - 0, 15 - 30, 30 - 60 and 45 - 90 kg N- P_2O_5 ha^{-1}) under field condition. Application of fertilizer significantly increased the seed yield and the maximum seed yield was obtained when 30 kg N ha^{-1} was applied.

Islam (2003) found that the number of branches per plant in bushbean significantly increased with increasing N levels from 0 to 36.8 kg ha^{-1}. The highest number of branches per plant was obtained at 36.8 kg N ha^{-1} and the lowest at 0 kg N ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P_2O_5 ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}) and harvest index (41.88%). They also observed that number of flowers $plant^{-1}$ was found to be significantly higher by varying levels of nitrogen and phosphorus and pod length was significantly affected by both nitrogen and phosphorus application.

Mozumder *et al.* (2003) conducted an experiment to study the effect of *Rhizobium* at different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on BINA moog-2. It was reported that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1}. The highest seed yield (1607 kg ha^{-1}) was obtained when 40 kg N ha^{-1} was applied with *Bradyrhizobium* inoculation and also observed that nitrogen application had negative effect on the harvest index. They also observed that applied N up to a certain level increased the seed yield of mungbean.

Rajender *et al.* (2003) investigated the effects of N (10, 20, 40, and 50 kg ha^{-1}) and P_2O_5 (20, 40, 60 and 80 kg ha^{-1}) fertilizer rates on lentil. Grain yield increased with increasing N rates up to 40 kg ha^{-1}. Further increase in N did not affect yield.

Rajender *et al.* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N rate did not affect yield.

Islam (2002) reported that N deficient lentil plants were shorter and bore less branches $plant^{-1}$ than the plants grown with applied N. The tallest plant and higher number of branches $plant^{-1}$ was obtained by 30 kg N ha^{-1}.

Islam (2002) reported that N fertilizer influenced proportionally the dry matter of lentil. Irrespective of N levels DM increased progressively till 90 DAE. The rate of dry matter production of lentil was higher during 50 to 70 DAE.

Mandal (2002) found that in lentil application of N fertilizer significantly increased seeds per pod. The crop treated with 30 kg N per ha gave the highest seed yield (1.7 t ha^{-1}) which was 150% higher than those in control plot.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different NPK level on the yield and yield components of lentil at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They reported that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1} application.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and phosphorus (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield of mungbean. They observed that the number of pods $plant^{-1}$ was increased with the increasing rates of N up to 40 $kgha^{-1}$ followed by a decrease with further increase in N. Pod length was increased with the increasing rates of N up to 40 kg ha^{-1}. 1000 seed weight was generally increased with increasing rates of P along with increasing rates of N up to 40 kg ha^{-1} which was followed by a decrease with further increase in N.

Yakadri *et al.* (2002) studied the effect of nitrogen (20, 40 and 60 kg ha^{-1}) and phosphorus (40 and 60 kg ha^{-1}) on crop growth and yield of greengram (cv.ML-267). Application of nitrogen at 20 kg $ha^{-1}$and phosphorus at 60 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

Patel *et al.* (2001) carried out a field experiment to examine different levels of nitrogen on mungbean and reported that the highest nodules per plant was obtained with 10 kg N ha^{-1} compared to 20 and 30 kg N ha^{-1} and highest yield was obtained with 30 kg N ha^{-1}.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers' practices (no fertilizer) or using different combinations of fertilizer application (10 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 t ha^{-1} with farmers' practices, while the highest yield was obtained by the fertilizer application (0.77 t ha^{-1}).

Patel and Patel (1999) found that 20 kg N + 40 kg P_2O_5 ha^{-1} gave the highest seed yield (1.74t ha^{-1}) which was not significantly different from foliar application of urea (1.5%) + DAP (0.5%) at 30 and 40 days after sowing (1.67 t ha^{-1}).

Mandal and Sikder (1999) conducted a greenhouse pot experiment on mungbean cv. BARI mung-5 under different N rates. They noted that the yield increased significantly with N application.

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on lentil. They reported that lentil seed production was higher with the application of 35 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Ashtana (1998) suggested a starter dose of 20kg N ha^{-1} along with 50kg P_2O_5 ha^{-1} as basal for optimum plant height for lentil.

Nandan and Prasad (1998) found a linear increase in seed yield and pods per plant due to increase in N level from 10 to 30 kg ha^{-1} in lentil.

Khanam *et al.* (1996) reported that the use of recommended dose of NPK plus compost increased the seed yield of mungbean by 83 - 87%.

Bhalu *et al.* (1995) found that a starter dose of 15-20 kg N ha^{-1} applied at the time of sowing resulted with better initial growth & development of blackgram. A positive response to increasing level of N up to 40 kg ha^{-1} was observed at Ropar and Patiala districts in Punjab, India.

Kaneria and Patel (1995) conducted a field experiment on Vertisol soil in Gujarat, India with lentil using 0 or 40 kg N ha^{-1}. They found that application of 40 kg N ha^{-1} significantly increased the seed yield (1.7 t ha^{-1}) when compared with that of control (1.08 t ha^{-1}).

Yadav *et al.* (1994) conducted a field experiment on sandy loam soil during the kharif (monsoon) season of 1986 at Hisar, Hariana, India, with mungbean cv. k 851. Treatments 0, 50 or 100% of the recommended N and P fertilizers (20 kg N as Urea and 40 kg P_2O_5 ha^{-1} as single super phosphate) were tested. They found that mungbean crop receiving the recommended dose gave the highest seed yield.

In a field experiment on clay soil during kharif season of 1990, Badole and Umale (1994) observed that the seed yield of mungbean cv. TAP was increased by N and P_2O_5 application. Application of 50% of the recommended N and P rate gave the highest yield of 1.17 t ha^{1}.

Bachchhav *et al.* (1994) conducted a field experiment on a clay soil during the summer season with mungbean (*Vigna radiata*) cv. Phule-M. They observed that root nodule weight per plant was highest with 30 kg N ha^{-1}. They also observed that among nitrogen fertilizers rates (0-45 kg ha^{1}) seed yield increased up to 30 kg N (1.65 ton ha^{-1}).

Quah and Jafar (1994) found that plant height of lentil was significantly increased by the application of N fertilizer at 50 kg ha^{-1}. They also noted that 100 seed weight of lentil was increased significantly due to the application of N at 40 kg ha^{-1}.

Santos *et al.* (1993) carried out an experiment on mungbean cv. Berken which was grown in pots in podzolic soil with 7 levels of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1}). They noted that application of N up to 200 kg ha^{-1} increased the total dry matter and with use of higher rates decreased, the total dry matter decreased.

Ardeshana *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen, phosphorus and *Rhizobium* inoculation. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 and inoculation with *Rhizobium.*

Kumar *et al.* (1993) have described the effect of P and N on growth and grain yield of lentil. They found that all the growth attributes were significantly increased by 20 kg N and 50 kg P_2O_5. Yield, yield attributes and quality of lentil also exhibited the same trend, although N application did not significantly increased seed yield.

Phimsirkul (1992) conducted a field trial on mungbean variety, U-Thong I grown in different soils under varying N levels. There was no effect of N fertilizer when mungbean was grown in Mab Bon soil. However, seed yield of mungbean was increased when the crop received N at 3 kg ha^{-1}.

Chowdhury and Rosario (1992) studied the effect of N levels (0,30,60 or 90 kg ha^{-1}) on the rate of growth and yield performance of lentil at Los Banos, Philippines in 1988. They observed that N above the rate of 40 kg N ha^{-1} reduced the dry matter yield, the nodule dry weight and the seed yield consequently.

Tank *et al* (1992) reported that lentil fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods plant^{-1}.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods plant^{-1} and seed yield over the unfertilized control.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilizaton under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P_2O_5 ha^{-1} or triple these rates and 0, 10, 20 or 30 kg sulphurha^{-1}as gypsum. Seed yield was 1.20 and 1.24 t ha^{-1} in Gujrarat 2 and K 851, respectively and was increased with the increase in fertilizer rate up to 20 kg N + 40 kg P_2O_5 ha^{-1}.

Agbenin *et al.* (1991) carried out an experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean. In another study, Leelavati *et al.* (1991) using different levels of nitrogen found a significant increase in dry matter production in mungbean with 60 kg N ha^{-1}.

Sarkar and Banik (1991) reported that application of 40 kg N ha^{-1} to lentil resulted in appreciable improvement in the number of pods plants^{-1} while compared with no N.

Sarkar and Banik (1991) made a field experiment to study the response of green gram to nitrogen, phosphorous and molybdenum. They reported that application of N and P improved plant productivity and enhanced the grain yield of green gram significantly. Growth parameters were recorded as better response for increased productivity. They also reported that response to N and P_2O_5 was recorded up to 45 and 60 kg ha^{-1} respectively for better yield.

Suhartatik (1991) observed that N, P and K fertilizers in combination significantly increased the number of leaves, pods plant^{-1},1000 seed weight and seed yield.

Bali *et al*. (1991) conducted a field trial in kharif season on silty clay loam soil. They observed that seed yield, 1000-seed weight and LAI of mungbean were increased with up to 40 kg N and 60 kg P_2O_5ha^{-1}.

Suhartatik (1991) in a study observed the application of 30 kg N ha^{-1} fertilizers significantly increased the plant height of lentil.

Azad and Gill (1989) set up a experiment where lentils cv.L9-12 were given 0 to 40 kg P_2O_5 ha^{-1} + 12.5 kg N ha^{-1} or soils low in available P and organic matter in Rabi (winter) season and found that seed yield increased with increasing P rate from 285 kg ha^{-1}(without applied P) to 758 kg ha^{-1}(with 40 kg P_2O_5). They got the greatest response of P in soil with lowest available P contents.

Kramer (1988) showed that *Rhizobium* inoculation along with the addition of 20 kg N ha^{-1} gave the maximum yield of lentil under both loamy sand and sandy loam soil.

Lopes *et al.* (1988) found that the application of 40 kg N/ha produced 96.7% of estimated maximum yield. They conducted field studies to determine the response of lentil to N fertilized at different levels (0, 20, 40, and 60 kg ha^{-1}) where N increased the seed yield.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiata* L.). He found that the plant height, 1000 seed weight and yield of mungbean cv. Mubarik increased by nitrogen at 40 kg ha^{-1}.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with P_2O_5 (50 kg ha^{-1}) increased mungbean yield. Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season showed that the application of N with P and K at 20 :2 :5 kg ha^{-1} gave higher seed yield.

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India. In that trial, they observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted with significant increase in plant height, number of pods $plant^{-1}$, 1000 seed weight and seed yield of lentil.

Salimullah *et al.* (1987) also reported that the number of pods $plant^{-1}$ was highest with the application of 10 kg N along with 75 kg P_2O_5 $ha^{-1}$and 60 kg K_2O ha^{-1} in summer mungbean.

Sardana and Varma (1987) carried out a study in New Delhi, India in 1983-84. They found that application of N. phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of lentil.
Inthong (1987) observed that the application of 15 kg N ha^{-1} to mungbean increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it. In another experiment he reported that application of 15 kg N ha^{-1} was found to be superior giving 23 % higher seed yield over the control. However, although not significantly, 60 kg N ha^{-1} tended to produce the highest yield.

Sardana and Varma (1987) stated that application of N, P and K fertilizers resulted in significant increased in 1000 seed weight of lentil.

Patel and Parmer (1986) conducted an experiment on the response of greengram to varying levels of nitrogen and phosphorus. They observed that increasing N application (30 to 45 kg ha^{-1}) with phosphorus (60 to 75 kg ha^{-1} to rainfed mungbean (cv. Gujrat-1) increased the number of branches $plant^{-1}$, pods $plant^{-1}$ and seed yield.

Saxena and Varma (1985) carried out a field experiment on lentil in Assam, India and reported that combined application of N and phosphorus significantly increased the dry weight of plants.

In trials, on clay soils during the summer season, Patel *et al.* (1984) studied the effect of N (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. In these experiments, it was found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant and seed yield. They also observed that application of 40 kg P_20_5 ha^{-1} along with 20 kg N ha^{-1}significantly increased the 1000 seed weight of mungbean.

Raju and Varma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusa Baishaki to varying levels of nitrogen (15, 30, 45 and 60 kg ha^{-1}) in the absence and presence of seed inoculation with *Rhizobium.* They found that maximum dry matter weight $plant^{-1}$ was obtained by the application of 15 kg N ha^{-1} inoculated with *Rhizobium*. They also reported that seed inoculation and/or application of 15 - 60 kg N ha^{-1} significantly increased seed yields of mungbean.

An experiment was conducted by Trung and Yoshida (1983) using 0 -100 ppm N as treatments in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that maximum plant height at all the stages of plant were obtained by the application of 25 ppm N; 1000 seed weight was the highest with 100 ppm N in all forms and seed yield of mungbean increased with the increase in N up to 50 ppm.

Yein (1982) conducted field tried on lentil in Assam, India and found that 40 kg N ha^{-1} in combination with 20kg P_2O_5 ha^{-1} resulted in significant increase in the seed yield.

Srivastava and Varma (1982) showed that N application at the rate of 15 kg ha^{-1} increased the number of green leaves in mungbean plants.

In an experiment, Yein *et al.* (1981) applied N and phosphorus fertilizer to lentil and reported that combined application of N and phosphorus fertilizers increased the number of pods $plant^{-1}$. The rate of N and phosphorus was 40 kg and 75 kg per hectare, respectively.

Yein *et al.* (1981) conducted a field experiment on N in combination with phosphorus fertilizer in lentil. They reported that application of 40 kg N ha^{-1} increased the plant height.

In a field experiment, Yein *et al.* (1981) applied nitrogen in combination with phosphorus fertilizer to mungbean. They observed that application of N fertilizer along with P increased plant height, dry weight $plant^{-1}$, number of pods $plant^{-1}$ and grain yield.

Yein *et al.* (1981) conducted a field trial in Assam, India, and applied N and P fertilizers to study their relative contributions towards increasing the seed yield of mungbean. Their studies showed that N along with P fertilizers increased the seed yield. They observed that 10 kg N in combination with 20 kg P_2O_5 ha^{-1} resulted in significant increases in the seed yield.

Clark *et al.* (1980) observed dry matter accumulation with increase in levels of N at all growth stages. The split application of N fertilizer increased the rate of photosynthetic accumulation, leaf dry weight; stem dry weight which finally resulted in increased DM production by plant at each stage of growth of lentil.

Panda (1979) observed that the application of N and P fertilizer @ 0 to 90 kg P_2O_5 ha^{-1} increased grain yield, hay, plant height, number of branches $plant^{-1}$.

Dutt (1979) found that split application of 40 kg N ha^{-1} increased the number of leaves of pulse.

Werakonphanit *et al.* (1979) stated that mungbean showed no significant difference in response of different fertilizer levels. NPK levels of 0 - 0 - 0, 3 - 0 - 0 and 3 - 9 - 0 gave seed yield of 156, 168 and 175 kg ha^{-1} respectively. From the results of that study, it was concluded that the fertilizer application in mungbean was not necessary.

Cardaso *et al.* (1978) reported that lentil production showed positive linear response to N level; the highest average yield (1890 kg ha^{-1}) was obtained from the plots receiving 40 kg N ha^{-1}.

It was noted that, no literature was found regarding the split application of nitrogen in pulse crop. So the application of different rates of N, P, K have been reviewed here.

After reviewing all this information in this section, it was pointed out that improved variety of crops gave maximum seed yield. On the other hand, N management is an important option to increase the yield of different crops.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter has been written on different resources, cultural managements, data collection and statistical analysis required in this experiment. The experiment was conducted during the period from November to March 2011 to study the response of grasspea varieties to different nitrogen managements. The details of materials and methods of this experiment are presented under the following headings:

3.1. Experimental site

The present research work was conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. The experimental area is located at 23.41˚ N and 90.22˚ E latitude and at an altitude of 8.6 m from the sea level. The land was medium high and well drained.

3.2. 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 initiation of the experiment.

3.3. Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon 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).

3.4. Planting materials

Three varieties of grasspea (BARI khesari-1, BARI khesari-2 and Local khesari) were used as experimental materials for the study. BARI Khesari-1 and BARI Khesari-2 were released by Bangladesh Agricultural Research Institute (BARI). The HYV seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur-1701 and the local one from Bangladesh Agricultural Development Corporation (BADC).

3.5. Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 5/6 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed and deep ploughing was done to obtain good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the soil clods into small pieces. All the weeds and stubbles were removed from the experimental field. The plots were spaded one day before planting and the whole amount of other fertilizers except urea were incorporated thoroughly before planting according to fertilizers recommendation guide (BARC, 1997). Nitrogen was applied as per treatments.

3.6. Fertilizers

The applied fertilizers were mixed properly with soil in the plot using a spade.

Manure and fertilizer	**Dose (kg ha^{-1})**
Urea	40
TSP	85
MoP	35
Gypsum	45

Source: ***BARC, 1997 (Fertilizer Recommendation Guide)***

3.7. Treatments of the experiment

The experiment consisted of two treatment factors as follows:

Factor A: Variety-3

V_1= BARI khesari-1

V_2= BARI khesari-2

V_3= Local khesari (Jamalpur)

Factor B: N management-6

N_0= Control (No fertilizer)

N_1=Basal application with 20 kg N ha^{-1}

N_2=Basal application with 40 kg N ha^{-1}

N_3=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage

N_4=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage

N_5=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

3.8. Experimental design and layout

The two factors experiment was laid out in factorial Randomized Complete Block Design (RCBD) with three replications. Each block was divided into 18 plots where 18 treatment combinations were allotted at random. The unit plot size was 4m ×2.5 m. The space between two blocks and two plots were 1.5 m and 0.50 m, respectively.

3.9. Sowing of seeds in the field

Seeds were sown on 19 November 2011. Row to row and plant to plant distances were 30 cm and 10 cm, respectively. Seeds were placed at about 2-3cm depth from the soil surface.

3.10. Intercultural operations

3.10.1. Thinning

Emergence of seedling was completed within 10 days after sowing. Over crowded seedlings were thinned out two times. First thinning was done after 15 days of sowing which is done to remove unhealthy seedlings. The second thinning was done 10 days after first thinning.

3.10.2. Weeding

First weeding was done at 20 DAS and then second weeding at 40 DAS.

3.10.3. Irrigation

The irrigation was done as per necessary. Water application was continued till soil saturation.

3.10.4. Disease and pest management

The research field looked nice with normal green plants. The field was observed time to time to detect visual difference among the treatments and any kind of infestation. The experimental crop was not infected with any pest.

3.11. Harvesting and threshing

Harvesting of the crop was done after 120 days of sowing for data collection when about 80% of the pods attained maturity. The morphological, growth and yield attributes for crop sampling was done at harvest stages. Data were recorded on three times the area of the middle portion of each plot for average results. The harvested plants of each treatment were brought to the cleaned threshing floor and separated the pods from plants by hand and allowed them for drying well under bright sunlight.

3.12. Crop sampling and data collection

The data of the different parameters of grasspea were collected from randomly selected ten plant samples of each four excluding the border lines. The sample plants were uprooted carefully from the soil. Plant height, branches plant^{-1}, above ground dry weight, nodules plant^{-1} and nodule dry weight plant^{-1} were recorded from selected plants at an interval of 20 days starting from 20 DAS upto harvest. Yield and yield contributing parameters were recorded from the plants collected from the central part of the plots. A brief outline of the data recording on morpho-physiological and yield contributing characters are given below.

3.12.1. Plant height (cm)

Plant height was measured in centimeter by a meter scale from the ground surface to the top of the main shoot and the mean height was expressed in cm.

3.12.2. Branches plant^{-1} (no.)

Number of branches per plant was counted from selected plants. The average number of branches per plant was determined.

3.12.3. Total dry weight plant^{-1}(g)

The plant dry matter was taken by oven dry method. Collected plants including roots, stem and leaves were oven dried at 70˚ C for 72 hours, then transferred into desiccator and allowed to cool down to the room temperature and final weight was taken and converted into total dry matter per plant.

3.12.4. Nodules plant^{-1} (no.)

Nodules were collected from selected plants. The nodules per plant were calculated from their mean values.

3.12.5. Nodule dry weight plant^{-1} (g)

Counted nodules were dried in an oven and the nodule dry weight plant^{-1}were measured.

3.12.6. Pods plant^{-1} (no.)

The pods from the branches of the selected ten plants were counted and the number of pods per plant was calculated from their mean values.

3.12.7. Seeds pod^{-1} (no.)

Number of seeds per pod was recorded from the towenty selected pods at the time of harvest. The seed per pod was calculated from their mean values.

3.12.8. 1000-seeds weight (g)

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

3.13.9. Seed yield and Stover yield (t ha^{-1})

The seed weight was taken from the selected plants threshed properly and then the yield was expressed in ton per hectare. Stover weight was taken without seed and converted to ton per hectare.

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

The summation of economic yield (grain yield) and biomass yield (stover yield) was considered as biological yield. Biological yield was calculated by using the following formula:

Biological yield= Grain yield + stover yield (dry weight basis)

3.13.11. Harvest index

It is the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

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

3.14. Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program by Randomized Complete Block Design (RCBD) (Russel, 1986). The mean values for all the parameters were Duncan's Multiple Range Test (DMRT) at 5% levels of probability (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to study the response of grasspea varieties to different nitrogen managements. Data on different yield contributing characters and yield were recorded. The data on different parameters are presented in Appendix I to XI and Table 1 to 6. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1. Plant height

Effect of variety

Plant height varied significantly at 20, 40, 60, 80 DAS and at harvest for BARI khesari-1, BARI khesari-2 and Local variety (Appendix I (a), I (b), I (c), I (d) & I (e) and Figure 1). The tallest plants (11.18 cm, 22.49 cm, 38.31 cm, 54.30 cm and 58.31 cm, respectively) were recorded from V_2 (BARI khesari-2) and the shortest plant heights (10.41 cm, 21.35 cm, 35.82 cm, 49.66 cm and 53.67 cm, respectively) from V_3 (Local Variety) at different DAS & at harvest. The plant height depends on their varietal characters. This character is governed by genetic factors. Similar sort of results were observed by many scientists while doing experiments on different crops.

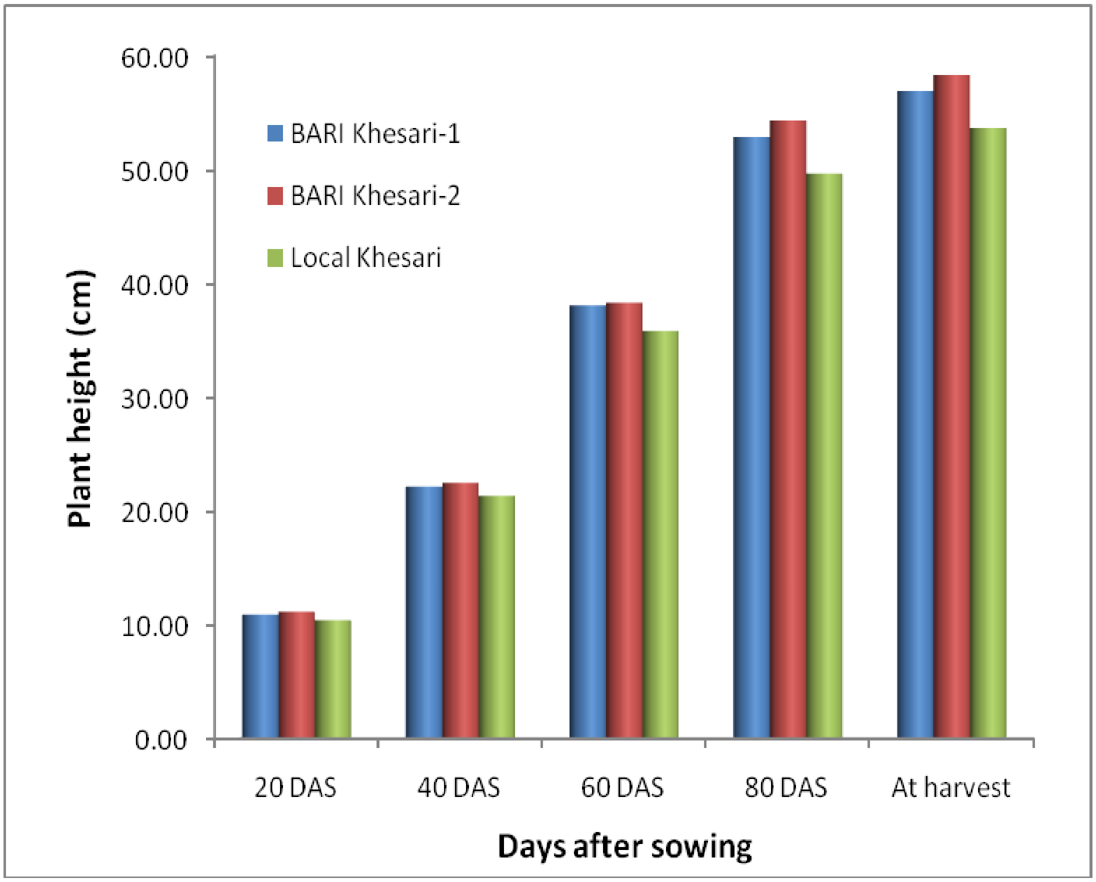


Figure 1: Effect of variety on plant height of grasspea (SE=0.2984, 0.3642, 0.3022, 0.6753 and 0.6753 at 20, 40, 60, 80 DAS and at harvest, respectively)

Effect of nitrogen management

Different nitrogen management showed significant differences on plant height at 20, 40, 60, 80 DAS and at harvest (Appendix I (a), I (b), I (c), I (d) & I (e) and Figure 2). The tallest plants (12.15 cm, 25.19 cm, 40.46 cm, 54.53 cm and 58.54 cm, respectively) were observed from N_2 (Basal application with 40 kg N ha^{-1}), which was similar to N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) at 80, 100 DAS and at harvest. The shortest plants (9.40 cm, 20.37 cm, 33.85 cm, 46.76 cm and 50.77 cm, respectively) were observed from N_0 (No fertilizer). It is revealed from the results that initial higher dose is better for initial growth of grasspea. Yein *et al*. (1981) reported that application of 40 kg N ha^{-1} increased plant height to lentil. Bhalu *et al* (1995) found that a starter dose of 15-20 kg N ha^{-1} applied at the time of sowing result in better initial growth & development of blackgram. Suhartatik (1991) in a study observed the application of 30 kg N ha^{-1} fertilizers significantly increased that plant height of mungbean.

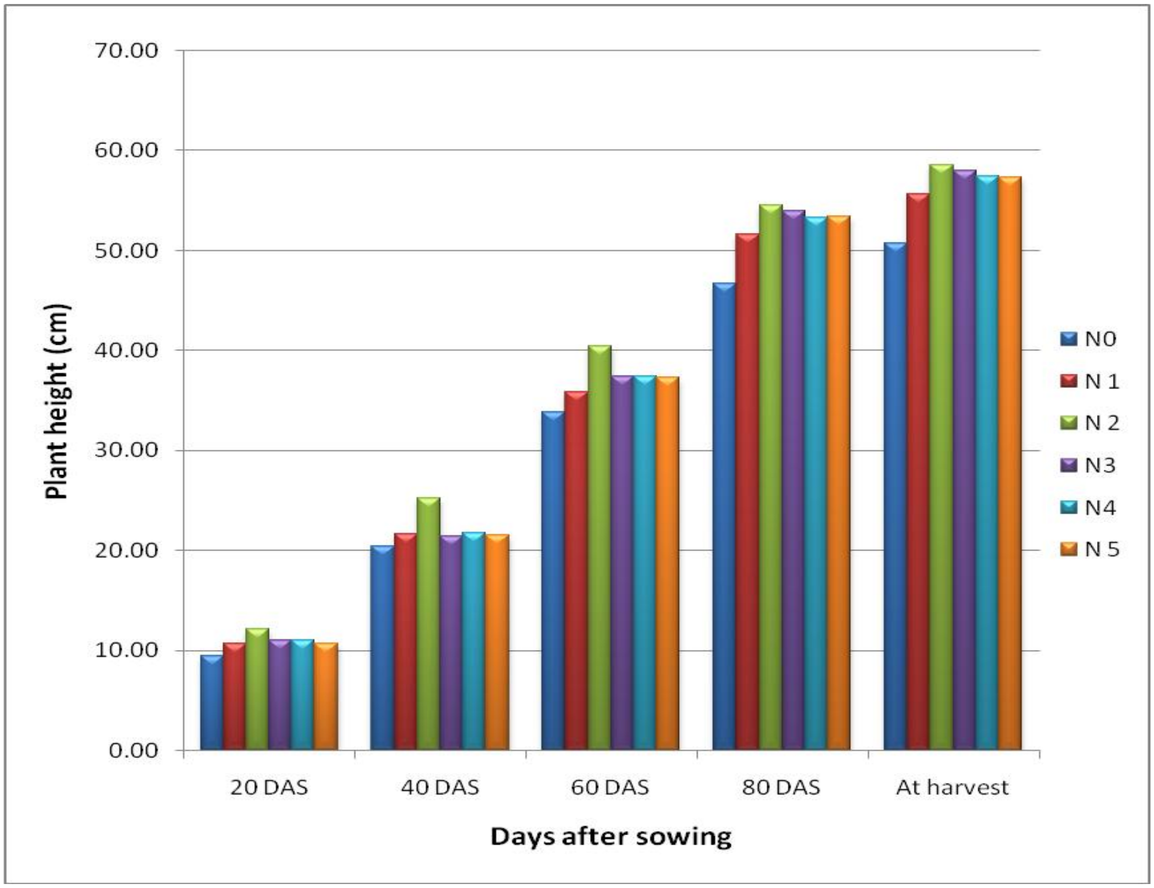


Figure 2: Effect of different nitrogen management on plant height of grasspea (SE=0.2998, 0.3658, 0.3037, 0.6807and 0.6785 at 20, 40, 60, 80 DAS and at harvest, respectively)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of grasspea variety and nitrogen managements showed significant differences on plant height at 20, 40, 60, 80 DAS and at harvest (Table 1).

At 20 DAS, maximum plant height (12.75 cm) was noted from V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) and it was statistically similar with V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) (12.37 cm). On the other hand, the lowest plant height (9.30 cm) was recorded in V_3N_0 (Local variety + No fertilizer) which was statistically similar with V_2N_0 (BARI khesari-2 + No fertilizer) (9.59 cm) and V_1N_0 (BARI khesari-1 + No fertilizer) (9.32 cm).

At 40 DAS, the highest plant height (26.06 cm) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was followed by V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (25.23 cm). On the other hand, the lowest plant height (20.09 cm) was recorded in V_1N_0 (BARI khesari-1 + No fertilizer) which was followed by V_3N_0 (Local variety + No fertilizer) (20.21 cm).

At 60 DAS, highest plant height (42.09 cm) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was at par with V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (41.17 cm). On the other hand, the lowest plant height (32.05 cm) was recorded in V_3N_0 (Local variety + No fertilizer).

At 80 DAS, highest plant height (56.21 cm) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) which was statistically similar to V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (56.20 cm) and V_2N_4 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (55.53 cm). On the other hand, the lowest plant height (49.74 cm) was recorded in V_3N_0(Local variety + No fertilizer) which was statistically similar to V_2N_0 (BARI khesari-2 + No fertilizer) (50.11 cm) and V_3N_4 (Local variety + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (50.50 cm).

At harvest, the highest plant height (60.22 cm) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) which was statistically similar to V_2N_3 (BARI khesari-3 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (60.21 cm). On the other hand, the lowest plant height (47.35 cm) was recorded in V_3N_0 (Local variety + No fertilizer).

Table 1: Interaction effect of variety and nitrogen management on plant height of grasspea

Treatments	**Plant Height**				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
V_1N_0	9.32 f	20.09 g	34.85 f	46.82 i	50.83 i
V_1N_1	10.33 e	21.89 d	38.31 d	52.18 e-g	56.19 e-g
V_1N_2	12.75 a	25.23 b	41.17 b	54.99 a-c	59.01 a-c
V_1N_3	11.21 bc	21.92 d	37.99 d	54.86 a-c	58.87 a-c
V_1N_4	11.00 bc	22.05 d	37.99 d	54.04 cd	58.05 cd
V_1N_5	10.80 b-e	21.86 d	37.99 d	54.48 b-d	58.49 b-d
V_2N_0	9.59 f	20.81 e-g	34.65 f	50.11 h	54.12 h
V_2N_1	11.28 bc	22.10 d	38.93 c	53.10 de	57.11 de
V_2N_2	12.37 a	26.06 a	42.09 a	56.21 a	60.22 a
V_2N_3	11.24 bc	21.94 d	38.13 d	56.20 a	60.21 a
V_2N_4	11.44 b	22.18 d	38.07 d	55.53 a	59.54 ab
V_2N_5	11.17 bc	21.87 d	37.97 d	54.67 bc	58.68bc
V_3N_0	9.30 f	20.21 fg	32.05 g	49.74 h	47.35 j
V_3N_1	10.44 de	20.98 ef	35.96 e	51.08 f-h	53.75 h
V_3N_2	11.32 bc	24.29 c	38.11 d	52.39 ef	56.40 ef
V_3N_3	10.69 c-e	20.55 e-g	36.22 e	50.91 gh	54.92 gh
V_3N_4	10.51 de	21.04 e	36.28 e	50.50 h	54.51 h
V_3N_5	10.20 f	21.02 e	36.30 e	51.08 f-h	55.09 f-h
CV %	11.70	6.24	10.50	7.80	5.67
SE	0.1060	0.1579	0.1088	0.5431	0.5431
Significance level	**	**	**	**	*

**** - Significant at 1% level**

*** - Significant at 5% level**

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

4.2 Branches plant^{-1}

Effect of variety

Significant variation was recorded for number of branches plant^{-1}at 40, 60, 80 DAS and at harvest for BARI khesari-1, BARI khesari-2 and Local variety under the present trial (Appendix II (a), II (b), II (c), II (d)& Figure 3). The maximum number of branches plant^{-1}(5.86, 11.34, 19.44 and 24.69, respectively) was found from V_2 (BARI khesari-2) and it was followed byV_1 (BARI khesari-1) (5.36, 10.97, 18.55 and 23.77, respectively). The minimum number of branches plant^{-1} (5.01, 9.70, 16.54 and 21.78, respectively) was recorded from V_3 (Local variety). The variety produced different number of branches plant^{-1} on the basis of their varietal characters and that was governed by genetical factor. Jadhav *et al.* (1995) found that cowpea genotype V-240 was found to be superior in terms of number of branches plant^{-1} over PS-16 cowpea genotype.

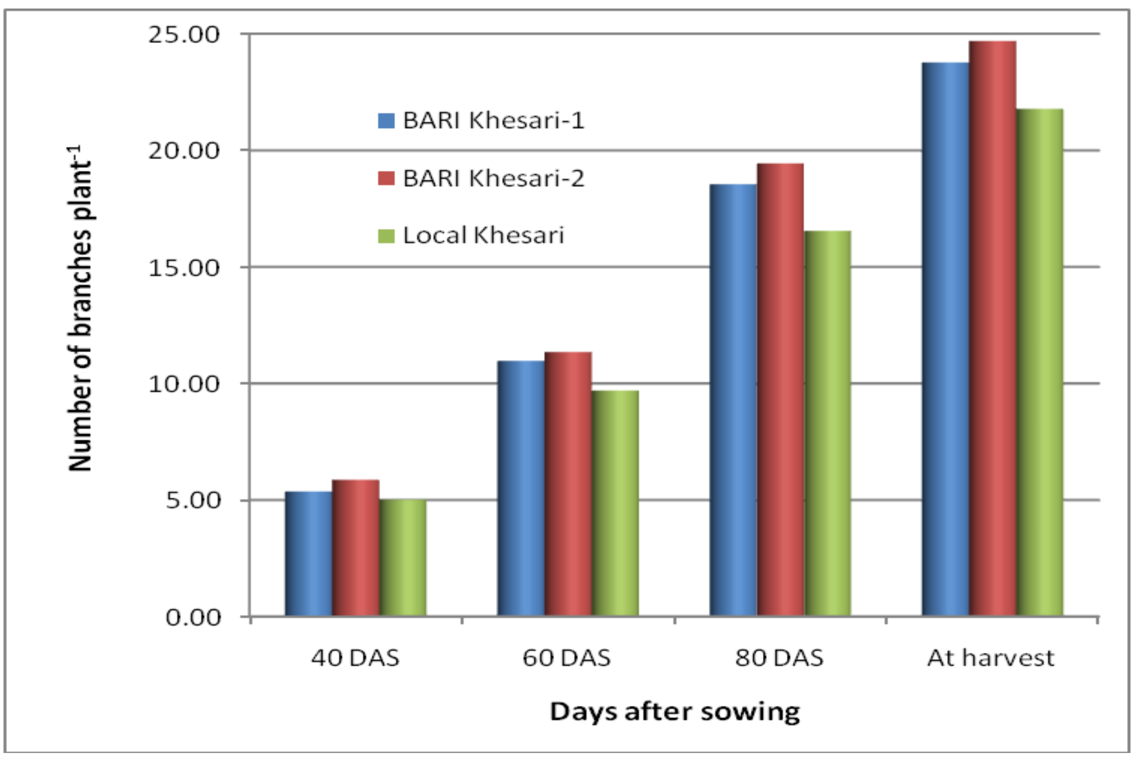


Figure 3: Effect of variety on number of branches plant^{-1} of grasspea (SE = 0.2554, 0.2998, 0.3707 and 0.3718 at 40, 60, 80 DAS and at harvest, respectively)

Effect of nitrogen management

Number of branches plant^{-1} showed significant variation for different nitrogen management at 40, 60, 80 DAS and at harvest (Appendix II (a), II (b), II (c), II (d) and Figure 4). The maximum number of branches plant^{-1} at 40 DAS was recorded from N_2 (Basal application with 40 kg N ha^{-1}) (6.46) and it was followed by N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (5.58) and N_5 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation) (5.50). At 60 DAS, the maximum number of branches plant^{-1} was recorded from N_3 (12.06) and it was followed by N_2 (11.27). At 80 DAS, the maximum number of branches plant^{-1} was recorded from N_3 (19.98) and it was closely followed by N_4(Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (18.67) and N_2 (18.19). At harvest, the maximum number of branches plant^{-1} was recorded from N_3 (25.67) and it was at par with N_4 (23.88) and N_2 (23.48). On the other hand, for different nitrogen management at 40, 60, 80 DAS and at harvest the minimum number of branches plant^{-1} were recorded from N_0(No fertilizer) (4.13, 8.37, 16.39 and 21.40). Islam (2003) found the number of branches per plant in bush bean significantly increased with increasing N levels from 0 to 36.8 kg ha^{-1}. Dutt (1979) found that split application of 40 kg N ha^{-1} increased the number of leaves of pulse.

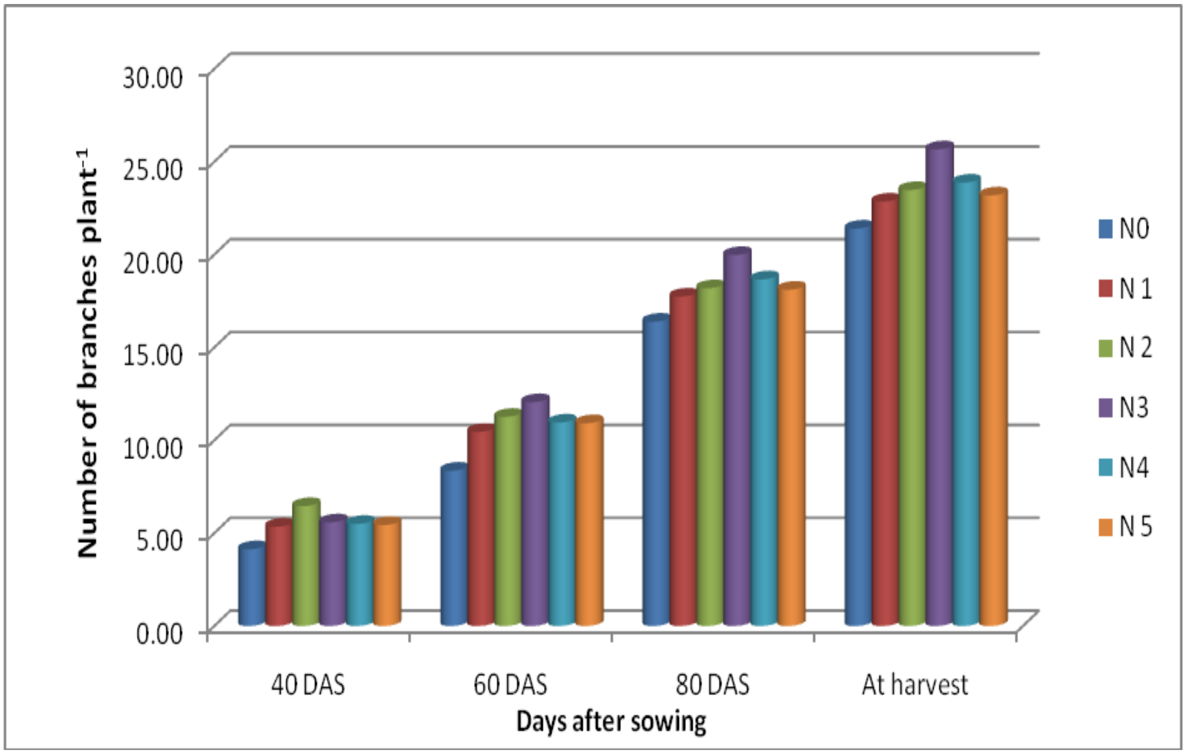


Figure 4: Effect of different nitrogen management on number of branches plant $^{-1}$ of grasspea (SE = 0.2568, 0.3015, 0.3723 and 0.3735 at 40, 60, 80 DAS and at harvest, respectively)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect on number of branches plant^{-1} at 40, 60, 80 DAS and at harvest was found significant (Table 2).

At 40 DAS, the highest branches plant^{-1} (7.33) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was at par with V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (6.17). On the other hand, the lowest branches plant^{-1} (4.00) was recorded in V_3N_0 (Local variety + No fertilizer) which was statistically similar with V_1N_0 (BARI khesari-1 + No fertilizer) (4.17) and V_2N_0 (BARI khesari-2 + No fertilizer) (4.23).

At 60 DAS, the highest branches plant^{-1} (12.70) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation)and it was followed byV_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (12.50). On the other hand, the lowest number of branches plant^{-1} (7.17) was recorded in V_3N_0 (Local variety + No fertilizer).

At 80 DAS, the highest branches plant^{-1} (21.30) was noted from V_2N_3 which was statistically similar with V_1N_3 (20.60). On the other hand, the lowest number of branches plant^{-1}(14.33) was recorded in V_3N_0.

At harvest, the highest branches plant^{-1} (27.00) was noted from V_2N_3 and it was statistically similar with V_1N_3 (26.30). On the other hand, the lowest branches plant^{-1}(19.33) was recorded in V_3N_0.

Table 2: Interaction effect of variety and nitrogen management on number of branches plant $^{-1}$ of grasspea

Treatments	Number of branches plant^{-1}			
	40 DAS	60 DAS	80 DAS	At harvest
V_1N_0	4.17 h	8.93 g	17.10 gh	22.10 h
V_1N_1	5.20 e-g	10.87 ef	18.23 ef	23.37 e-g
V_1N_2	6.17 b	11.47 c-e	18.30 ef	23.50 e-g
V_1N_3	5.60 c-e	12.50 ab	20.60 a	26.30 a
V_1N_4	5.63 b-f	10.97 de	18.90 de	24.10 c-e
V_1N_5	5.40 d-g	11.07 de	18.17 ef	23.23 fg
V_2N_0	4.23 h	9.00 g	17.73 fg	22.77 gh
V_2N_1	5.73 b-e	11.33 de	18.90de	23.97 c-f
V_2N_2	7.33 a	12.03 bc	19.37 cd	24.70 bc
V_2N_3	6.03 bc	12.70 a	21.30 a	27.00 a
V_2N_4	5.77 b-d	11.60 cd	20.10 bc	25.33 b
V_2N_5	6.07 bc	11.40 c-e	19.27 d	24.37 cd
V_3N_0	4.00 h	7.17 h	14.33 j	19.33 j
V_3N_1	5.10 fg	10.30 f	16.10 i	21.23 i
V_3N_2	5.03 g	10.30 f	16.90 h	22.23 h
V_3N_3	5.10 fg	10.97 de	18.03 f	23.70 d-f
V_3N_4	4.93 g	9.17 g	17.00 gh	22.20 h
V_3N_5	5.03 g	10.30 f	16.90 h	21.97 hj
CV %	6.49	5.74	8.56	5.22
SE	0.0777	0.1071	0.1635	0.1646
Significance level	**	**	*	**

**** - Significant at 1% level ,**

*** - Significant at 5% level**

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

4.3. Plant dry weight

Effect of variety

Plant dry weight showed non-significant variation at 20, 40DAS for BARI khesari-1, BARI khesari-2 and Local variety (Appendix III (a), III (b), III (c), III (d) and III (e) & Figure 5) though numerically higher values were shown by V_2 (BARI khesari-2) and lower values were found from V_3 (Local variety). At 60, 80 DAS and at harvest, BARI khesari-2 showed the significantly highest (4.35 g, 6.55 g and 8.29 g) plant dry weight, which was statistically similar with BARI khesari-1 (4.28 g, 6.54 g and 8.24 g). On the other hand Local variety showed the significantly lowest (3.93 g, 6.15 g and 6.92 g) plant dry weight at 60, 80DAS and at harvest. Plant dry weight of a variety depends on growing environment as well as on its genetic buildup. Jadhav *et al.* (1995) found that cowpea genotype V-240 was found to be superior in terms of plant dry weight over PS-16 cowpea genotype.

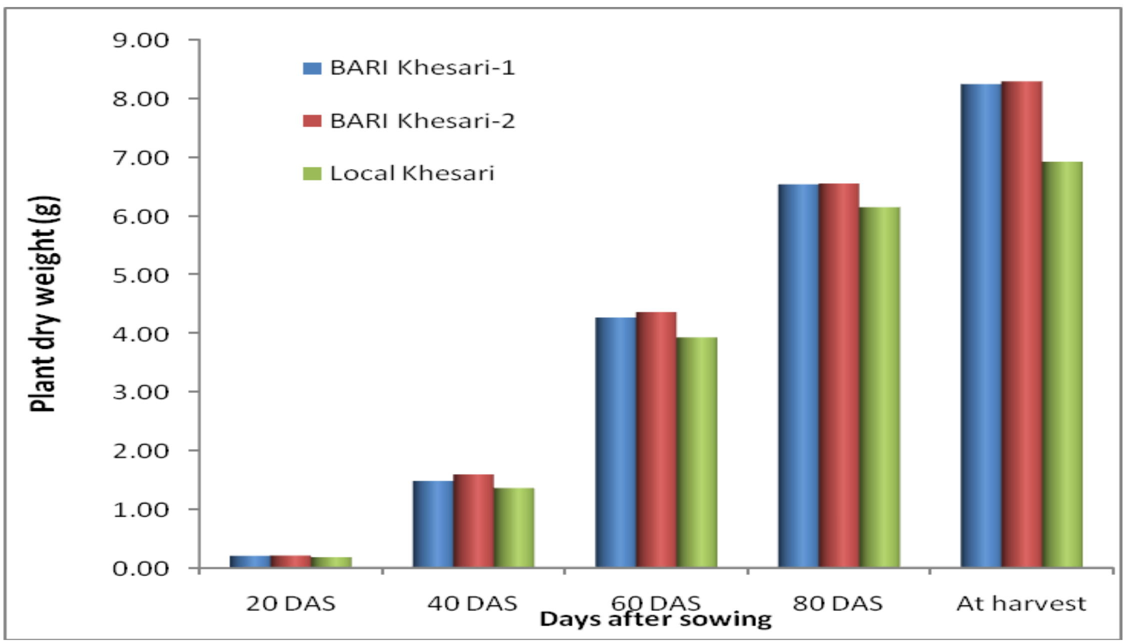


Figure 5: Effect of variety on plant dry weight of grasspea (SE = 0.08239, 0.2451, 0.2998, 0.3124 and 0.3645 at 20, 40, 60, 80 DAS and at harvest, respectively)

Effect of nitrogen management

Plant dry weight showed significant variation for different nitrogen management at 20, 40, 60, 80 DAS and at harvest (Appendix III (a), III (b), III (c), III (d) and III (e) & Figure 6). The highest plant dry weight at 20, 40 and 60 DAS was recorded from N_2 (Basal application with 40 kg N ha^{-1}) (0.263 g, 1.94 g and 5.32 g). At 80 DAS and at harvest, the maximum plant dry weight was recorded from N_2 (7.66 g and 9.48 g) and it was statistically similar with N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (7.57 g and 9.47 g). On the other hand, for different nitrogen management at 20, 40, 60, 80 DAS and at harvest the lowest plant dry weight were recorded from N_0 (No fertilizer) (0.149 g, 0.953 g, 3.096 g, 4.851 g and 5.626 g).Islam (2002) reported that N fertilizer influenced proportionally on the dry matter of lentil. Chowdhury and Rosario (1992) observed that N above the rate of 40 kg N ha^{-1} reduced the dry matter yield. Clark *et al.* (1980) observed dry matter accumulation with increase in levels of N at all growth stages. The split application of N fertilizer increased the rate of photosynthetic accumulation, leaf dry weight; stem dry weight which finally resulted in increased DM production by plant at each stage of growth of lentil.

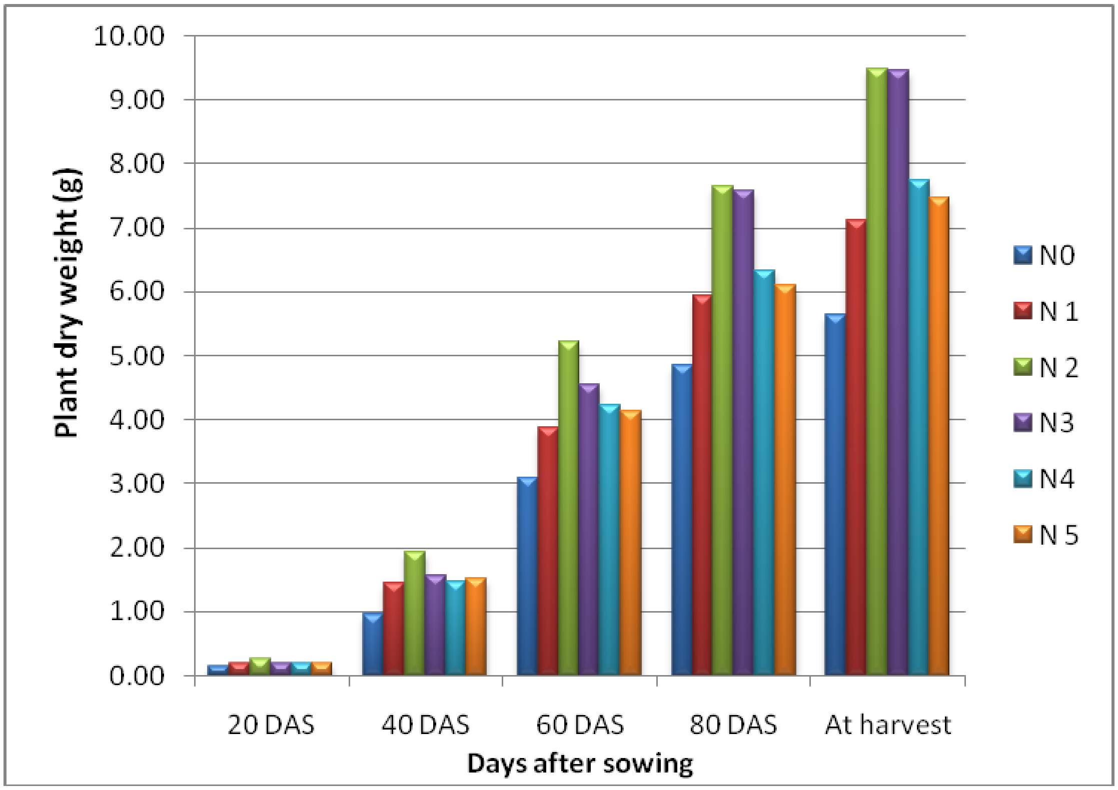


Figure 6: Effect of different nitrogen management on plant dry weight of grasspea (SE = 0.08308, 0.2463, 0.3015, 0.3150 and 0.3662 at 20, 40, 60, 80 DAS and at harvest, respectively)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Except 20 DAS, interaction effect on plant dry weight at different plant growth stages was found significant (Table 3).

At 20 DAS, numerically higher value (0.29 g) was found from V_1N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1})and it was closely followed byV_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) (0.28 g).On the other hand, the lowest plant dry weight (0.123 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At 40 DAS, the highest plant dry weight (2.03 g) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was closely followed by V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (1.95 g). On the other hand, the lowest plant dry weight (0.83 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At 60 DAS, the highest plant dry weight (5.49 g) was noted from V_2N_2 and it was followed by V_1N_2 (5.37 g). On the other hand, the lowest plant dry weight (2.98 g) was recorded in V_3N_0 (Local variety + No fertilizer) at all five plant growth stages.

At 80 DAS, the highest plant dry weight (8.25 g) was noted from V_2N_2 which was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (7.87 g).On the other hand, the lowest plant dry weight (4.57 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At harvest, the highest plant dry weight (10.23 g) was noted from V_2N_2 and it was statistically similar with V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (10.16 g),V_1N_3 (10.16 g) and V_1N_2 (10.10 g). On the other hand, the lowest plant dry weight (5.04 g) was recorded in V_3N_0 (Local variety + No fertilizer).

Table 3: Interaction effect of variety and nitrogen management on plant dry weight of grasspea

Treatments	Plant dry weight (g)				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
V_1N_0	0.16	0.97 ef	3.10 g	4.91 fg	6.01 e
V_1N_1	0.20	1.44 b-e	3.99 ef	5.96 de	7.70 b-d
V_1N_2	0.29	1.95 ab	5.38 ab	7.82 ab	10.10 a
V_1N_3	0.19	1.58 a-d	4.84 bc	7.87 ab	10.16 a
V_1N_4	0.19	1.46 b-e	4.19 c-e	6.38 cd	7.93 bc
V_1N_5	0.20	1.49 a-e	4.10 de	5.98 de	7.57 b-d
V_2N_0	0.17	1.06 d-f	3.20 g	5.07 fg	5.83 e
V_2N_1	0.21	1.69 a-c	4.20 c-e	6.40 cd	7.73 b-d
V_2N_2	0.28	2.03 a	5.49 a	8.25 a	10.23 a
V_2N_3	0.20	1.62 a-c	4.67 cd	7.42 b	10.16 a
V_2N_4	0.21	1.52 a-d	4.41 c-e	6.23 de	8.04 bc
V_2N_5	0.20	1.66 a-c	4.17 de	6.23 de	7.75 b-d
V_3N_0	0.12	0.83 f	2.98 g	4.57 g	5.04 f
V_3N_1	0.19	1.22 c-f	3.41 fg	5.46 ef	5.94 e
V_3N_2	0.22	1.83 ab	4.83 bc	7.29 b	8.07 bc
V_3N_3	0.18	1.47 b-e	4.15 de	7.09 bc	8.11 b
V_3N_4	0.19	1.41 b-e	4.08 de	6.42 cd	7.28 cd
V_3N_5	0.20	1.41 b-e	4.12 de	6.06 de	7.09 d
CV %	7.10	8.37	14.43	4.33	7.50
SE	0.0082	0.0715	0.1071	0.1604	0.1582
Significance level	NS	*	*	*	**

**** - Significant at 1% level**

*** - Significant at 5% level**

NS – Non-significant

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

4.4 Nodule number plant^{-1}

Effect of variety

BARI khesari-1, BARI khesari-2 and Local variety showed significant variation at 40, 60, 80 DAS and at harvest for the parameter of nodule number plant^{-1}(Appendix IV (a), IV (b), IV (c), IV (d) & Figure 7). At 40 and 60 DAS, BARI khesari-2 showed the significantly highest (17.61 and 20.78, respectively) nodule number plant^{-1}, which was statistically similar with BARI khesari-1 (17.39and 20.56, respectively). At 80DAS, BARI khesari-1 showed the significantly highest (17.58) nodule number plant^{-1}, which was followed by BARI khesari-2 (15.94). At harvest, BARI khesari-1 showed the highest (13.61) nodule number plant^{-1}, which was statistically similar with BARI khesari-2 (13.47). On the other hand Local variety showed the significantly lowest (12.17, 15.72, 13.19and 10.81, respectively) nodule number plant^{-1}at 40, 60, 80DAS and at harvest. It is obvious that different cultivars have difference in their nodule number plant^{-1}. Hossain and Solaiman (2004) carried out a field experiment where they observed that BARI Mung-4 produced the highest nodule number plant^{-1}compare to other five cultivars (BARI Mung-2, BARI Mung-3, BARI Mung-5, BINA Moog-2 and BU Mung-1).

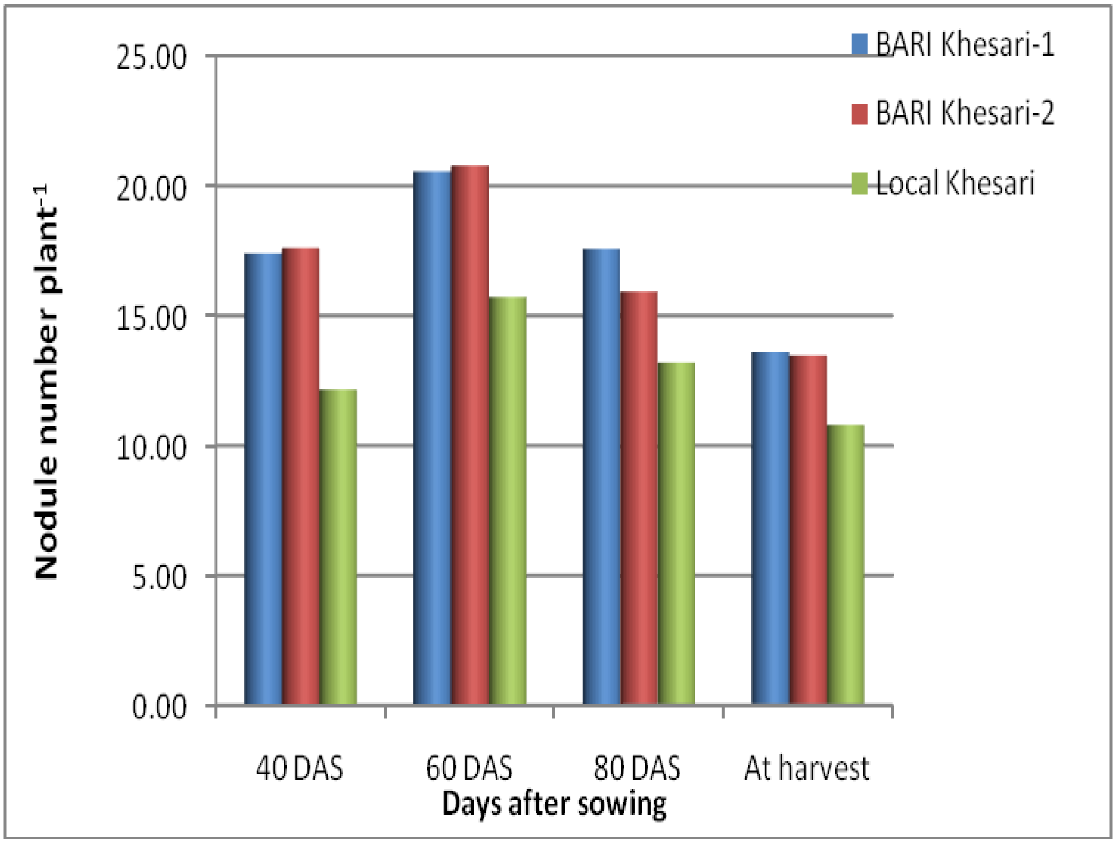


Figure 7: Effect of variety on nodule number plant^{-1} of grasspea (SE = 1.095, 1.102, 0.6629, 0.6536 at 40, 60, 80 DAS and at harvest, respectively)

Effect of nitrogen management

Number of nodule plant^{-1}showed significant variation for different nitrogen management at 20, 40, 60, 80 DAS and at harvest (Appendix IV (a), IV (b), IV (c), IV (d) & Figure 8). The highest nodule number plant^{-1}at 40 and 60 DAS were recorded from N_2 (Basal application with 40 kg N ha^{-1}) (22.33 and 25.78). At 80 DAS, the maximum nodule number plant^{-1}was recorded from N_4 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (17.44) and it was statistically similar with N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (17.33). At harvest, the maximum nodule number plant^{-1} was recorded from N_3 (15.89) and it was statistically similar with N_2 (15.56). On the other hand, for different nitrogen management at 40, 60, 80 DAS and at harvest the lowest nodule numbers plant^{-1}were recorded from N_0 (No fertilizer) (9.11, 12.11, 9.83 and 6.22). Inthong (1987) observed that the application of 15 kg N ha^{-1} to mungbean increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it. In another experiment he reported that application of 15 kg N ha^{-1} was found to be superior giving 23 % higher seed yield over the control.

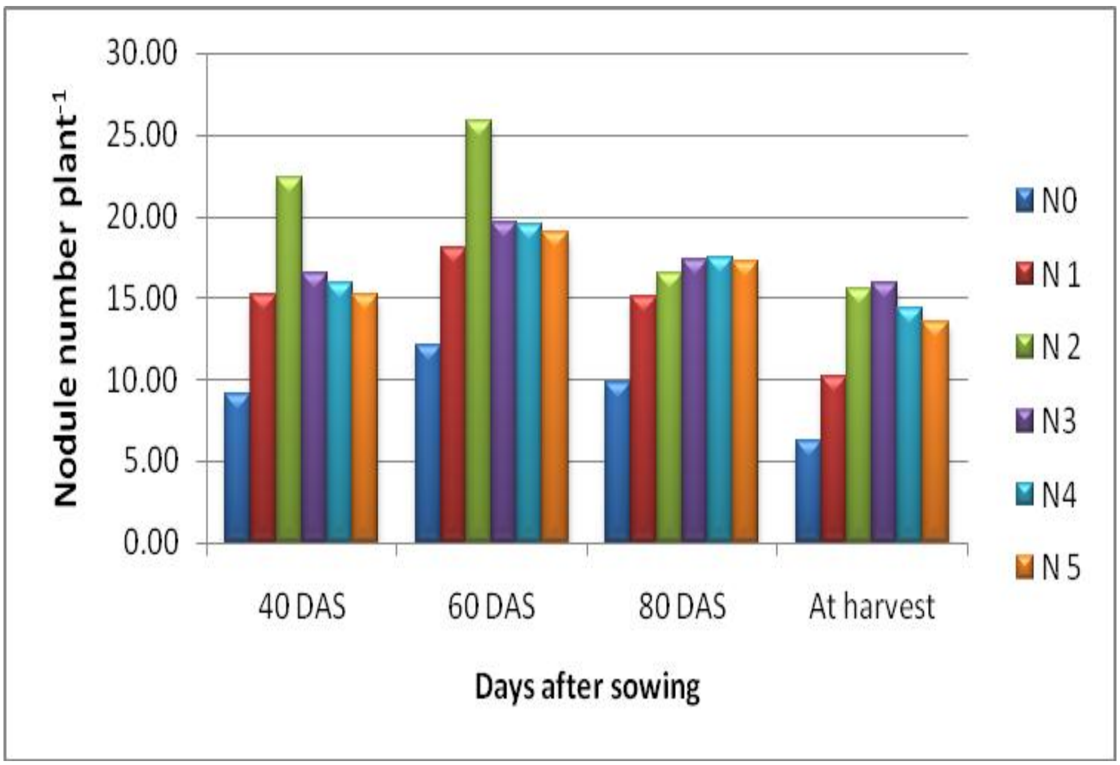


Figure 8: Effect of different nitrogen management on nodule number plant^{-1} of grasspea (SE = 1.1, 1.107, 0.666, 0.6568 at 40, 60, 80 DAS and at harvest, respectively)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on nodule number plant^{-1}at different plant growth stages was found significant (Table 4).

At 40 DAS, the highest nodule number plant^{-1}(25.00) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was statistically similar with V_1N_2.

(BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (24.67). On the other hand, the lowest nodule number plant^{-1}(6.667) was recorded in V_3N_0 (Local variety + No fertilizer).

At 60 DAS, the highest nodule number plant^{-1}(27.67) was noted from V_1N_2 and it was followed by V_1N_4 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (21.67).On the other hand, the lowest nodule number plant^{-1}(9.667) was recorded in V_3N_0 (Local variety + No fertilizer).

At 80 DAS, the highest nodule number plant^{-1}(20.83) was noted from V_1N_2which was statistically similar with V_1N_4 (20.17). On the other hand, the lowest nodule number plant^{-1}(7.833) was recorded in V_3N_0 (Local variety + No fertilizer).

At harvest, the highest nodule number plant^{-1}(16.50) was noted from both $V_1N_4$and V_2N_2 and they were statistically similar with V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (16.167),V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (16.167),V_1N_2 (16.00) andV_1N_5 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation) (15.67). On the other hand, the lowest nodule number plant^{-1}(5.167) was recorded in V_3N_0 (Local variety + No fertilizer).

Table 4: Interaction effect of variety and nitrogen management on nodule number plant^{-1} of grasspea

Treatments	Nodule number/plant			
	40 DAS	60 DAS	80 DAS	At harvest
V_1N_0	10.33 d	13.33 ef	10.33 h	6.67 f
V_1N_1	16.00 c	19.00 c	16.33 e	10.67 cd
V_1N_2	24.67 a	27.67 a	20.83 a	16.00a
V_1N_3	18.67 b	21.33 bc	20.00 ab	16.17 a
V_1N_4	18.33 bc	21.67 b	20.17 a	16.50 a
V_1N_5	16.33 bc	20.33 bc	17.83 cd	15.67 a
V_2N_0	10.33 d	13.33 f	11.33 gh	6.83 f
V_2N_1	17.00 bc	20.00 bc	16.83 de	11.00 cd
V_2N_2	25.00 a	16.00 d	11.83 g	16.50 a
V_2N_3	18.67 b	21.33bc	17.17 de	16.17 a
V_2N_4	17.67 bc	21.00 bc	13.83 f	15.17 ab
V_2N_5	17.00 bc	20.67 bc	19.83 ab	15.17 ab
V_3N_0	6.67 e	9.67 g	7.83 i	5.17 g
V_3N_1	12.33 d	15.33 d-f	12.17 g	9.00 e
V_3N_2	17.33 bc	21.33 b	17.00 de	14.17 b
V_3N_3	12.33 d	16.33 d	14.83 f	9.67 de
V_3N_4	11.67 d	15.67 de	13.50 f	11.50c
V_3N_5	12.67 d	16.00 d	13.83 f	9.67 de
CV %	15.73	13.17	5.82	6.98
SE	1.4276	1.4461	0.5233	0.5088
Significance level	**	*	**	**

**** - Significant at 1% level**

*** - Significant at 5% level**

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

4.5 Nodule dry weight

Effect of variety

Nodule dry weight showed non-significant variation at 40, 60 DAS for the three varieties (Appendix V (a), V (b), V (c), V (d) & Figure 9) though numerically higher values were shown by V_2 (BARI khesari-2) and lower values were found from V_3 (Local variety). At 80DAS, BARI khesari-1 showed the significantly highest (0.65 g) nodule dry weight followed by BARI khesari-2 (0.59 g).At harvest, BARI khesari-1 showed the significantly highest (0.86 g) nodule dry weight, which was statistically similar with BARI khesari-2 (0.85 g). On the other hand, Local variety showed the significantly lowest (0.49 g and 0.68 g) nodule dry weight at 80 DAS and at harvest. Similar results were observed by many other scientists while experimenting with various legumes. Hossain and Solaiman (2004) carried out a field experiment where they observed that BARI Mung-4 produced the highest nodule dry weight compare to other five cultivars (BARI Mung-2, BARI Mung-3, BARI Mung-5, BINA Moog-2 and BU Mung-1).

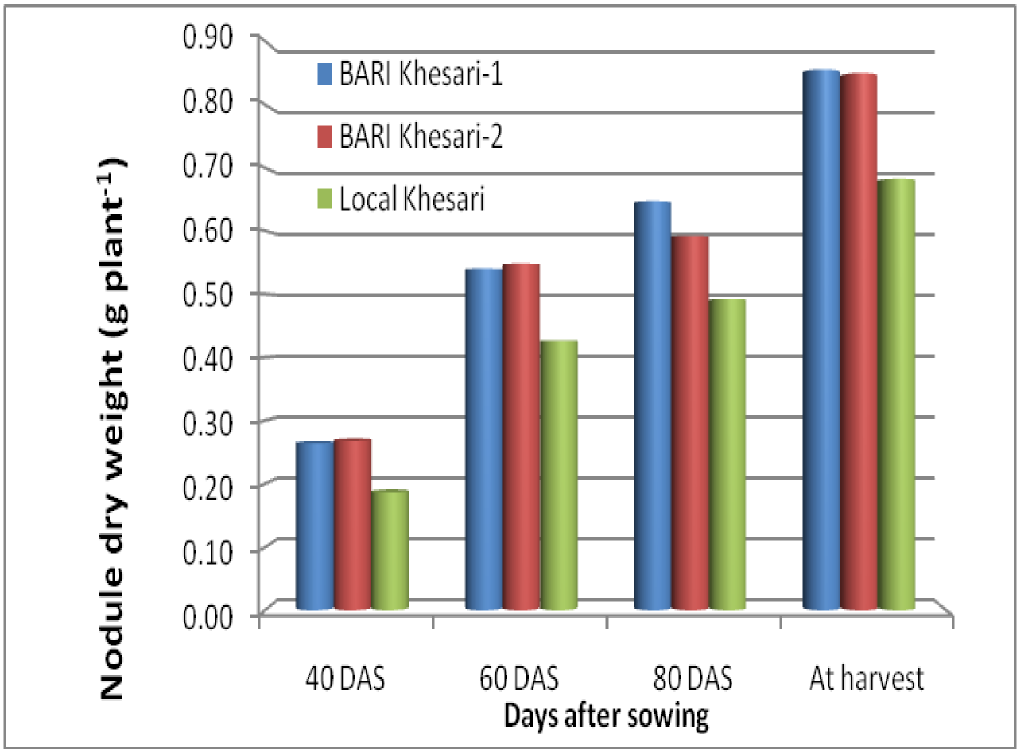


Figure 9: Effect of variety on nodule dry weight of grasspea (SE= 0.1338, 0.1886, 0.1217, and 0.1616 at 40, 60, and 80 DAS and at harvest, respectively)

Effect of nitrogen management

Nodule dry weight showed significant variation for different nitrogen management at 40, 60, 80 DAS and at harvest (Appendix V (a), (b), (c), (d) &Figure 10). The highest nodule dry weight at 40 and 60 DAS was recorded from N_2 (Basal application with 40 kg N ha^{-1}) (0.34 g and 0.66 g). At 80 DAS and at harvest, the maximum nodule dry weight was recorded from N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (0.64 g and 1.00 g) and it was statistically similar with N_2 (0.61 g and 0.98 g), N_4 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (0.64 g and 0.91 g) and N_5(Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation) (0.64 g and 0.85 g). On the other hand, for different nitrogen management at 40, 60, 80 DAS and at harvest the lowest nodule dry weight were recorded from N_0 (No fertilizer) (0.14 g, 0.33 g, 0.37 g, 0.38 g). Islam (2002) reported that N fertilizer positively influenced on the nodule weight of lentil .Chowdhury and Rosario (1992) noted that applied N at the levels above 40 kg ha^{-1} reduced the nodule dry weight. Bachchhav *et al.* (1994) observed that root nodule weight per plant was highest with 30 kg N $ha^{-1}$for mungbean (*Vigna radiata*) cv. Phule-M.

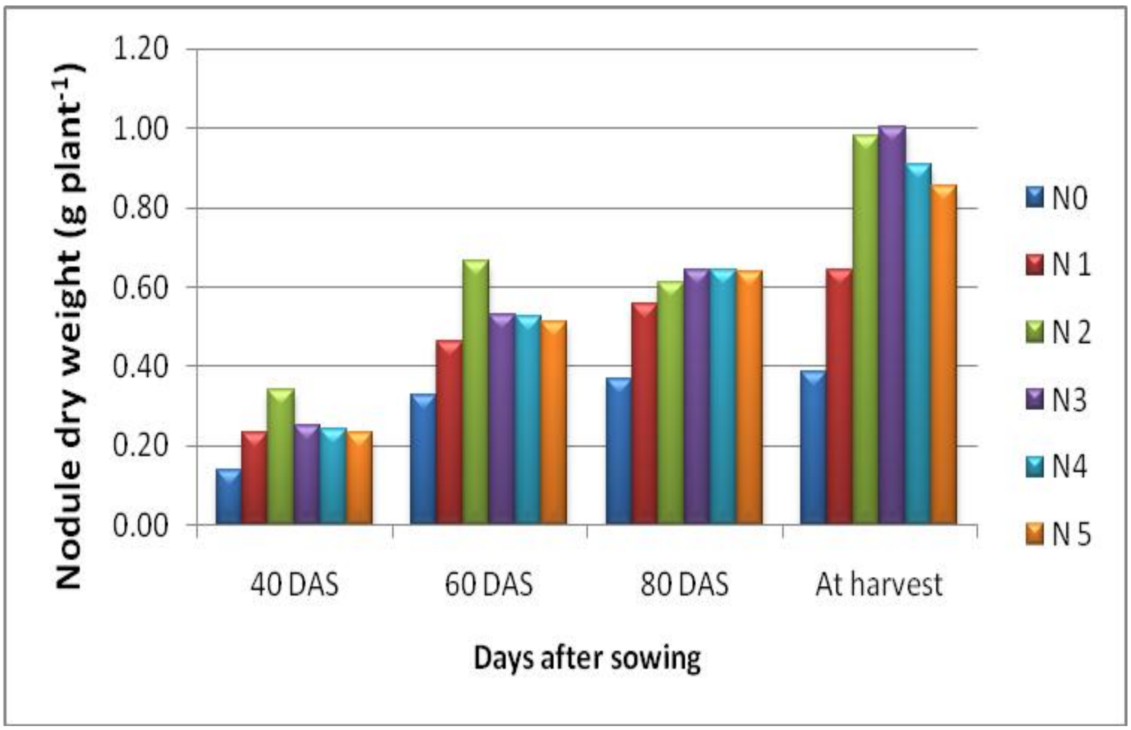


Figure 10: Effect of different nitrogen management on nodule dry weight of grasspea (SE = 0.1349, 0.1897, 0.1236, 0.1621 at 40, 60, 80 DAS and at harvest, respectively)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Except 40 DAS, interaction effect on nodule dry weight at different plant growth stages was found non-significant (Table 5). At 40 DAS, numerically higher nodule dry weight (0.38 g) was recorded in V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1})and it was closely followed by V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (0.37 g).On the other hand, the lowest nodule dry weight (0.10 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At 60 DAS, the highest nodule dry weight (0.76 g) was noted from V_2N_2 and it was closely followed by V_1N_2 (0.65 g). On the other hand, the lowest nodule dry weight (0.26 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At 80 DAS, the highest nodule dry weight (0.77 g) was noted from V_1N_2 and it was statistically similar with V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (0.73 g), V_1N_4 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (0.74 g) and V_2N_5 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation)(0.74 g). On the other hand, the lowest nodule dry weight (0.30 g) was recorded in V_3N_0 (Local variety + No fertilizer).

At harvest, the highest nodule dry weight (1.04 g) was noted from $V_1N_4$and V_2N_2. Also V_1N_2 (1.01 g),V_1N_3 (1.02 g) and V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (1.02 g)showed better results. On the other hand, the lowest nodule dry weight (0.33 g) was recorded in V_3N_0 (Local variety + No fertilizer).

Table 5: Interaction effect of variety and nitrogen management on nodule dry weight of grasspea

Treatments	Nodule dry weight			
	40 DAS	60 DAS	80 DAS	At harvest
V_1N_0	0.17	0.36 ab	0.38 cd	0.40 ef
V_1N_1	0.24	0.51 ab	0.60 a-c	0.67 b-f
V_1N_2	0.37	0.65 ab	0.77 a	1.01 ab
V_1N_3	0.28	0.58 ab	0.73 a	1.02 ab
V_1N_4	0.28	0.59 ab	0.74 a	1.04 a
V_1N_5	0.25	0.55 ab	0.66 ab	0.99 ab
V_2N_0	0.16	0.36 ab	0.42 b-d	0.43 ef
V_2N_1	0.26	0.46 ab	0.63 a-c	0.69 a-e
V_2N_2	0.38	0.76 a	0.44 b-d	1.04 a
V_2N_3	0.28	0.58 ab	0.64 a-c	1.02 ab
V_2N_4	0.27	0.57 ab	0.69 ab	0.96 a-c
V_2N_5	0.26	0.56 ab	0.74 a	0.96 a-c
V_3N_0	0.10	0.26 b	0.30 d	0.33 f
V_3N_1	0.19	0.42 ab	0.45 b-d	0.57 d-f
V_3N_2	0.26	0.58 ab	0.63 a-c	0.89 a-d
V_3N_3	0.19	0.43 ab	0.55 a-d	0.97 ab
V_3N_4	0.18	0.42 ab	0.51 a-d	0.77 a-d
V_3N_5	0.19	0.44 ab	0.50 a-d	0.60 c-f
CV %	15.50	14.55	5.42	6.77
SE	0.0214	0.0424	0.0180	0.0311
Significance level	NS	**	**	**

**** - Significant at 1% level, NS - Non-significant**

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

4.6 Pod number plant^{-1}

Effect of variety

BARI khesari-1, BARI khesari-2 and Local variety showed significant variation among them for the parameter of pod number plant^{-1} (Appendix VI & Figure 11).

The significantly highest (13.16) pod number plant^{-1}was found in BARI khesari-2, which was followed by BARI khesari-1 (12.11). On the other hand, Local variety showed the significantly lowest (9.56) pod number plant^{-1}among the three varieties. Pod number plant^{-1} of a variety depends on nutrient availability during reproductive stage as well as on genetical factor. Birari *et al.* (1993) at Dapoli observed that among seven promising genotypes of cowpea, ACCC-210 showed a high degree of predictability for pods per plant.

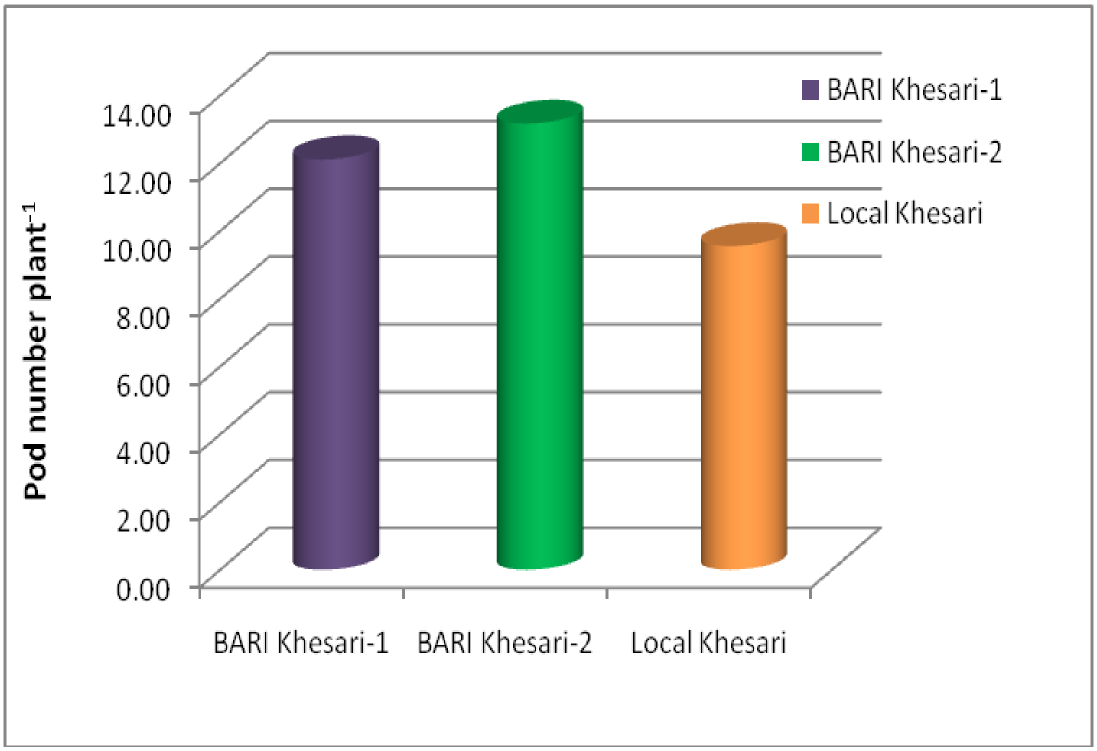


Figure 11: Effect of variety on number of pods plant^{-1}of grasspea (SE= 0.7080)

Effect of nitrogen management

Number of pods plant^{-1} showed significant variation for different nitrogen management (Appendix VI & Figure 12). The highest pod number plant^{-1}was recorded from N_3(Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (16.89) and it was followed by N_2(Basal application with 40 kg N ha^{-1})

(13.56). On the other hand, for different nitrogen management techniques, the lowest pod number plant^{-1} was recorded from N_0 (No fertilizer) (6.22). Sarkar and Banik (1991) reported that application of 40 kg N ha^{-1} to lentil resulted in appreciable improvement in the number of pods plants^{-1} while compared with no N. Nandan and Prasad (1998) found a linear increase in seed yield and pods per plant due to increased in N level form 10 to 30 kg ha^{-1} in lentil.

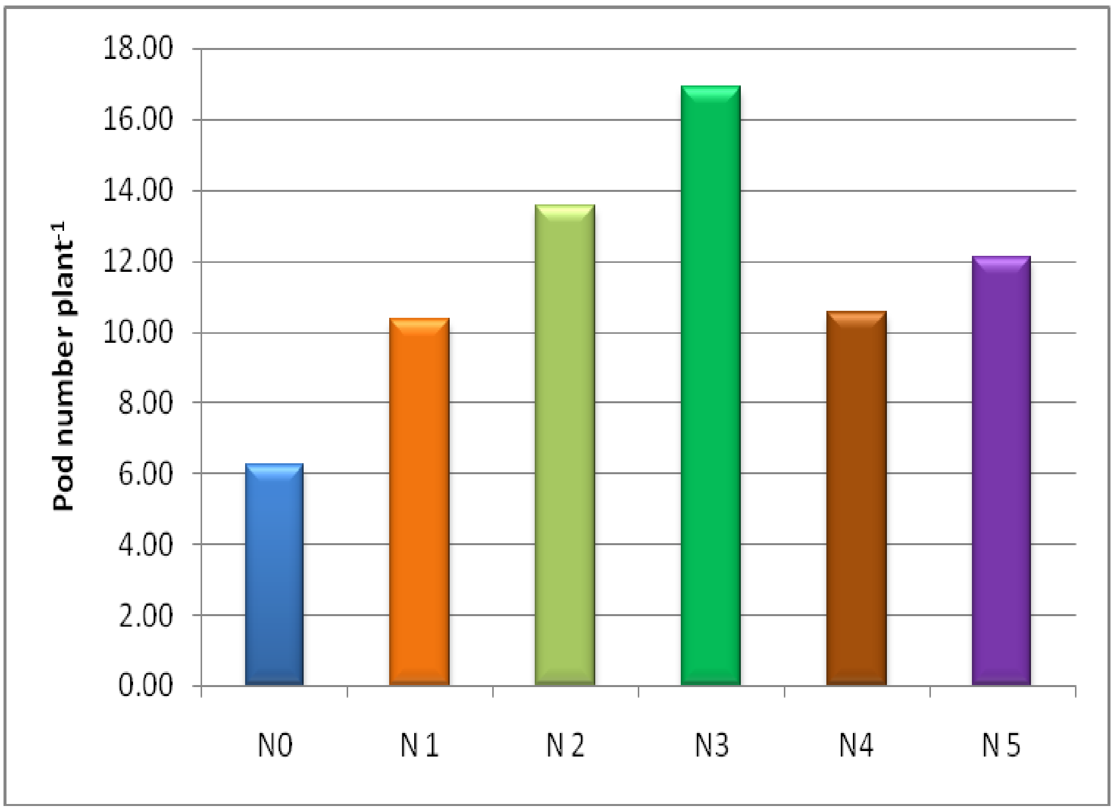


Figure 12: Effect of different nitrogen management on number of pods plant^{-1} of grasspea (SE = 0.7113)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on pod number plant^{-1}at different plant growth stages was found significant (Table 6). The highest pod number plant^{-1}(20.00) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and it was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (17.67). On the other hand, the lowest pod number plant^{-1}(5.33) was recorded in V_3N_0 (Local variety + No fertilizer).

Dougherty *et al*. (1978) found that nitrogen applied at tillering increased grain yield by increasing the number of ears and spikelets per ear. Application of nitrogen to wheat at tillering stage increased the number of ears per unit area and grain set than when nitrogen supplied at floret differentiation stage.

4.7Number of seeds pod^{-1}

Effect of variety

BARI khesari-1, BARI khesari-2 and Local variety showed significant variation for the parameter of number of seeds pod^{-1} (Appendix VII & Figure 13). The significantly highest (4.75) seed number pod^{-1}was found in BARI khesari-2, which was statistically similar with BARI khesari-1 (4.42). On the other hand, Local variety showed the significantly lowest (2.52) seed number pod^{-1}among the three varieties. Number of seeds pod^{-1} is also a character which largely depends on varietal properties. Wein and Ackah (1978) compared different cowpea genotypes for variation in pod development period and its influence on seed weight and seed number per pod. The study indicated that genotypes with more pod development period having higher seed growth would be desirable character for maintaining higher yield.

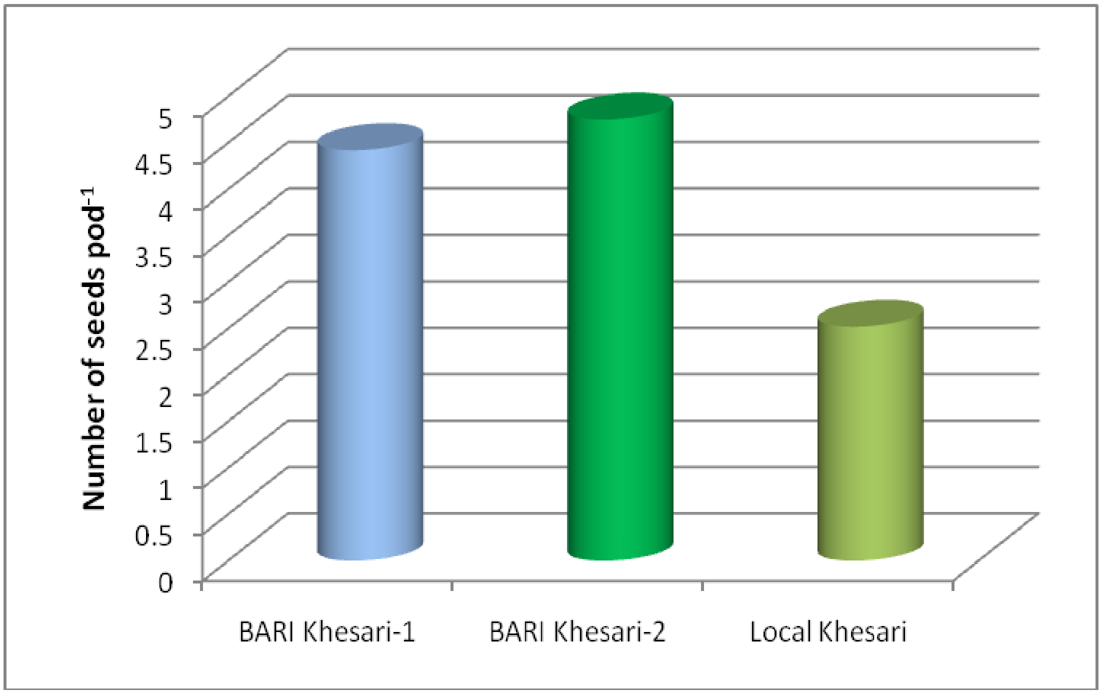


Figure 13: Effect of variety on number of seeds pod^{-1}of grasspea (SE= 1.354)

Effect of nitrogen management

Number of seed pod^{-1}showed significant variation for different nitrogen management (Appendix VII & Figure 14). The highest seed number pod^{-1}was recorded from N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation)(4.09) and it was statistically similar with N_2(Basal application with 40 kg N ha^{-1}) (3.94). On the other hand, for different nitrogen management techniques, the lowest seed number pod^{-1} was recorded from N_0 (No fertilizer) (2.23). Mandal (2002) found that in lentil application of N fertilizer significantly increased seeds per pod. Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on lentil. They reported that lentil seed production was higher with the application of 35 kg N ha^{-1} due to higher number of seeds per plant.

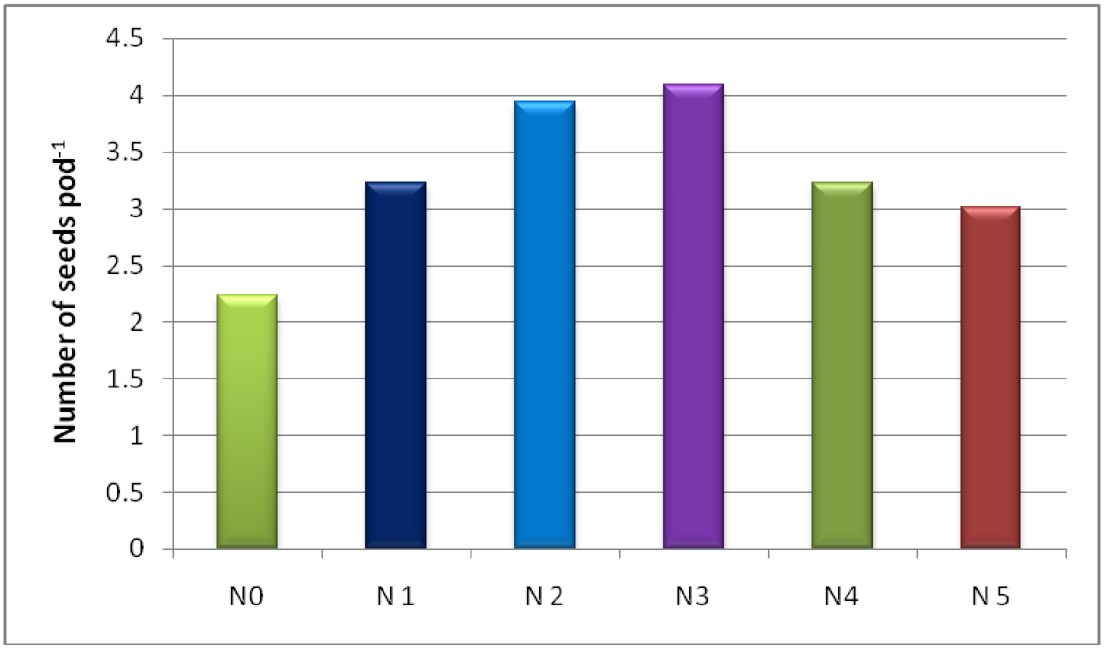


Figure 14: Effect of different nitrogen management on number of seed $pod^{-1}$of grasspea (SE= 0.6123)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on seed number pod^{-1}at different plant growth stages was found significant (Table 6). The highest seed number pod^{-1}(4.39) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and it was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (4.13). On the other hand, the lowest seed number pod^{-1}(2.37) was recorded in V_3N_0 (Local variety + No fertilizer).

4.8 1000-seed weight

Effect of variety

1000-seed weight varied significantly among the three varieties (Appendix VIII & Figure 15). The significantly highest (40.97 g) 1000-seed weight was found in BARI khesari-2, which was statistically similar with BARI khesari-1 (40.92 g). On the other hand Local variety showed the significantly lowest (38.03 g) 1000-seed weight among the three varieties. Birari *et al.* (1993) at Dapoli observed that among seven promising genotypes of cowpea, ACCC-210 showed a high degree of predictability for 100-grain weight and harvest index and was rated as the most stable genotype.

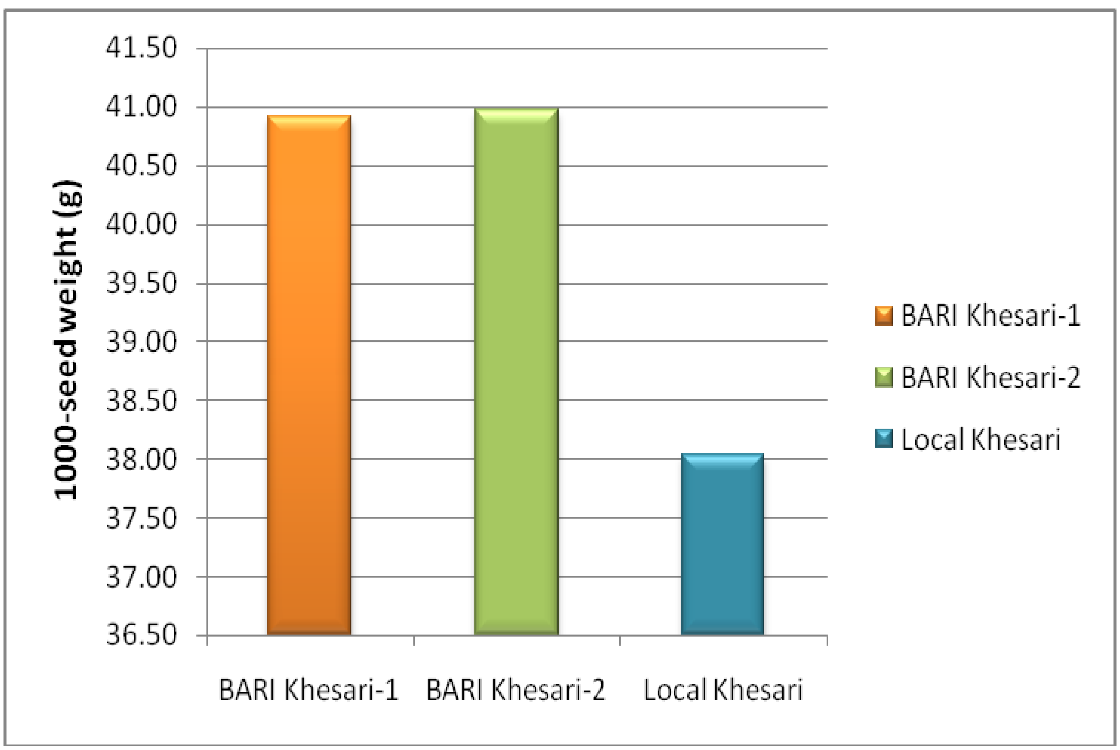


Figure 15: Effect of variety on 1000-seed weight of grasspea (SE = 0.7874)

Effect of nitrogen management

1000-seed weight showed significant variation for different nitrogen management (Appendix VIII & Figure 16). The highest 1000-seed weight was recorded from N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (44.71 g) and it was followed by N_2 (Basal application with 40 kg N ha^{-1}) (40.49 g). On the other hand, for different nitrogen management techniques, the lowest 1000-seed weight was recorded from N_0 (No fertilizer) (35.99 g). Hamid (1988) found that 1000 seed weight and yield of mungbean cv. Mubarik was increased by nitrogen at 40 kg ha^{-1}.Sardana and Varma (1987) stated that application of N, P and K fertilizers resulted in significant increased in 1000 seed weight of lentil . Mahboob and Asghar (2002) reported that various yield components of lentil like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1} application.

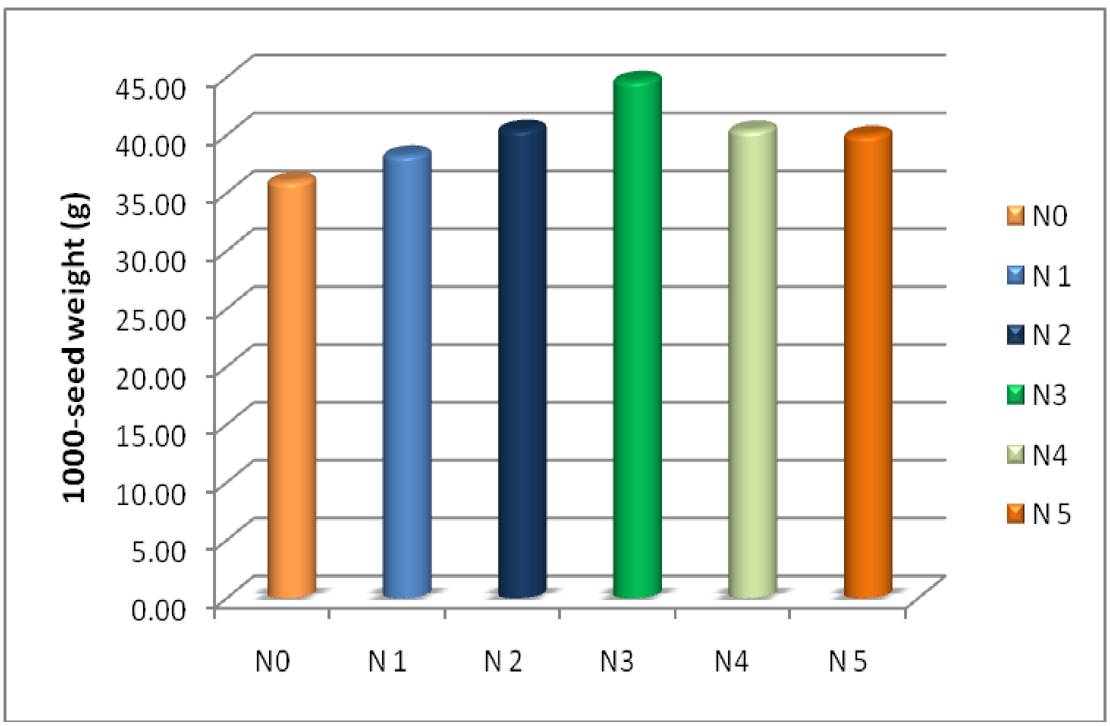


Figure 16: Effect of different nitrogen management on 1000-seed weight of grasspea (SE = 0.7912)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on 1000-seed weight at different plant growth stages was found significant (Table6). The highest 1000-seed weight (45.84 g) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and it was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (44.90 g) and V_3N_3 (Local variety + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (43.39 g). On the other hand, the lowest 1000-seed weight (32.62 g) was recorded in V_3N_0 (Local variety + No fertilizer).

4.9 Grain yield

Effect of variety

Grain yield varied significantly among the three varieties (Appendix IX & Figure 17). The significantly highest (0.833 t/ha) grain yield was found in BARI khesari-2, which was statistically similar with BARI khesari-1 (0.808 t/ha). On the other hand Local variety showed the significantly lowest (0.638 t/ha) grain yield among the three varieties. Kalpana (2000) reported that genotypes KM-5 and KM-4 among the determinate and C-44 and C-22 among indeterminate had higher seed yield and also recorded higher values for photosynthetic rate and transpiration rate. Gracy-Mathew *et al.* (1998) in Kerala reported that Cv. GC-3 and GC-8968 of cowpea were high yielding compare to others .At Port Blair, Ram *et al.* (1994) evaluated twenty-seven *Vigna unguiculata* varieties during 1985 and 1986. Highest seed yields were recorded for Cov Y2 (1.16 t/ha), RC-48 (1.25 t/ha) and C-152 (1.2 t/ha).

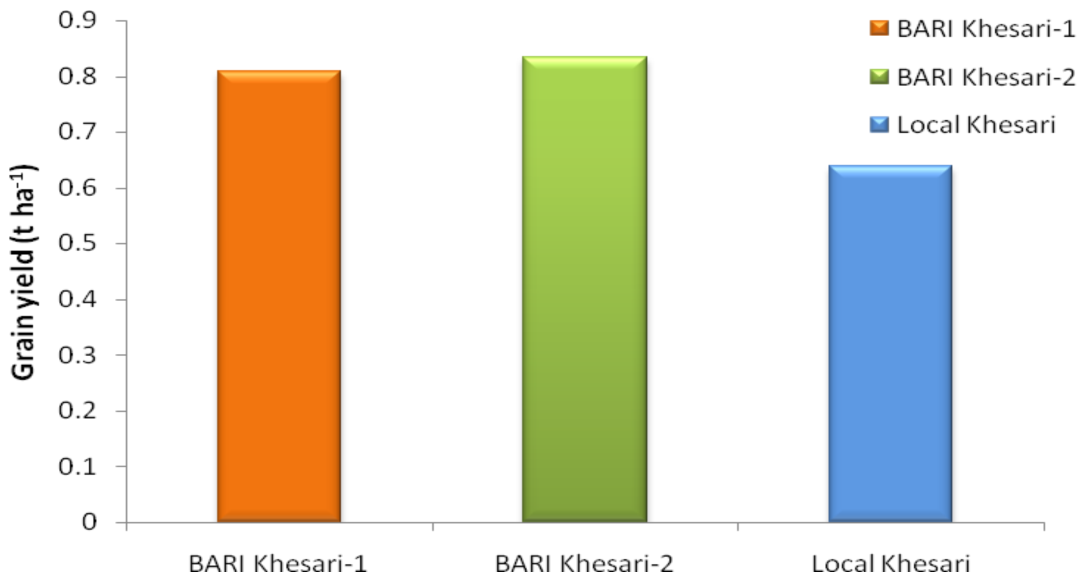


Figure 17: Effect of variety on grain yield of grasspea (SE = 0.1578)

Effect of nitrogen management

Grain yield showed significant variation for different nitrogen management (Appendix IX & Figure 18). The highest grain yield was recorded from N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation)(1.114gplant^{-1}) and it was followed by N_2 (Basal application with 40 kg N ha^{-1}) (0.872gplant^{-1}). On the other hand, for different nitrogen management techniques, the lowest grain yield was recorded from N_0 (No fertilizer)(0.447gplant^{-1}). Mahboob and Asghar (2002) reported that seed inoculation + 40-80-30 NPK kg ha^{-1} exhibits superior performance in respect of seed yield (1670 kg ha^{-1}) of lentil. Yein (1982) found that 40 kg N ha^{-1} in combination with 20kg P_2O_5 ha^{-1} resulted in significant increase in the seed yield of lentil. Sarkar and Banik (1991) reported that application of N and P improved plant productivity and enhanced the grain yield of green gram significantly.

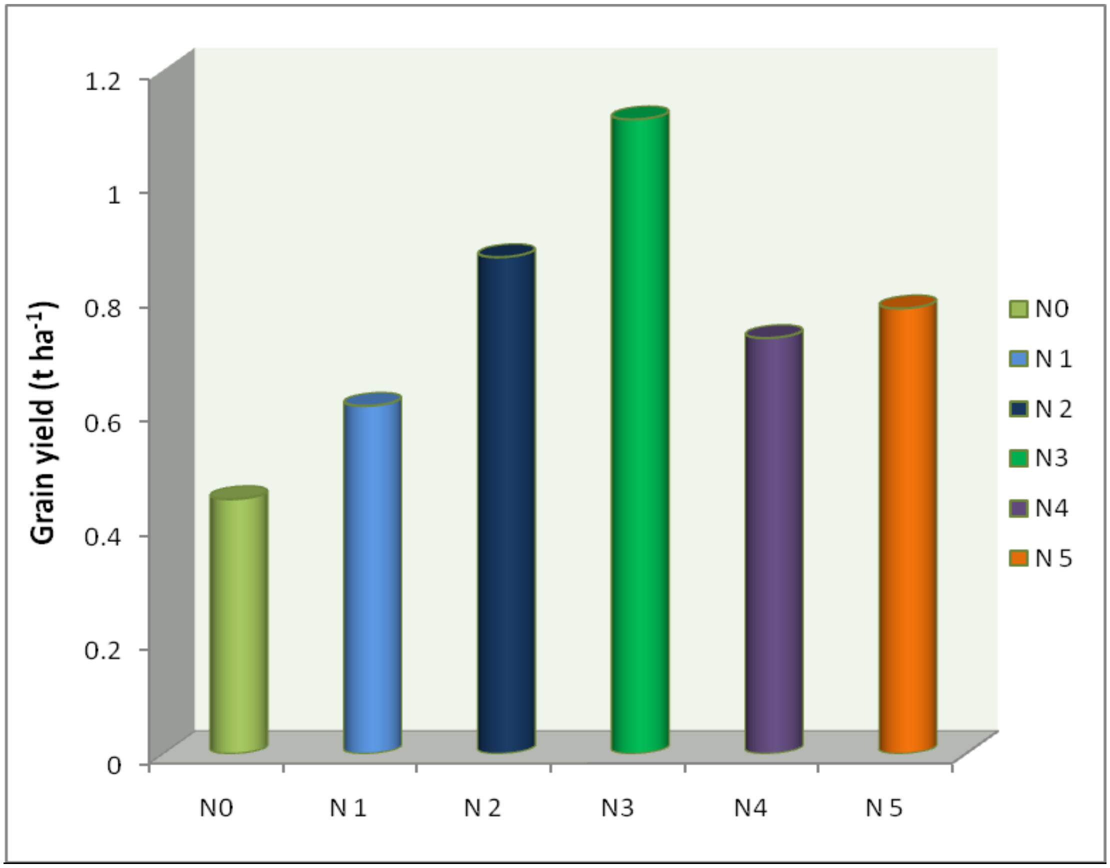


Figure 18: Effect of different nitrogen management on grain yield of grasspea (SE = 0.1585)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on grain yield at different plant growth stages was found significant (Table6). The highest grain yield (1.313 g plant^{-1}) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and it was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (1.203 g plant^{-1}) and V_1N_4 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (0.963 g plant^{-1}). On the other hand, the lowest grain yield (0.41 g plant^{-1}) was recorded in V_3N_0 (Local variety + No fertilizer).

Sharma and Mahendra singh (1971) reported that nitrogen applied in three equal splits at sowing, first irrigation and later tillering stages gave higher yield (5.46 t ha^{-1}) than when applied in a single dressing or in two split dressings (4.83 and 5.39 t ha^{-1}, respectively). Sharma and Kumar (1972) reported that application of half of the recommended nitrogen at sowing and half nitrogen at second irrigation produced maximum dry matter, whereas higher grain yield was obtained with application of 25 per cent N at sowing + 25 per cent at first irrigation + 50 per cent N at second irrigation than when nitrogen was applied at other timings.

4.10 Stover yield

Effect of variety

Stover yield varied significantly among the three varieties (Appendix X & Figure 19). The significantly highest (1.735 g plant^{-1}) stover yield was found in BARI khesari-1, which was followed by BARI khesari-2 (1.711 g plant^{-1}). On the other hand, Local variety showed the significantly lowest (1.546 g plant^{-1}) stover yield among the three varieties. Purushotham *et al.* (2001) reported that among different cultivars UPC-921, UPC-952, UPC-953, IFC-9502, IFC-9503, UPC-5286 and Bund lobia (control), the highest mean dry matter was registered by IFC-9503 (18.1 q/ha).

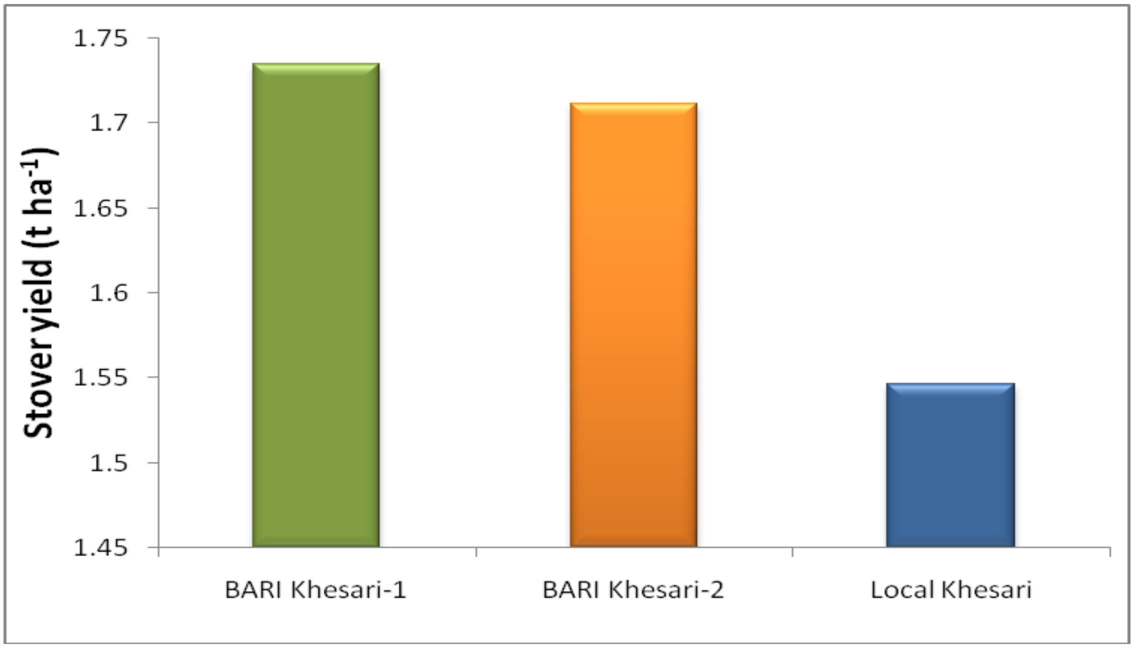


Figure 19: Effect of variety on stover yield of grasspea (SE = 0.1675)

Effect of nitrogen management

Stover yield showed significant variation for different nitrogen management (Appendix X & Figure 20). The highest stover yield was recorded from N_2 (Basal application with 40 kg ha^{-1}) (2.079 g $plant^{-1}$) and it was followed by N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1}at branch initiation) (1.69 g $plant^{-1}$)which was statistically similar with N_4(Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation)(1.66 g $plant^{-1}$), N_5(Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation)(1.62g $plant^{-1}$) and N_1(Basal application with 20 kg N ha^{-1}) (1.57 g $plant^{-1}$). On the other hand, for different nitrogen management techniques, the lowest stover yield was recorded from N_0 (No fertilizer) (1.367 g $plant^{-1}$). Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P_2O_5 ha^{-1} increased lentil grain and stover yield.

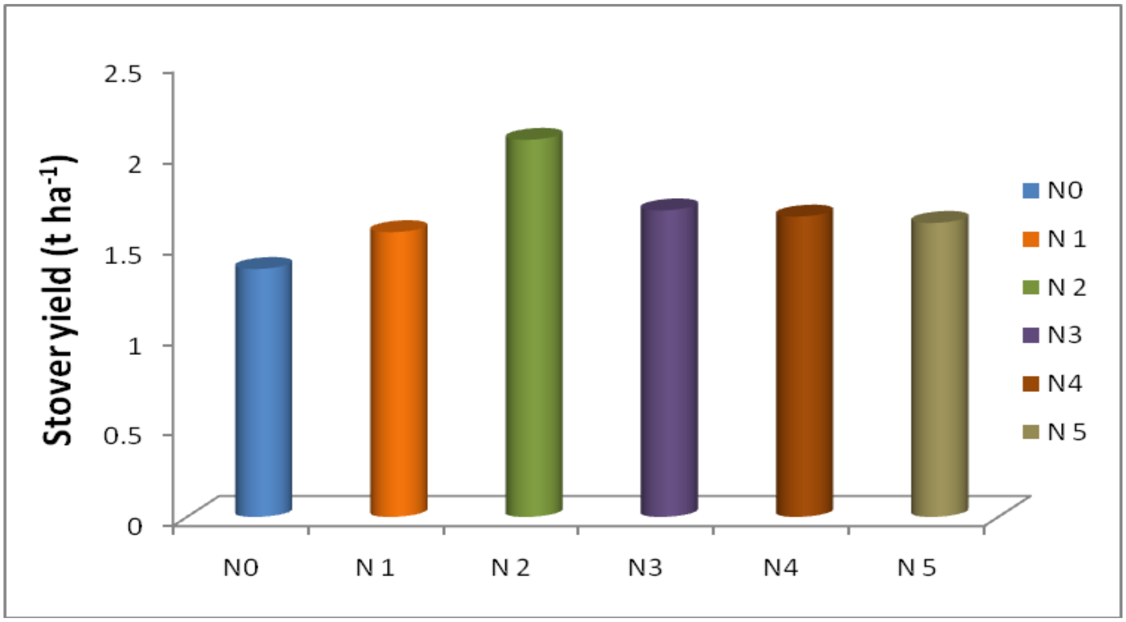


Figure 20: Effect of different nitrogen management on stover yield of grasspea (SE=0.3780)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on stover yield at different plant growth stages was found significant (Table 6). The highest stover yield (2.317 $gplant^{-1}$) was noted from V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}) and it was statistically similar with V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) (2.26 $gplant^{-1}$). On the other hand, the lowest stover yield (1.37 $gplant^{-1}$) was recorded in V_3N_0 (Local variety + No fertilizer) which has statistically no difference with the rest of the combinations except the highest ones.

Halikatti (1980) reported that application of nitrogen levels (80 and 120 kg ha^{-1}) in two splits, half at planting and remaining half at 25 days after sowing recorded higher leaf area index, plant height, dry matter production per meter row length and higher grain yield, than application of nitrogen all at planting or in three (one-third each at planting, 25 and 55 days after sowing) or in four (one fourth each at planting, 25, 55 and 70 days after sowing) splits.

4.11 Harvest index

Effect of variety

Harvest index varied significantly among the three varieties (Appendix XI & Figure 21). The significantly highest (32.30%) harvest index was found in BARI khesari-2, which was followed by BARI khesari-1 (31.29%). On the other hand Local variety showed the significantly lowest (28.91%) harvest index among the three varieties.

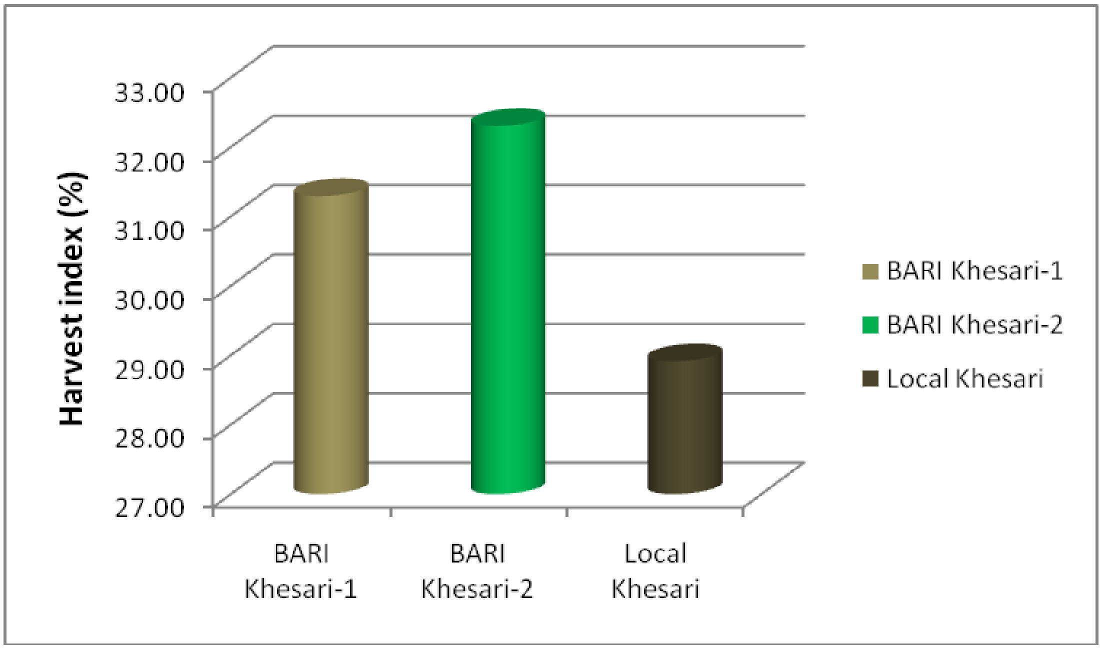


Figure 21: Effect of variety on harvest index of grasspea (SE = 0.7510)

Effect of nitrogen management

Harvest index showed significant variation for different nitrogen management (Appendix XI & Figure 22). The highest harvest index was recorded from N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) (39.36%) and it was followed by N_2 (Basal application with 40 kg N ha^{-1}) (34.37%). On the other hand, for different nitrogen management techniques, the lowest harvest index was recorded from N_0 (No fertilizer) (24.66%).

It seems from the results that initial higher dose of nitrogen (N_2=basal application with 40 kg N ha^{-1}) helped in initial growth of the plants but basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation (N_3) ensured more nitrogen availability during reproductive stage and thus provided higher on pods $plant^{-1}$, seeds pod^{-1}, 1000-seed weight, grain yield, stover yield and harvest index of grasspea than any other treatments. So, split application can surely benefit the farmers to get more yield and economic return.

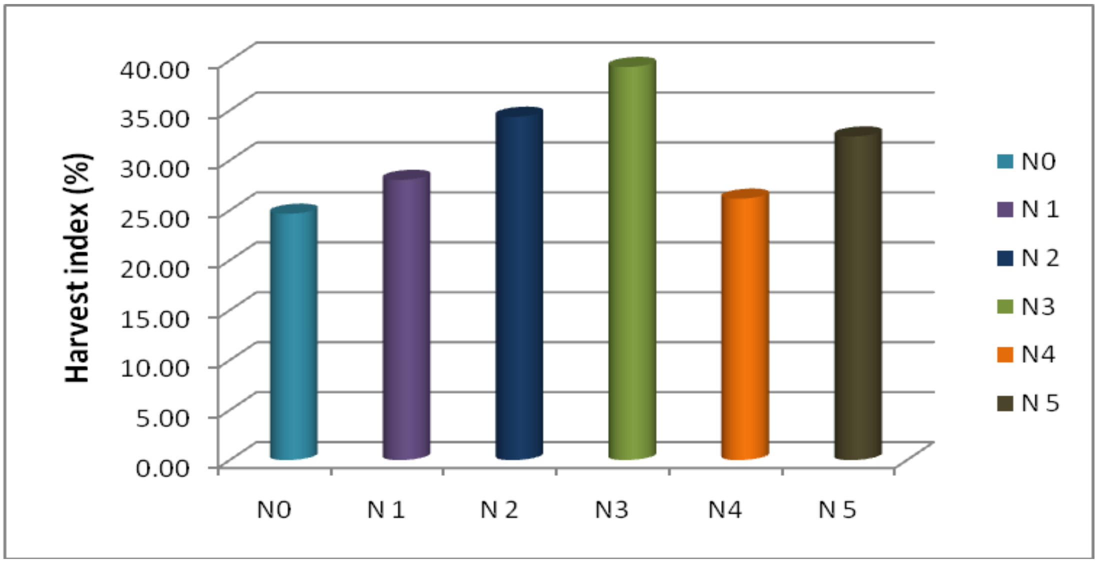


Figure 22: Effect of different nitrogen management on harvest index of grasspea (SE = 4.11)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Interaction effect of variety and nitrogen management

Interaction effect of variety and nitrogen management on harvest index at different plant growth stages was found significant (Table 6). The highest harvest index (42.99%) was noted from V_2N_3 (BARI khesari-2 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and it was followed by V_1N_3 (BARI khesari-1 + Basal application with 20 kg N $ha^{-1}$and 20 kg N ha^{-1} at branch initiation) (40.81%) and V_1N_4 (BARI khesari-1 + Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation) (36.20%). On the other hand, the lowest harvest index (23.01%) was recorded in V_3N_0 (Local variety + No fertilizer).

Table 6: Interaction effect of variety and nitrogen management on pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, grain yield, stover yield and harvest index of grasspea

Treatments	Pod number/plant	Number of seeds pod^{-1}	1000-seed weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
V_1N_0	6.67 j	3.11 c	37.87 fg	0.453 fg	1.367 b	24.92 k
V_1N_1	11.00 f-h	3.19 c	39.69 c-e	0.620 d-g	1.657 b	27.26 ij
V_1N_2	10.67 gh	3.89 a-c	41.16 c	0.753 c-f	2.260 a	24.99 k
V_1N_3	17.67 b	4.13 ab	44.90 ab	1.203 ab	1.743 b	40.81 b
V_1N_4	14.33 cd	3.85 a-c	41.15 c	0.963 bc	1.697 b	36.20 c
V_1N_5	12.33ef	3.82 a-c	40.75 cd	0.853 c-e	1.687 b	33.58 de
V_2N_0	6.67 j	3.23 c	37.48 g	0.477 fg	1.363 b	26.05 jk
V_2N_1	11.33 fg	3.61 bc	39.57 c-e	0.643 c-g	1.477 b	30.37 fg
V_2N_2	11.33 fg	4.22 ab	41.12 c	0.783 c-f	2.317 a	25.27 k
V_2N_3	20.00 a	4.39 a	45.84 a	1.313 a	1.740 b	42.99 a
V_2N_4	15.33 c	3.63 bc	40.94 c	0.927 b-d	1.720 b	34.99 cd
V_2N_5	14.33 cd	3.59 bc	40.91 c	0.640 c-g	1.647 b	34.13 d
V_3N_0	5.33 j	2.37 d	32.62 i	0.410 g	1.370 b	23.01 l
V_3N_1	8.67 i	3.75 a-c	35.58 h	0.570 e-g	1.577 b	26.54 i-k
V_3N_2	9.67 hi	3.70 a-c	39.19 d-g	0.653 c-g	1.660 b	28.25 hi
V_3N_3	13.00 de	4.13 ab	43.39 b	0.827 c-e	1.587 b	34.26 d
V_3N_4	11.00 f-h	3.89 a-c	39.16 d-g	0.727 c-g	1.550 b	31.92 ef
V_3N_5	9.67 hi	3.80 a-c	38.25 e-g	0.640 c-g	1.530 b	29.48 gh
CV %	8.90	13.26	7.20	6.07	13.90	5.40
SE	0.5968	0.7145	0.7384	0.0266	0.0374	0.9614
Significance level	*	**	*	**	**	**

**** - Significant at 1% level,**

*** - Significant at 5% level**

V_1= BARI khesari-1, V_2= BARI khesari-2, V_3= Local khesari (Jamalpur)

N_0= Control (No fertilizer), N_1= Basal application with 20 kg N ha^{-1}, N_2= Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation stage, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation stage, N_5= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation stage

Chapter 5

Summary and conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was carried out at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka from November to March 2011 to study the response of grasspea varieties to different nitrogen managements. Three varieties of grasspea (V_1= BARI khesari-1, V_2= BARI khesari-2 and V_3= Local khesari) and six nitrogen management treatments (N_0=Control, N_1=Basal application with 20 kg N ha^{-1}, N_2=Basal application with 40 kg N ha^{-1}, N_3= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation, N_4= Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at flower initiation and N_5=Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation) were used in this experiment. A summary of results of this study is given below.

Plant height varied significantly at 20, 40, 60, 80 DAS and at harvest for BARI khesari-1, BARI khesari-2 and Local variety. The tallest plants were recorded from BARI khesari-2 and the shortest plant heights from Local variety at different DAS & at harvest. The maximum numbers of branches $plant^{-1}$ were found from BARI khesari-2 and it was followed by BARI khesari-1 while the minimum numbers were recorded from Local variety at different stages. Plant dry weight showed non-significant variation at 20, 40 DAS for varietal effect. Though numerically higher values were shown by V_2 and lower values were found from V_3. At 60, 80 DAS and at harvest, BARI khesari-2 showed the significantly highest plant dry weight, which was statistically similar with BARI khesari-1 while Local variety showed the significantly lowest plant dry weight. At 40 and 60 DAS, BARI khesari-2 showed the significantly highest nodule number $plant^{-1}$, which was statistically similar with BARI khesari-1 while at 80 DAS and at harvest BARI khesari-1 showed the highest nodule number plant^{-1}, which was closely followed and statistically similar with BARI khesari-2 respectively. Local variety showed the significantly lowest nodule numbers plant^{-1} at all the stages. Nodule dry weight showed non-significant variation at 40, 60 DAS for the three varieties though numerically higher values were shown by V_2 and lower values were found from V_3. At 80 DAS, BARI khesari-1 showed the significantly highest nodule dry weight followed by BARI khesari-2. At harvest, BARI khesari-1 showed the significantly highest nodule dry weight, which was statistically similar with BARI khesari-2. On the other hand, Local variety showed the lowest nodule dry weight at all the stages. Significantly highest pod number plant^{-1}was found in BARI khesari-2, which was followed by BARI khesari-1. On the other hand local variety showed the significantly lowest pod number plant^{-1} among the three varieties. The significantly highest seed number pod^{-1} was found in BARI khesari-2, which was statistically similar with BARI khesari-1. On the other hand, Local variety showed the significantly lowest seed number pod^{-1}among the three varieties. Highest 1000-seed weight was found in BARI khesari-2, which was statistically similar with BARI khesari-1 while local variety showed the significantly lowest 1000-seed weight among the three varieties. Highest grain yield was found in BARI khesari-2, which was statistically similar with BARI khesari-1. Local variety showed the significantly lowest grain yield. The significantly highest stover yield was found in BARI khesari-1, which was followed by BARI khesari-2. On the other hand, local variety showed the significantly lowest stover yield among the three varieties. The significantly highest harvest index was found in BARI khesari-2, which was followed by BARI khesari-1. On the other hand local variety showed the significantly lowest harvest index among the three varieties.

Different nitrogen management showed significant differences on plant height at 20, 40, 60, 80 DAS and at harvest. The tallest plants were observed from N_2 (Basal application with 40 kg N ha^{-1}), which was similar to N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) at 80, 100 DAS and at harvest. The shortest plants were observed from N_0 (No fertilizer).The maximum number of branches plant $^{-1}$ at 40 DAS was recorded from N_2 (Basal application with 40 kg N ha^{-1}) and it was followed by N_3 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at branch initiation) and N_5 (Basal application with 20 kg N ha^{-1} and 20 kg N ha^{-1} at pod initiation). At 60 and 80 DAS and at harvest, the maximum number of branches $plant^{-1}$ was recorded from N_3 and it was followed by N_2 and N_4. On the other hand, for different nitrogen management at 40, 60, 80 DAS and at harvest the minimum number of branches $plant^{-1}$ were recorded from N_0 (No fertilizer). The highest plant dry weights at all stages were recorded from N_2 while at 80 DAS and at harvest, it was statistically similar with N_3.On the other hand, for different nitrogen management at 20, 40, 60, 80 DAS and at harvest the lowest plant dry weight were recorded from N_0 (No fertilizer).The highest nodule number $plant^{-1}$ at 40 and 60 DAS were recorded from N_2. At 80 DAS, the maximum nodule number $plant^{-1}$ was recorded from N_4 and it was statistically similar with N_3.At harvest, the maximum nodule number $plant^{-1}$ was recorded from N_3 and it was statistically similar with N_2.Lowest nodule numbers $plant^{-1}$were recorded from N_0. The highest nodule dry weight at 40 and 60 DAS was recorded from N_2 while at 80 DAS and at harvest, the maximum nodule dry weight was recorded from N_3 and it was statistically similar with N_2, N_4 and N_5. On the other hand, for different nitrogen management at 40, 60, 80 DAS and at harvest the lowest nodule dry weight were recorded from N_0. The highest pod number $plant^{-1}$ was recorded from N_3 and it was followed by N_2. On the other hand, for different nitrogen management techniques, the lowest pod number $plant^{-1}$ was recorded from N_0.The highest seed number pod^{-1} was recorded from N_3 and it was statistically similar with N_2. On the other hand, for different nitrogen management techniques, the lowest seed number pod^{-1} was recorded from N_0. The highest 1000-seed weight was recorded from N_3 and it was followed by N_2. On the other hand, for different nitrogen management techniques, the lowest 1000-seed weight was recorded from N_0. The highest grain yield was recorded from N_3 and it was followed by N_2. On the other hand, for different nitrogen management techniques, the lowest grain yield was recorded from N_0.The highest stover yield was recorded from N_2 and it was followed by N_3 which was statistically similar with N_4, N_5 and N_1. On the other hand, for different nitrogen management techniques, the lowest stover yield was recorded from N_0.The highest harvest index was recorded from N_3 and it was followed by N_2. On the other hand, for different nitrogen management techniques, the lowest harvest index was recorded from N_0 (No fertilizer).

Interaction effect of grasspea variety and nitrogen managements showed significant differences on plant height at 20, 40, 60, 80 DAS and at harvest (Table 1). At different stages, maximum plant heights were noted from V_1N_2 (BARI khesari-1 + Basal application with 40 kg N ha^{-1}) and V_2N_2 (BARI khesari-2 + Basal application with 40 kg N ha^{-1}). On the other hand, the lowest plant heights were recorded in V_3N_0 (Local variety + No fertilizer) which was statistically similar with or closely followed by V_2N_0 (BARI khesari-2 + No fertilizer) and V_1N_0 (BARI khesari-1 + No fertilizer).At 40 DAS, the highest branches $plant^{-1}$ was noted from V_2N_2 and it was at par with V_1N_2. But at later stages, highest branches $plant^{-1}$was noted from V_2N_3 and it was either similar or closely followed byV_1N_3.Lowest number of branches $plant^{-1}$ was recorded in V_3N_0.At 40 and 60 DAS, the highest plant dry weight was noted from V_2N_2 and it was followed by V_1N_2.At 80 DAS, the highest plant dry weight was noted from V_2N_2which was followed by V_1N_3 while at harvest, the highest plant dry weight was noted from V_2N_2 and it was statistically similar with V_2N_3, V_1N_3 and V_1N_2. Lowest plant dry weight was recorded in V_3N_0.At 40 DAS, the highest nodule number $plant^{-1}$was noted from V_2N_2 and it was statistically similar with V_1N_2.At 60 and 80 DAS, the highest nodule number $plant^{-1}$ was noted from V_1N_2 and it was followed by V_1N_4.At harvest, the highest nodule number $plant^{-1}$(16.50) was noted from both V_1N_4 and V_2N_2 and they were statistically similar with V_2N_3,V_1N_3,V_1N_2 and

V_1N_5.The lowest nodule numbers plant^{-1}were recorded in V_3N_0 at all four growth stages. At 60 DAS, the highest nodule dry weight was noted from V_2N_2 and it was closely followed by V_1N_2. At 80 DAS, the highest nodule dry weight was noted from V_1N_2 and it was statistically similar with V_1N_3, V_1N_4 and V_2N_5. At harvest, the highest nodule dry weight (1.04 g) was noted from V_1N_4 and V_2N_2. Also V_1N_2, V_1N_3 and V_2N_3 showed better results. The lowest nodule dry weights were recorded in V_3N_0 at all the four plant growth stages. The highest pod number plant^{-1}was noted from V_2N_3 and it was followed by V_1N_3. On the other hand, the lowest pod number plant^{-1}was recorded in V_3N_0.The highest seed number pod^{-1} was noted from V_2N_3 and it was followed by V_1N_3. On the other hand, the lowest seed number pod^{-1}was recorded in V_3N_0.The highest 1000-seed weight was noted from V_2N_3 and it was followed by V_1N_3 and V_3N_3. On the other hand, the lowest 1000-seed weight was recorded in V_3N_0.The highest grain yield was noted from V_2N_3 and it was followed by V_1N_3 and V_1N_4. On the other hand, the lowest grain yield was recorded in V_3N_0. The highest stover yield was noted from V_2N_2 and it was statistically similar with V_1N_2. On the other hand, the lowest stover yield was recorded in V_3N_0. The highest harvest index was noted from V_2N_3 and it was followed by V_1N_3 and V_1N_4. On the other hand, the lowest harvest index was recorded in V_3N_0.

From the above results it can be concluded that BARI khesari-2 is more productive compare to BARI khesari-1 and Local variety. Basal application with 40 kg N ha^{-1} is better for initial growth and development but it can be stated that split application with 20 kg N ha^{-1} as basal dose and 20 kg N ha^{-1} at branch initiation helped in the development of reproductive units of khesari and thus gave better yield in comparison to others. By combining the both treatments, it may be able to increase the production of khesari.

Recommendation for further researches:

i. The same Research works may be conducted with the other important legumes at different agroecological zones (AEZ).

References

CHAPTER 6

REFERENCES

Agbenin, J. O., Lombin, G. and Owonubi, J. J. (1991). Direct and interective effect of boron and nitrogen on selected agronomic parameters and nutrient uptake by mungbean (*Vigna radiata*) under glass house conditions. *Tropic. Agric*. (Trinidad and Tobago) **68**(4):352-362.

Amanullah, J .N. (2004). Performance of lentil varieties at different levels of nitrogen and phosphorus under rainfed condition.*Sarhad J. Agric*. **20** (3):355-358.

Ardeshana, R. B., Modhwadia, M. M., Khanparal, V. D. and Patel, J. C. (1993).Response of greengram (*Phaseoulus radiatus*) to nitrogen, phosphorus and Rhizobium inoculation.*Indian J. Agron*.**38**(3):490-492.

Arya, M. P. S. and Kalra, G. S. (1988). Effect of phosphorus doses on growth, yield and quality of lentil (*Lens culinaris*) and soil. N. *Indian J.Agric. Res.* **22**(1):23-30.

Asthana, A. N. (1998). Pulse crop research in India. *Indian J. Agric. Sci*. **68** (8):448.

Azad, A. S. and Gill, A. S. (1989). Effect of the application of phosphours fertilizer on grain yield of lentil. *News L.***16(**1): 28-30.

Bachchhav, S. M., Jadhav, A. S., Naidu, T. R. V. and Bachhav, M. M. (1994). Effects of nitrogen and nitrogen on leaf area, nodulation and dry matter production in summer greengram.*J. MaharastraAgril. Univ*.**19**(2):211-213.

Badole, W. P. and Umale, R. S. (1994). Efficacy of seed fortification and graded doses of fertilizers on growth, development and yield of mungbean (*Vigna radiata*).*Indian J. Agron*.**39**(4):654-656.

Bali, A. S., Sing, K. N., Shah, M. H. and Khandey, B. A. (1991). Effect of nitrogen and phosphorus fertilizer on yield and plant characters of mungbean (*Vigna radiata* (L.)Wilczek) under the late sown condition of Kasmir valley.*Fertilizer News. India*. **36** (7):59 - 61.

BARC (Bangladesh Agricultural Research Council). (1997). Fertilizer Recommendation. 1997.

BARC (Bangladesh Agricultural Research Council).(2005). Fertilizer Recommendation. 2005.

BBS (Bangladesh Bureau of Statistics). (2011). Stistical Year Book of Bangladesh. Statistics Dvision, Ministry of Planning, Government of the People Republic of Bangladesh, p. 34.

BBS (Bangladesh Bureau of Statistics). (2008). Statistical Year book of Bangladesh. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh.

Bhalu V. B., Sadaria , S G., Kaneria, B.B. and Khan Para, V.D. (1995). Effect of N, P and *Rhizobium* inoculation on yield and quality, N and P uptake and economics of black gram (*Phaselous mungo) Indian J. Agron*. **40**:316-318.

Birari, D.S., Birari, S.P. and Jamadagni, B.M.(1993).Stability analysis of promisinggenotypes of cowpea (*Vigna unguiculata*).*Indian Journal of Agricultural Sciences*, 63(2) : 103-106.

Campbell, C.G., R.B. Mehra., S.K. Agrawal. Y.Z. Chen. A.M. Abd El Moneim., H.I.T. Khawaja.,C.R. Yadov., J.U. Tay., W.A. Araya. (1994). Current status and future strategy in breeding grasspea *Lathyrus sativus*).*Euphytica*73: 167–175.

Cardaso, A. A., Fonts, L. A. and Viebra, C. (1978).Effect of N and magnesium on the pod development of lentil.*Hort. Abst*. **49** (4): 2546.

Chowdhury, M. K. and Rosario, E. L. (1992). Utilization efficiency of applied N as related to yield advantages in maize/lentil (*Lens culinaris*) intercropping. *Field Crops Res.***30**(1-2):441-518.

Clark, R. B., Olsen, J. C. and Bennet, J. H. (1980).Biological aspects of iron in plants. Environment Protection Agency , Cincinnati, OH, USA.

Dutt, R. (1979). N: the major limiting factor for lentil yield. Proc.Second lnfil, Lentil Symposium, AVRDC, Shanhua, Tainan, Taiwan. pp. 244-251.

Edris KM, Islam ATMT, Chowdhury MS, Haque AKM. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh. Dept. Soil Survey, Govt. People's Republic of Bangladesh.118 p.

FAO (Food and Agriculture Organization). (1999). FAO Production Year book.Basic Data Unit. Statistic Division, FAO. Rome, Italy.

Gomez, K. A. and A. A. Gomez. (1984). Statistical procedures for Agricultural Research. John Wiley and Sons. New York, Brisbance. Singapore. PP. 139-240.

Gracy, M., Sreenivasan, E., Anilkumar, K. and Mathew, R., (1998). Effect of phosphorus and sulphur on growth and yield and nutrient uptake of rainfed upland cowpea.*Journal of Tropical Agriculture*, 36 (1-2) : 31-33.

Hamid, A. (1988). Nitrogen and carbon effect on the growth and yield performance of mungbean (*Vigna radiata* L.,). *J. Agron. Crop Sci*. **161**(1):11-16.

Inthong, W. (1987).Effect of inoculation and amount of nitrogen fertilizer at sowing and flowering on nitrogen fixation and yield of mungbean (*Vigna radiata*(L.),.pp.143-145.

Islam, M. M. (2003). Effect of irrigation and N management on the performance of bush bean. (*Phaseolus vulgaris* L.) M. S. thesis. Bangabondhu Shiek Mujibor Rahman Agricultural University.Gazipur-1706.

Islam, M. N. (2002). Competitive interference and productivity in wheat-lentil intercropping system. Ph. D. thesis. Bangabondhu Shiek Mujibor Rahman Agricultural University.Gazipur-1706.

Jadhav, A.G., Shinde, S.H. and Pol, P.S. (1995).Growth and yield of cowpea varieties as influenced by seedling dates.*J. of Maharashtra Agricul. Univ.*, 20 :295-296.

Kalpana, S. (2000). Morpho-physiological traits associated with productivity in cowpea (*Vigna unguiculata*(L.) Walp). *M. Sc. (Agri.) Thesis,* University of Agricultural Sciences

Kaneria, B. B. and Patel, Z. G. (1995).Intergrated weed management and N in India mustard (*Brassica juncea*) and their residual effect of succeeding lentil (*Lens culinaris*). *Indian J. Agron*.**40**(3):444-449.

Karle, A. S. and Pawar, G. G. (1998).Effect of legume residue incorporation and fertilizer in lentil (*Lens culinaris*) safflower cropping system.*J.MaharasthaAgril. Univ*. **23** (3):333-334.

Khanam, D., Rahman, H. H., Bhuiyan, A. H., Islam, Z. and Hossain, A. K. M. (1996).The use of organic residues in increasing crop production in a wheat- mungbean- T. Aman cropping system on red- brown terrace soils. Biological Nitrogen Fixation Associated with Rice Production, International Symposium, Dhaka, Bangladesh. 28 Nov. to 2 Dec. pp. 43-48.

Kramer, P. J. (1988). Water stress and plant growth. *Agron. J*.**55**:31-35.

Kumar, P., Agarwal, J. P. and Chandra, S. (1993). Effect of inoculation, nitrogen and phosphorus on growth yield of lentil. *Lense News L*. **20** (1):57.

Lopes, N. F., Oliva, M. A., Gomes, M. M., Souza, V. P. and Cardoso. M. J. (1988). Growth morphology assimilates partitioning and dry matter production of lentil (*Lens culinaris*) plant under three height levels and two water regims. *Hort. Abst*. **58**(10):733.

Mahboob, A. and Asghar, M. (2002).Effect of seed inoculation and different N levels on the grain yield of lentil (*Lens culinaris*).*Asian J. Pl. Sci*. **1**(4):314-315.

Malik, M. A., Saleem, M. F., Asghar, A. and Ijaz, M. (2003).Effect of N and phophorus application on growth, yield and quality of mungbean (*Vigna radiata* L.). *Pakistan J. Agril. Sci*. **40**(3/4):133-136.

Mandal, K. (2002). Effects of N and phosphorus fertilizer on nutrients uptake and productivity of lentil. M.S. Thesis. Bangladesh Agricultural University, Mymensingh.

Mandal, R. and Sikder, B. C. (1999).Effect of N and phosphorus on the growth and yield of mungbean in saline soil of Khulna, Bangladesh, Dhaka University. **12**(1-2):85-88.

Mozumder, S. N., Salim, M., Islam, M., Nazrul M. I. and Aman, M. M. (2003).Effect of *Bradyrhizonus* inoculums at different N levels on summer mungbean. *Asian J. PI. Sci*.**2** (11):817-822.

Nadeem, M. A., Ahmad, R. and Ahmad, M. S. (2004). Effect of seed inoculation and different fertilizer levels on the growth and yield of mungbean (*Vigna radiata* L.). *J. Agron*. **3** (1):40-42.

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

Panda, N. (1979). Response of crops to phosphorus in India (stern Region) Orissa Uni. of Agric. and Tech. Bhubaneswar, Orissa. pp. 25-27.

Patel, J. R. and Patel, Z. G. (1999). Effects of foliar fertilization of nitrogen and phosphorous on growth and yield of summer mungbean (*Vigna radiata* L. .*IndianJ. Agron.* **39** (4):578-580.

Patel, J. S. and Parmer, M. T. (1986).Response of greengram to varying levels of nitrogen and phosphorus. *Madras Agril. J.* **73** (6):355-356.

Patel, K. S., Thakur, N. P., Chandhari, S. M. and Shah, R. M. (2001).Response of mungbean with nitrogen and nodulation in soil sustaining a high native population.**14**:22-23.

Patel, L. R., Salvi, N. M. and Patel, R. H. (1992). Response of greengram (*Phaseolus vulgaris*) varieties to sulphur fertilization under different levels of nitrogen and phosphorus.*Indian J. Agron* .**37**(4):831-833.

Patel, R. G., Palel, M. P., Palel, H. C. and Palel, R. B. (1984).Effect of graded levels of nitrogen and phosphorus on growth, yield and economics of summer mungbean. *Indian J. Agron.* **29**(3):42-44.

Phimsirkul, P. (1992). N fertilizer rate optimal for Rhizobium on four varieties of mungbean in Mab Bon and Chan Tuk Soil series.Bangkok (Thailand) pp. 76-78.

Purushotham, S., Narayanswamy, G.V., Siddaraju, R. and Girejesh, G.K., (2001).Production potential of fodder cowpea genotypes under rainfed conditions.*Karnataka Journal of Agricultural Sciences*, 14 (2): 446-448.

Quah, S. C. and Jafar, N. (1994). Effect of N fertilizer on seed protein of lentil (*Lens culinaris*). Applied biology beyond the year 2000.ln.Proc. 3rd Symp.Malaysian Soc. Applied Biol. pp.72-74.

Rajender, K., Sing, V. P., Sing, R.C. and Kumar, R. (2003). Monetary analysis on lentil (*Lens culinaris*) during winter season.*Ann. Biol*. **19** (2):123-127.

Raju, M. S. and Varma, S. C. (1984). Response of greengram (*Vigna radiata*) to *Rhizobium* inoculaiton in relation N fertilizer.*Lugume Res.***7** (2):7376.

Russel, D.F. 1986. MSTAT-C Package Programme.Dept. of Crop and Soil Science, Michigan State University, USA.

Salimullah, M., Akhtar, M., Afridi, M. M. R. K. and Ansari, S. A. (1987). Effect of nitrogen and phosphorus on the yield performance of *Vigna radiata* (summer mungbean). Comparative *Physiol. Ecol.(India)***12**(2):85-88.

Santos, P. J. A., Edwards, D. G., Asher, C. J., Dart, P. J. and Barrow, J. J. (1993). Response of Bradyrhibium-inoculated mungbean (*Vigna radiata* L.) to applied N. Plant nutrition from genetic engineering to field practice: Proceedings of the 12th International Plant Nutrition Colloquium, 21-26 September, Perth, Western Australia. pp. 443-446.

Sardana, H. R. and Verma, S. (1987). Combined effect of insecticide and fertilizers on the growth and yield of mungbean (*Vigna radiata* L) *Indian J. Entom*. **49**(1):64-68.

Sarkar, R. K. and Banik, P. (1991).Response of mungbean (*Vigna radiata*) to nitrogen, phosphorus and molybdeum.*Indian J. Agron*.**36**(1):91-94.

Saxena, K. K. and Varma, V. S. (1985).Effect of N, P and K on the growth of yield of lentil (*Lens culinaris*).*Indian J. Agron*. **40** (2): 249-252.

Srinivas, M., Shaik, M., Mohammad, S. (2002). Performance of greengram (*Vigna radiata* L.) and response functions as influienced by different levels of nitrogen and phosphorus. *Crop Res. Hisar*.**24**(3):458-462.

Srivastava, S. N. L. and Varma, S. C. (1982).Effect of bacterial and inorganic fertilization on the growth, nodulatioin and quality of greengram. *Indian J. Agron.***29**(3):230-237.

Suhartatik, E. (1991). Residual effect of lime and organic fertilizer on mungbean (*Vigna radiata* L.) in red yellow podzolic soil: Proceedings of the seminar of food crops Research Balittan Bogor (Indonesia). **2**:267-275.

Tank, U. N., Damor, U. M., Patel, J. C. and Chauhan, D. S. (1992).Response of summer mungbean (*Vigna radiata*) to irrigation, nitrogen and phosphorus .*Indian J. Agron*.**37**(4):833-835.

Tiwari K. R., Campbell CG.(1996). Inheritance of seed weight in grasspea (*Lathyrus sativus* L.).FABIS Newsletter 38/39, 30–33.

Trung, B. C. and Yoshida, S. (1983). Significance and nitrogen nutrition on the productivity of mungbean (*Vigna radiata* L.). *Japanese J. Crop Sci*, **52**(4):493-499.

Werakonphanit, P., Thawonmat, D. and Samani, C. (1979). Study of fertilizer usage for a relay cropping system: Soyabean-sweet corn-mungbean. \= Annual Report of Chainat Field Crop Experiment Station, Bangkok, Thailand. p. 59-68.

Yadav, S. K., Singh, B. R., Kumar, S. and Verma, O. P. S. (1994). Correlation and economic studies on the growth yield and yield parameters of mungbean under inter cropping system with cowpea. *Intl. J. Tropic. Agric*. **12**(1-2):33-35.

Yakadri, M., Thatikunta, R. and Rao, L. M., Thatikunta, R. (2002).Effect of nitrogen and phosphorus on growth and yield of greengram (*Vigna radiata* L.). *Legume Res***.** **25**(2):139 - 141.

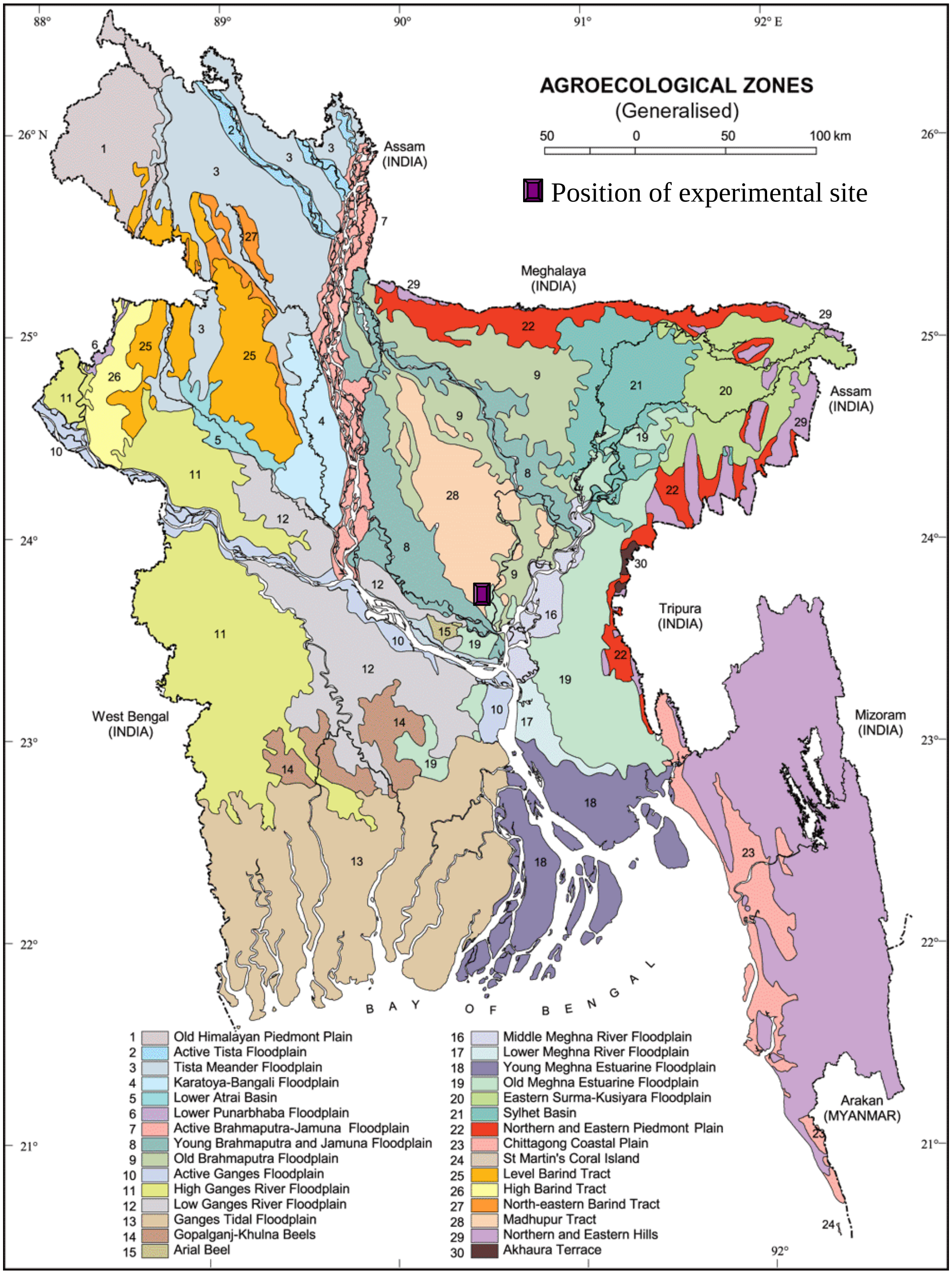
Yein, B. R. (1982). Effect of carbofuran and fertilizers on the incidence of insect pests and on the growth and yield of mungbean (*Vigna radiata* L.). *J. Res*. (*Assam Agril. Univ.)***3**(2):197-203.

Yein, B. R., Harcharan, S., Cheema, S. S. and Singh, H. (1981). Effect of combined application of pesticides and fertilizers on the growth and yield of mungbean (*Vigna radiata* L). *Indian J. Ecol*. **8**(2):180 - 188.

Appendices

APPENDICES

Map showing the experimental site under study



APPENDICES

Appendix I (a): ANOVA table of plant height of grasspea at different growth stages (at 20 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.065	0.033	0.9643	
2	Factor A	2	5.456	2.728	80.8798	0.0000
4	Factor B	5	34.936	6.987	207.1655	0.0000
6	AB	10	2.878	0.288	8.5320	0.0000
-7	Error	34	1.147	0.034		
	Total	53	44.482			

Appendix I (b): ANOVA table of plant height of grasspea at different growth stages (at 40 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.917	0.458	6.1304	0.0053
2	Factor A	2	12.532	6.266	83.8026	0.0000
4	Factor B	5	121.394	24.279	324.7174	0.0000
6	AB	10	2.721	0.272	3.6392	0.0022
-7	Error	34	2.542	0.075		
	Total	53	140.105			

Appendix I (c): ANOVA table of plant height of grasspea at different growth stages (at 60 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.138	0.069	1.9397	0.1593
2	Factor A	2	67.279	33.639	948.0990	0.0000
4	Factor B	5	199.489	39.898	1124.4872	0.0000
6	AB	10	5.812	0.581	16.3795	0.0000
-7	Error	34	1.206	0.035		
	Total	53	273.924			

Appendix I (d): ANOVA table of plant height of grasspea at different growth stages (at 80 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	459.269	229.634	259.5374	0.0000
2	Factor A	2	203.958	101.979	115.2590	0.0000
4	Factor B	5	371.667	74.333	84.0131	0.0000
6	AB	10	15.496	1.550	1.7514	0.1089
-7	Error	34	30.083	0.885		
	Total	53	1080.473			

Appendix I (e): ANOVA table of plant height of grasspea at different growth stages (at harvest)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	459.269	229.634	259.5374	0.0000
2	Factor A	2	203.958	101.979	115.2589	0.0000
4	Factor B	5	371.667	74.333	84.0130	0.0000
6	AB	10	15.496	1.550	1.7514	0.1089
-7	Error	34	30.083	0.885		
	Total	53	1080.473			

Appendix II (a): ANOVA table of number of branches plant^{-1} of grasspea at different growth stages (at 40 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.024	0.012	0.6538	
2	Factor A	2	6.650	3.325	183.4447	0.0000
4	Factor B	5	24.883	4.977	274.5521	0.0000
6	AB	10	1.892	0.189	10.4370	0.0000
-7	Error	34	0.616	0.018		
	Total	53	34.065			

Appendix II (b): ANOVA table of number of branches plant^{-1} of grasspea at different growth stages (at 60 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.136	0.068	1.9737	0.1545
2	Factor A	2	26.708	13.354	387.8215	0.0000
4	Factor B	5	69.950	13.990	406.2918	0.0000
6	AB	10	2.107	0.211	6.1202	0.0000
-7	Error	34	1.171	0.034		
	Total	53	100.073			

Appendix II (c): ANOVA table of number of branches plant^{-1} of grasspea at different growth stages (at 80 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.339	0.170	2.1146	0.1363
2	Factor A	2	79.394	39.697	494.8630	0.0000
4	Factor B	5	61.843	12.369	154.1880	0.0000
6	AB	10	3.064	0.306	3.8197	0.0016
-7	Error	34	2.727	0.080		
	Total	53	147.368			

Appendix II (d): ANOVA table of number of branches plant^{-1} of grasspea at different growth stages (at harvest)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.243	0.122	1.4970	0.2382
2	Factor A	2	79.684	39.842	490.2176	0.0000
4	Factor B	5	87.411	17.482	215.1008	0.0000
6	AB	10	3.451	0.345	4.2462	0.0007
-7	Error	34	2.763	0.081		
	Total	53	173.553			

Appendix III (a): ANOVA table of plant dry weight (g) of grasspea at different growth stages (at 20 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.002	0.001	4.7033	0.0157
2	Factor A	2	0.007	0.004	17.7087	0.0000
4	Factor B	5	0.060	0.012	59.9390	0.0000
6	AB	10	0.006	0.001	3.1515	0.0059
-7	Error	34	0.007	0.000		
	Total	53	0.082			

Appendix III (b): ANOVA table of plant dry weight (g) of grasspea at different growth stages (at 40 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.047	0.024	1.5456	0.2278
2	Factor A	2	0.481	0.240	15.6545	0.0000
4	Factor B	5	4.437	0.887	57.7863	0.0000
6	AB	10	0.124	0.012	0.8051	
-7	Error	34	0.522	0.015		
	Total	53	5.611			

Appendix III (c): ANOVA table of plant dry weight (g) of grasspea at different growth stages (at 60 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.104	0.052	1.5082	0.2357
2	Factor A	2	1.833	0.916	26.6115	0.0000
4	Factor B	5	22.713	4.543	131.9033	0.0000
6	AB	10	0.933	0.093	2.7093	0.0146
-7	Error	34	1.171	0.034		
	Total	53	26.754			

Appendix III (d): ANOVA table of plant dry weight (g) of grasspea at different growth stages (at 80 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.171	0.086	1.1108	0.3409
2	Factor A	2	1.885	0.943	12.2115	0.0001
4	Factor B	5	51.338	10.268	133.0296	0.0000
6	AB	10	2.752	0.275	3.5654	0.0026
-7	Error	34	2.624	0.077		
	Total	53	58.770			

Appendix III (e): ANOVA table of plant dry weight (g) of grasspea at different growth stages (at harvest)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.536	0.268	3.5742	0.0390
2	Factor A	2	21.843	10.922	145.5337	0.0000
4	Factor B	5	97.875	19.575	260.8422	0.0000
6	AB	10	5.067	0.507	6.7522	0.0000
-7	Error	34	2.552	0.075		
	Total	53	127.873			

Appendix IV (a): ANOVA table of nodule number plant^{-1}of grasspea at different growth stages (at 40 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	5.444	2.722	0.4452	
2	Factor A	2	341.778	170.889	27.9487	0.0000
4	Factor B	5	797.722	159.544	26.0933	0.0000
6	AB	10	28.000	2.800	0.4579	
-7	Error	34	207.889	6.114		
	Total	53	1380.833			

Appendix IV (b): ANOVA table of nodule number plant^{-1} of grasspea at different growth stages (at 60 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	8.037	4.019	0.6406	
2	Factor A	2	293.815	146.907	23.4174	0.0000
4	Factor B	5	853.426	170.685	27.2077	0.0000
6	AB	10	14.407	1.441	0.2297	
-7	Error	34	213.296	6.273		
	Total	53	1382.981			

Appendix IV (c): ANOVA table of nodule number plant^{-1} of grasspea at different growth stages (at 80 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	24.565	12.282	14.9490	0.0000
2	Factor A	2	177.065	88.532	107.7531	0.0000
4	Factor B	5	389.370	77.874	94.7808	0.0000
6	AB	10	173.769	17.377	21.1494	0.0000
-7	Error	34	27.935	0.822		
	Total	53	792.704			

Appendix IV (d): ANOVA table of nodule number plant^{-1} of grasspea at different growth stages (at harvest)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	3.593	1.796	2.3128	0.1144
2	Factor A	2	90.009	45.005	57.9442	0.0000
4	Factor B	5	628.981	125.796	161.9649	0.0000
6	AB	10	39.102	3.910	5.0344	0.0002
-7	Error	34	26.407	0.777		
	Total	53	788.093			

Appendix V (a): ANOVA table of nodule dry weight (g) of grasspea at different growth stages (at 40 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.001	0.001	0.4456	
2	Factor A	2	0.076	0.038	27.7689	0.0000
4	Factor B	5	0.180	0.036	26.2254	0.0000
6	AB	10	0.006	0.001	0.4633	
-7	Error	34	0.047	0.001		
	Total	53	0.311			

Appendix V (b): ANOVA table of nodule dry weight(g) of grasspea at different growth stages (at 60 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.011	0.006	1.0593	0.3578
2	Factor A	2	0.169	0.084	15.6498	0.0000
4	Factor B	5	0.532	0.106	19.7733	0.0000
6	AB	10	0.033	0.003	0.6115	
-7	Error	34	0.183	0.005		
	Total	53	0.929			

Appendix V (c): ANOVA table of nodule dry weight (g) of grasspea at different growth stages (at 80 DAS)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.034	0.017	17.2881	0.0000
2	Factor A	2	0.224	0.112	114.4832	0.0000
4	Factor B	5	0.514	0.103	105.1430	0.0000
6	AB	10	0.238	0.024	24.3629	0.0000
-7	Error	34	0.033	0.001		
	Total	53	1.042			

Appendix V (d): ANOVA table of nodule dry weight (g) of grasspea at different growth stages (at harvest)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.013	0.006	2.2321	0.1228
2	Factor A	2	0.349	0.175	60.2755	0.0000
4	Factor B	5	2.563	0.513	176.8947	0.0000
6	AB	10	0.161	0.016	5.5414	0.0001
-7	Error	34	0.099	0.003		
	Total	53	3.185			

Appendix VI: ANOVA table of number of pods plant^{-1} of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	3.000	1.500	1.4037	0.2596
2	Factor A	2	124.111	62.056	58.0703	0.0000
4	Factor B	5	573.056	114.611	107.2508	0.0000
6	AB	10	36.333	3.633	3.4000	0.0036
-7	Error	34	36.333	1.069		
	Total	53	772.833			

Appendix VII: ANOVA table of number of seeds pod^{-1} weight of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	1.943	0.972	0.5941	
2	Factor A	2	121.893	60.946	31.1468	0.0000
4	Factor B	5	304.932	60.986	45.8441	0.0000
6	AB	10	19.201	1.901	1.1788	0.0084
-7	Error	34	45.613	1.342		
	Total	53	493.582			

Appendix VIII: ANOVA table of 1000-seed weight of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	1.943	0.972	0.5941	
2	Factor A	2	101.893	50.946	31.1468	0.0000
4	Factor B	5	374.932	74.986	45.8441	0.0000
6	AB	10	19.281	1.928	1.1788	0.3384
-7	Error	34	55.613	1.636		
	Total	53	553.662			

Appendix IX: ANOVA table of grain yield of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.005	0.002	1.1728	0.3217
2	Factor A	2	0.405	0.203	95.4895	0.0000
4	Factor B	5	2.340	0.468	220.4916	0.0000
6	AB	10	0.217	0.022	10.2246	0.0000
-7	Error	34	0.072	0.002		
	Total	53	3.039			

Appendix X: ANOVA table of stover yield of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.019	0.010	2.3079	0.1149
2	Factor A	2	0.382	0.191	45.4671	0.0000
4	Factor B	5	2.448	0.490	116.4495	0.0000
6	AB	10	0.600	0.060	14.2679	0.0000
-7	Error	34	0.143	0.004		
	Total	53	3.592			

Appendix XI: ANOVA table of harvest index (%) of grasspea

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	2.862	1.431	0.5161	
2	Factor A	2	109.155	54.577	19.6823	0.0000
4	Factor B	5	1396.755	279.351	100.7428	0.0000
6	AB	10	141.466	14.147	5.1017	0.0002
-7	Error	34	94.279	2.773		
	Total	53	1744.518			