# APPROACH TO HIGHER PRODUCTION OF GRASSPEA THROUGH MANIPULATING ITS CANOPY STRUCTURE

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**JUNE, 2018**

# APPROACH TO HIGHER PRODUCTION OF GRASSPEA THROUGH MANIPULATING ITS CANOPY STRUCTURE

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**REGISTRATION NO. 17-08186**

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of

**MASTER OF SCIENCE**

**IN**

**AGRONOMY**

**SEMESTER: JANUARY- JUNE, 2018**

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# *CERTIFICATE*

This is to certify that the thesis entitled **"APPROACH TO HIGHER PRODUCTION OF GRASSPEA THROUGH MANIPULATING ITS CANOPY STRUCTURE"** submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **EVANA AKTAR**, Registration No. **17-08186** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

**June, 2018**
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**Dedicated to**

**My**

**Beloved Parents**

***ACKNOWLEDGEMENTS***

*The author first wants to articulate her enormous wisdom of kindness to the Almighty "**ALLAH**" for His never ending blessing, protection, regulation, perception and assent to successfully complete of research and prepare thesis.*

*The author would like to express her deepest sense of gratitude to her research supervisor, **Professor Dr. Md. Fazlul Karim,** Department of Agronomy, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, for his scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.*

*The author also grateful to her respected Co-Supervisor **Associate Professor Dr. Anisur Rahman,** Department of Agronomy, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.*

*The author would like to express her deepest respect and boundless gratitude to her honorable teachers, Department of Agronomy, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, for their valuable teaching, sympathetic co-operation, direct and indirect advice, suggestions and inspirations during the whole study period.*

*The author expresses her unfathomable tributes, sincere gratitude and heartfelt indebtedness from her core of heart to her father, mother, brother and sister whose blessings, inspirations, sacrifices and moral supports opened the gate and paved to way of her higher study.*

***June, 2018*** ***The Author***

***SAU, Dhaka***

**APPROACH TO HIGHER PRODUCTION OF GRASSPEA THROUGH MANIPULATING ITS CANOPY STRUCTURE**

## ABSTRACT

The experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka to study the effects of shoot clipping of grasspea on its growth and yield during the period of November 2017 to February 2018. The experiment was consisted of two factors *viz*. (1) two varieties of grasspea $V_1$ (BARI Khesari-3) and $V_2$ (BARI Khesari-4) and (2) six levels of shoot clipping, *viz*. $C_0$ (No shoot clipping), $C_1$ (Shoot clipping at 10 cm plant height), $C_2$ (Shoot clipping at 15 cm plant height), $C_3$ (Shoot clipping at 20 cm plant height), $C_4$ (Shoot clipping at 25 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height). The experiment was laid out in Split Plot Design with three replications. Results revealed that both varieties had similar performance during their growth and development. Shoot clipping at 20 cm plant height showed better performance comparing other clipping treatment. Considering combined effect of variety and shoot clipping, both varieties gave maximum seed yields (1.55- 1.61 t $ha^{-1}$) which was about 27.4 % greater than without practice ( without clipping, $V_1C_0$, $V_2C_0$) when they were being clipped down at 20 cm plant height. However, the highest number of pods $plant^{-1}$ (28.10), number of seeds $pod^{-1}$ (3.70), and grain yield (1.55 and 1.61 t $ha^{-1}$) were found from treatment combination $V_1C_3$, and $V_2C_3$, respectively. Treatment $V_2C_3$ produced significantly higher yields (1.61 t $ha^{-1}$) due to maximum pods $plant^{-1}$ (28.10) and seeds $pod^{-1}$ (3.70).

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## ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| cm | = | Centimeter |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan's Multiple Range Test |
| *et al.,* | = | And others |
| e.g. | = | exempli gratia (L), for example |
| etc. | = | Etcetera |
| FAO | = | Food and Agricultural Organization |
| g | = | Gram (s) |
| i.e. | = | id est (L), that is |
| Kg | = | Kilogram (s) |
| LSD | = | Least Significant Difference |
| $m^2$ | = | Meter squares |
| ml | = | MiliLitre |
| M.S. | = | Master of Science |
| No. | = | Number |
| SAU | = | Sher-e-Bangla Agricultural University |
| var. | = | Variety |
| $^oC$ | = | Degree Celceous |
| % | = | Percentage |
| NaOH | = | Sodium hydroxide |
| GM | = | Geometric mean |
| mg | = | Miligram |
| P | = | Phosphorus |
| K | = | Potassium |
| Ca | = | Calcium |
| L | = | Litre |
| µg | = | Microgram |
| USA | = | United States of America |
| WHO | = | World Health Organization |

# CHAPTER I

# INTRODUCTION

Pulses are considered as one of the most important sources of vegetable protein in human daily diet. Owing to rapid increase in population and the importance of pulses, the interest for growing pulses is increasing day by day when farmer's interest was declined in pulse cultivation (FAO, 2016)

Among major pulses growing in Bangladesh, grasspea (*Lathyrus sativus* L.) is an important pulse crop commonly known as khesari. It occupies the second highest position in terms of both acreage (89,474 ha) and production (83,000 ton) (BBS, 2011). According to FAO (2016), per-capita intake of pulse should be 80 g day$^{-1}$, where as it is only 12 g in Bangladesh (BBS, 2017). Grasspea is also important pulse crop in India, China, Pakistan and Nepal (Campbell *et al*., 1994; Yadav and Mehta, 1995).

In Bangladesh, grasspea is grown as Rabi crop and is known as 'poor men's diet' and is valued as a nutritious staple food and fodder crop primarily due to its relatively high protein content (18–34% in dry seeds, 17% in mature plant) and also high lysine, amino acid content (Siddique *et al*., 1996.and Jabeen *et al*., 1988). 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) as unlike others pulses it is also classified as good soil nitrogen fixer through symbiosis with rhizobium bacteria (Negi *et al*., 2006). Pulses add about 60-100 kg N ha$^{-1}$ in soil through its nodals or roots (Alam *et al*., 2010).

In Bangladesh grasspea is cultivated for human food and fodder for livestock as well adapted to low rainfall, fairly tolerant to water-logging (Rahman *et al*., 2015). It is often the last crop to stand in case of extreme conditions. The average yield (500 kg ha$^{-1}$) of grasspea is very poor comparing other growing countries (Khan *et al*., 2013) in the world.

There are many reasons have been identified against with backdrop production of this crop. Improper management coupled with its morphological structure is very important to be addressed for improving yield. Grasspea has got a vigorous postural growth habit as indeterminate crop. The maximum leaf area is not productive due to mutual sowing effects (wang *et al*., 2000). Shoot clipping or canopy architecture can be considered as an important improved cultural approach which may influence plant closer to determinant crop having less mutual sheding for improving yield.Verburg *et al*. (1996) reported that resource acquisition in clipped plant consequently improve yield. Ruess and Coughenour (1983) opined that clipped plant has great nitrogen use efficiency. Costa *et al*. (1992) suggested that clipping a portion of the shoot is one of the most important means for getting productive vegetative biomass for yield improvement. Shoot clipping altered the size of different *Indigofera spp*. to a great extent, producing more inflorescence towards higher yield (Jahan *et al.*, 2014). Mondal *et al*. (2011) got an optimum yield and yield attributes in mungbean through defoliation. Hossain *et al*. (2006a, b) reported that partial source removal in cowpea induces increase in pod and seed yield through the production of higher number of flowers in plant with reduced rate of floral abscission. In maize plant grain yield was improved through clipping three leaves above the cob (Tilahun, 1993). Clipped shoot also has a great option for feeding of livestock. Hence this may be a new era of grasspea cultivation both for human and livestock.

Considering the above fact, shoot clipping of different grasspea genotypes could be an important management option to obtain higher yield which did not get attention in our country. Hence this experiment was undertaken with following objectives –

1. To find out  the varietal performance of the two grasspea varieties
2. To find out the optimum height/or days when shoot clipping is important of grasspea for higher seed yield
3. To study the combined effect of variety and shoot cliping on the growth and yield of grasspea

# CHAPTER II

# REVIEW OF LITERATURE

A good number of research works on different aspects of grasspea production have been done by research workers in and outside of the country, especially in the South East Asia for the improvement of grasspea production. Recently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started research on varietal development and improvement of this crop. In this chapter, relevant literatures from home and abroad have been reviewed to gather knowledge on different varieties and shoot clipping in pulse crops under the following heads.

## 2.1 Effect of variety/genotype on growth and yield

Abbas *et al*. (2019) carried out an experiment to evaluate the adaptability of ten elite genotypes of lentil (*Lens culinaris* M.) and one check variety at three different locations. Trials were conducted during two consecutive years (2013–2014). Genotype × environment interactions (of crossover nature) among 11 genotypes and 3 environments were observed to be highly significant. Mean seed yield was found maximum for NL 56-1 (718 kg $ha^{-1}$) followed by NL 96475A (709 kg $ha^{-1}$). NL 96475A was the most stable genotype with mean yield greater than the grand mean, non-significant estimates of unit regression coefficient, and deviation from regression.

Kalita and Chakrabarty (2017) conducted a field trial to study the performance of grass pea (*Lathyrus sativus* L.) varieties (Ratan, Nirmal, Prateek and Mahateora) under varying seed rates (50, 55 and 60 kg $ha^{-1}$) in winter rice relay cropping situations during Rabi 2014-15 and 2015-16. Among the varieties, ‘Prateek’ performed very well and gave the highest grain yield (863.89 kg $ha^{-1}$ in 2014-15 and 791.67 kg $ha^{-1}$ in 2015-16).

Laghari *et al*. (2016) conducted an experiment to evaluate the growth and yield response of five elite grass pea (*Lathyrus sativus*L.) genotypes to varying levels of potassium. The study involved five grasspea genotypes (Sel-B 111, Sel-449, Sel-190, Sel-1785 and Sel-945) and three K doses (0, 10 and 20 kg K ha$^{-1}$). The results revealed that the variety, Sel-449 was the most responsive genotype to K nutrition which resulted in higher branches per plant (5.3), pods per plant (29.7), seeds per pod (4.5), 1000 seed weight (87.3 g) and seed yield (2504 kg ha$^{-1}$) as compared to its counterparts. The genotype Sel-1785 was much closer to Sel-449 for its growth and yield traits. Moreover, the grasspea genotype Sel-449 was more responsive to potassium nutrition as compared to other genotypes.

Rahman *et al*. (2015) collected four lentil genotypes from ICARDA (International Center for Agricultural Research in Dry Areas), Aleppo, Syria and evaluated under five locations in Bangladesh *viz*. Pulses Research Center, Ishurdi; Regional Agricultural Research Station, Jessore; Regional Agricultural Research Station, Jamalpur; Regional Pulse Research Station, Madaripur and Bangladesh Agricultural Research Institute, Gazipur during the year 2013-14. The lines are BLX 07003-6, BLX 07004-7, BLX 07004-2, BLX 07004-12 and BARI masur-7 as check. Significant variation was observed for days to flowering, days to maturity, pods plant$^{-1}$, 1000 seed weight and yield in kg hectare$^{-1}$. Among the test entries, BLX 07004-2 showed the highest numbers of pods plant$^{-1}$ followed by BLX 07004-12 while the largest seed size was recorded in BLX 07004-12. The lowest days to maturity was recorded in BLX 07004-7. The entry BLX 07003-6 showed the highest plant height followed by BLX 07004-2. The lowest disease score of stemphylium blight was recorded in BLX 07004-12 and BARImasur-7 followed by BLX 07004-2 and BLX 07003-6. The entry BLX 07004-2 showed the highest yield followed by BLX 07004-12.

Goa and Ashamo (2014) conducted field experiments consisting of 24 field pea genotypes for performance and correlation of yield and its components in five locations. Significant difference was observed in all locations among the field pea genotypes for grain yield. The top mean grain yield (2659 kg ha$^{-1}$) over the locations was achieved by the genotype Gume followed by Milky (2625 kg ha$^{-1}$), FpEx-Dz (2511 kg ha$^{-1}$) and Weyyetu (2460 kg ha$^{-1}$).

Bhavi *et al*. (2013) reported that the seed yield and husk yield differs significantly among the three pigeonpea genotypes. The seed yield and husk yield produced by genotypes BSMR 736 (1447 kg ha$^{-1}$ and 1052 kg ha$^{-1}$, respectively) and ICPL 87119 (1368 kg ha$^{-1}$ and 992 kg ha$^{-1}$, respectively) were found to be significantly higher than the seed yield (1259 kg ha$^{-1}$ and 901 kg ha$^{-1}$, respectively) obtained by ICPL 8863. The extent of reduction in seed yield by ICPL 8863 was 15 and 9 per cent when compared to BSMR 736 and ICPL 87119, respectively. Among different genotypes nitrogen availability was significantly superior with ICPL 8863 (217.93 kg ha$^{-1}$). 30 genotypes were grouped into seven clusters.

Tuppad *et al*. (2012) found that the seed yield (1308 kg ha$^{-1}$) produced by genotype BSMR-736 was found to be significantly higher than the seed yield (1125 kg ha$^{-1}$) obtained by TS-3R and it was found to be at par with ICPL-85063 (1146 kg ha$^{-1}$). The extent of reduction in seed yield by TS-3R and ICPL-85063 was 16 and 14 percent when compared to BSMR -736, respectively.

Rasul *et al*. (2012) conducted a field trial to establish the proper inter-row spacing and suitable variety evaluation. Three mung bean varieties $V_1$, $V_2$, $V_3$ (NM-92, NM-98, and M-1) were grown at three inter-row spacings respectively. The highest seed yield was obtained from variety $V_2$ at 30 cm spacing. Among varieties $V_2$ exhibited the highest yield 727.02 kg ha$^{-1}$, while the lowest seed yield 484.79 kg ha$^{-1}$ was obtained from $V_3$.

Hariram *et al*. (2011) tested four genotype viz., AL 201', 'AL 1492', 'AL 1507' and 'AL 1514' in respect to their growth, development and yield parameters; and noticed that genotypes AL 1492 gave significant higher grain yield than all other genotypes and took maximum duration as well as growing degree days for flowering (50%) and maturity.

Das *et al*. (2011) reported that the pooled deviation was significant for all the characters except pod length. Three varieties namely Jagriti 1, ICP 909 and DSLR 38 were considered as stable for seed yield plant$^{-1}$, as they showed average stability with high yield. The varieties Jagriti 1 and ICP 909 also possessed average stability for pods plant$^{-1}$.

Agugo *et al*. (2010) grown four mungbean accessions collected from the Asian Vegetable Research and Development Centre (AVRDC) and reported a significant difference in the yield of the varieties with VC 6372 (45-8-1) producing the highest seed yield of 0.53 t ha$^{-1}$. This was followed by NM 92, 0.48 t ha$^{-1}$; NM 94, 0.40 t ha$^{-1}$; and VC 1163 with 0.37 t ha$^{-1}$. The variety, VC 6372 (45-8-1), also formed good agronomic characters.

Pramod *et al*. (2010) found that the three genotypes in sub plots (Asha, Maruti and BSMR-736). Among different genotypes, BSMR-736 (14.95 q ha$^{-1}$) and Asha (14.13 q ha$^{-1}$) produced, significantly higher seed yield when compared to Maruti genotype.

Kumar *et al*. (2009) carried out field studies to determine the growth behavior of mungbean genotypes sown on different dates under irrigated conditions. The treatments consisted of 2 genotypes (SML 668 and MH 318) and 6 sowing dates starting from 1 March to 19 April, at of 10-days interval. Results showed that SML 668 had higher plant height than MH 318 and the less height of both the genotypes during summer was due to low average temperature during the initial growth stage. SML 668 accumulated more drymatter than MH 318. The contribution of leaves and stem was more in SML 668, whereas the contribution of pods towards total aboveground biomass at harvest was higher in MH 318.

Tickoo *et al*. (2006) conducted a field experiment with mungbean cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP $ha^{-1}$. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t $ha^{-1}$, respectively) compared to cv. Pusa 105.

Tikle and gupta (2006) reported that the grain yield was highest in JSMP 98-2 (2704 kg $ha^{-1}$). Nodule number and grain yield of JSMP 98-2 were significantly higher than JA 4, indicating significance of genotypes in effects on grain yield. The correlation coefficient among different characters showed positive association of nodule number with grain yield (0.96 t $ha^{-1}$).

Rahman *et al*. (2005) carried out an experiment with mungbean involving 2 planting methods (line sowing and broadcasting) with 5 mungbean cultivars (Local, BARI mung 2, BARI mung 3, Binamoog 2 and BINA moog 5). Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of Binamoog 2 and the lowest in local cultivar. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Bhati *et al*. (2005) conducted studies to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean). The experiment with mungbean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher grain yield and 13.7% higher fodder yield than the local cultivar.

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, and G, H) to evaluate yield performance. Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbeam cultivars was also conducted in the farmer's field.

Kaplana (2000) reported that the different growth habit belonging to cowpea genotypes indicated higher values of photosynthetic rate, transpiration rate, stomata 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.

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.

Briar *et al*. (1993) observed that among seven promising genotypes of cowpea, the high yielding genotypes were V-16 (9.39 g plant$^{-1}$) and ACCC-210 (8.17 g plant$^{-1}$). ACCC-210 showed a high degree of predictability for pods plant$^{-1}$, pod length, 100-grain weight and harvest index and was rated as the most stable genotype.

**2.2 Effect of canopy management**

Leao and Lima (2018) carried out an experiment to evaluate the influence of the canopy management for the formation of lateral shoots associated with density of canes on the yield and quality of grapes “Surgeon”. The experiment was carried out over two growing seasons (2011-2012). The treatments consisted of two canopy managements (shoot topping associated to elimination of lateral shoots and shoot topping and formation of lateral shoots) combined with two to three densities of canes after pruning (1.8, 2.8 and 3.8 canes m$^{-2}$ ). The formation of “lateral shoots” increased yield and number of clusters plant$^{-1}$ during two consecutive growing seasons, besides using 2.8 varas m$^{-2}$ resulted in the highest yields only in 2011 growing season. The variables mass bunch, mass berry, soluble solids (SS), soluble sugar, titratable acidity (TA) and pulp firmness were not affected by treatments, while the attributes related to color, as like brightness and hue angle of the skin, and total extractable polyphenols content were influenced by canopy management, especially in the 2012 growing season.

Mitra *et al*. (2018) observed that high density planting (HDP) is a highly efficient and advanced production system of fruit cultivation. High yield and good fruit quality can be achieved with a high density orchard in guava when the orchard has good light distribution throughout the tree canopy and there is a balance between vegetative growth and cropping. Guava bears on the current season emerging shoots. Regular pruning of shoots after fruit harvest encourages development of lateral shoots from which flowering occurs. Researchers from major guava growing countries like India, Mexico, Cuba, Venezuela, Australia, etc. have worked out the optimum plant density and canopy management techniques for higher yield and quality guava production. The techniques for ultra-high density (5000 plants $ha^{-1}$) planting and rejuvenation of old, unproductive or senile orchards by canopy management have also been standardized in India.

Singh *et al*. (2017) conducted a field experiment on guava *cv*. Hisar Safeda planted under different plant density to study the changes in nutrient composition of leaves after pruning and pinching. A significant difference was observed in N, P and K content due to different pruning levels and pinching numbers at different planting density of guava during rainy season. The highest N, P and K content was recorded in leaves taken from plants subjected to severe pruning up to 60% removal of shoot followed by 40 and 20% removal of shoot as compared to leaves taken from unpruned plants irrespective of pinching and spacing. Regarding pinching, the maximum N, P and K content in leaves and fruit yield was recorded taken from plants pinched twice, which was followed by leaves taken from plants pinched one time and the minimum in leaves and fruit yield taken from control plants with no pinching irrespective of pruning and spacing, while irrespective of pruning and pinching spacing also significantly affected the leaves nutrient composition as the highest N, P and K content was registered in leaves and fruit yield taken from plants at 5m × 5m spacing, which was followed by leaves taken from plants at 5m × 4m and 5m × 3m spacing and the minimum taken from plants at closer spacing (5m × 2m).

Pathirana *et al*. (2014) conducted the present study to find a suitable method of canopy management and fruit cluster pruning for high seed quality. Tomato variety Thilina was used for the experiment and plants were established in a replicated field trial. Three levels of cluster pruning and canopy management were employed namely,; nopruning and fruit thinning, pruning with thinning up to 2 fruits cluster$^{-1}$ and 5 fruit clusters plant$^{-1}$, pruning with thinning up to 5 fruits/cluster and 5 fruit clusters plant$^{-1}$. Treatments were evaluated in terms of fruit yield, seed purity, 1000 seed weight, seed germination, seed viability and seedling vigour. Pruning with thinning up to 2 fruits cluster$^{-1}$ and 5 fruit clusters plant$^{-1}$ yielded larger fruits compared to the fruits produced by the other plants. Pruning along with fruit thinning had increased the seed weight compared to the control treatment. The cluster pruning had no advantage on seed germination however,seedling vigour was greatly benefited. The highest shoot length was observed in pruning with thinning up to 2 fruits cluster$^{-1}$ and 5 fruit clusters plant$^{-1}$ compared to other treatments. The results revealed that canopy management and fruit thinning are good practices for improving the seedling vigour of the resultant seeds.

Jogaiah *et al*. (2013) carried out an experiment to find out the effect of canopy management practices on berry composition of red and white grape cultivars grown. Cabernet Sauvignon and Sauvignon Blanc vines were selected for the study. Both the cultivars exhibited significant variation in fruit composition parameters in response to various canopy management practices. Combination treatment of leaf removal (LR) either with shoot thinning (ST) or cluster thinning (CT) exhibited high total soluble solids (TSS), the lowest acidity (malic acid), lower potassium content and higher anthocyanin content. The vines which received ST+CT+LR treatment and control vines recorded least anthocyanin concentration and phenolic compound sindicating excess light exposure or excess shade to clusters is not congenial for producing better quality fruits. Leaf removal treatment in combination with either shoot thinning or cluster thinning was found to be superior under semi-arid tropical conditions to obtain good quality fruits and higher yield.

Anon (2010) reported that usually, two to ten flowers could be found in one flower cluster of tomato. Proper pollination causes to transform 8 flowers into fruits on an average. However, this level of heavy bearing decreases the ultimate fruit quality of the harvest due to misshaping, formation of small fruits and uneven ripening. This is often seen in cultivars having large fruits. Therefore, to regulate fruit size and other related quality attributes, tomato clusters are pruned in order to maintain a lower number of fruits cluster$^{-1}$. It is essentially done in controlled environment agriculture (CEA). As a rule of thumb, in cultivars having larger fruits, clusters should be thinned to 3 – 4 fruits and it is practiced once a week. Pruning should be practiced in tomato at regular intervals for maintaining a well balance between the plant growth and fruit production. Pruning and other training practices should be done in weekly intervals. Most indeterminate type tomatoes are pruned in to a single stem in CEA. Inappropriate pruning may result weak stems with heavy loads of irregular sized and shaped fruits. Fruit maturity also becomes unequal under this situation, thus making the harvesting difficult.

Xiao *et al*. (2004) conducted an experiment on tomato plant and found that removal of young leaves have shown positive effects on dry matter partitioning towards the fruits, while maintaining LAI at a sufficiently higher level. As the number of fruits in a cluster has to share the photosynthate, the reserves for seeds are distributed among all the fruits in the plant when the source is limited, equal distribution of photosynthate causes to underdevelopment of fruits. It reduces the size of fruit, seed size and also the seed quality. As the harvesting progresses, plant vigour is also reduced resulting decline in seed vigour and seed reserves leading to deterioration of seed quality.

Cus *et al*. (2004) carried out three years experiment (1995-1997) with Sipon, Zametovka, and Rebula that are locally spread grapevine (*Vitis vinifera*) cultivars to improve their quality. Training system performed for each cultivar was double. All three experiments were grounded as block trial with two factors: crop load (two levels) and canopy management (three levels). At the harvest yield vine$^{-1}$ and must sugar and acid contents were recorded. Lower number of buds vine$^{-1}$ of Sipon and Zametovka significantly lowered the yield per vine in all three years and only in 1996 for Rebula. Cluster thinning or cluster shortening had no significant effect on the yield vine$^{-1}$ of Sipon and Zametovka, but cluster thinning of Rebula significantly decreased it in 1995 and 1997. Higher must sugar content of Sipon and Zametovka was reached by the lower yield charge (20 buds per vine). The latter had no significant influence on the must sugar content of Rebula. Commonly used canopy management practices, consisting of shoot positioning, suckering, lateral removal, and topping significantly increased must sugar content of Sipon and Zametovka.

Naor *et al*. (2002) observed that crop load affects canopy density and consecutively impact on the fruit or seed quality. It is determined by winter pruning and thus represents the first practice for control growth vigour and producing capacity of the cluster plant$^{-1}$. Pruning is the cheapest way of reducing the number of clusters plant$^{-1}$ and influence on the leaf area yield ratio.

Vasconcelos and Castagnoli (2000) carried out an experiment on leaf canopy structure of mature Pinot noir grapevines which was manipulated during two consecutive seasons:shoot tipping at full bloom (yes or no), lateral shoot length (no laterals, laterals cut back to four leaves at fullbloom, laterals allowed to grow undisturbed), and cluster zone leaf removal (leaf removal in the cluster zone orno leaf removal). Shoot tipping at bloom increased percent fruit set, berries cluster$^{-1}$, cluster weight, yield shoot$^{-1}$, and yield to pruning ratio. Shoot tip removal also increased main and lateral leaf size and the contribution of lateral leaves to total leaf area. Tipping decreased total yield vine$^{-1}$, juice pH, leaf area vine$^{-1}$, pruning weight, and cane weight and sugars in the trunk during dormancy. Increasing lateral shoot length increased juice soluble solids, juice pH, skin anthocyanin content, cane weight, and sugar and total non-structural carbohydrates in the trunk during dormancy. Percent fruit set increased in the absence of vegetative growing tips, on either the main or lateral shoots. Leaf removal in the cluster zone four weeks after bloom had no impact on yield components but reduced juice soluble solids.

Koblet *et al*. (1996) found that Grapevine canopy management affects canopy microclimate, photosynthetic activity, yield, grape composition and wine quality. Type and extent of canopy management practices depend on many factors such as rootstock-scion combination, density of plantation, training system, crop load, grapevine vigour, soil type, and climate conditions (Hunter, 2000). Accordingly, canopy management should be applied regarding to the grapevine cultivar that is grown in the defined conditions and respecting to the goal of the viticulture production(Carbonneau, 1996).

Heuvelink (1996) reported that source - sink relationship is apparently the major determinant of the final fruit yield of tomato. Studies have shown that, the relationship between source and sink of tomato plants might be varied with light penetrationthrough the canopy, plant density of the particular field and its genetic make-up. Hence agronomic practices such as leaf removal is followed to manipulate source–sink relationship mainly through modified leaf area index (LAI). LAI in tomato is influenced by stem density, number of leaves on a stem and individual leaf size.

# CHAPTER III

# MATERIALS AND METHODS

In this chapter a short description of the location of experimental plot, climatic condition of research area, materials and methods used, design of the experiment, method of cultivation, data collection, statistical analysis etc. have been presented.

## 3.1 Experimental site

The research work was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 2017 to February 2018. Experimental field was located at 90°22$^{/}$ E longitude and 23°41$^{/}$ N latitude and altitude of 8.2 m above the sea level. The experimental site is presented in Appendix I.

## 3.2 Climate

Experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high temperature and relatively long day period during “Kharif-1” season (April-September) and scarce rainfall, low humidity, low temperature and short day period during “Rabi” season (October-March). This climate is also characterized by distinct season, *viz*. the monsoon extending from May to October, the winter or dry season from November to February and per-monsoon period or hot season from March to April. The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix II.

## 3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract in Agroecological Zone (AEZ)-28 (UNDP, 1988). It was medium high land and the soil series was Tejgaon (FAO, 1988). The soil was having a texture of sandy loam with pH and CEC were 5.6 and 2.64 meq/100 g soil, respectively. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix III.

### 3.4 Planting materials

The varieties of grasspea used in the present experiment was BARI Khesari-3 and BARI Khesari-4. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

### 3.5 Treatments of the experiment

**Factor A – Variety -2**

1. $V_1$ = BARI Khesari-3
2. $V_2$ = BARI Khesari-4

**Factor B – Shoot clipping - 6**

1. $C_0$ =No clipping
2. $C_1$ = shoot clipping at 10 cm (25 DAS) plant height
3. $C_2$ = shoot clipping at 15 cm (30 DAS) plant height
4. $C_3$= shoot clipping at 20 cm (35 DAS) plant height
5. $C_4$ = shoot clipping at 25 cm (40 DAS) plant height
6. $C_5$ = shoot clipping at 30 cm (45 DAS) plant height

There were 12 (2×6) treatment combinations given below:
$V_1C_0$, $V_1C_1$, $V_1C_2$, $V_1C_3$, $V_1C_4$, $V_1C_5$, $V_2C_0$, $V_2C_1$, $V_2C_2$, $V_2C_3$, $V_2C_4$, $V_2C_5$

### 3.6 Design and layout of the experiment

The two factor experiment was laid out in the Split Plot Design with three replications. In total 36 plots for 3 replications. The size of each unit plot was (4 m × 2.5 m) or 10 $m^2$. The distance maintained between two replications and two plots were 1 m and 0.5 m, respectively. The layout of the experiment is shown in Appendix IV.

### 3.7 Land preparation

The experimental area was first ploughed by a power tiller and the soil was exposed to sun for 5 days. Then the land was thoroughly prepared by ploughing and cross ploughing. The weeds and stubbles were removed from the field. Then the land was divided into 36 unit plots keeping plot and block to block spacing. During land preparation, carbofuran @ 16 kg $ha^{-1}$ was mixed with the soil uniformly for controlling soil borne insects.

### 3.8 Application of fertilizer and manure

Recommended dose of N, $P_2O_5$, $K_2O$, S and B at the rate of 20, 40, 20, 20, and 1 kg $ha^{-1}$ respectively, were added to the soil as basal dose in the form of Urea, Triple Super Phosphate, Murate of Potash, Gypsum and Boric acid. Whole amount of cowdung, urea, TSP, MoP, $ZnSO_4$ and Boric acid were applied at the time of final land preparation as basal dose.

### 3.9 Sowing of seeds

Seeds were sown in line on 15 November 2017, maintaining plant to plant distance of 10 cm and row to row distance of 30 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. Surrounding of the experimental plots, grasspea seeds were also sown as border crop to reduce border effects.

### 3.10 Intercultural operation

#### 3.10.1 Thinning

When the plants established, 1 healthy plant at 10 cm distance in a row was kept and remaining was thinnedout.

#### 3.10.2 Weeding and mulching

Weeding and mulching were done whenever it was necessary to keep the plots free from weeds and to pulverize the soil.

#### 3.10.3 Plant protection

No pesticide was applied as the crop was not infected either by insect or disease.

### 3.11 Harvesting

At full maturity, the grasspea crop was harvested plot wise. Plants from each plot was harvested from marked area.

### 3.12 Collection of data

Five representative plants were selected at random from each unit plot to avoid border effect and tagged in the field. Data were recorded periodically from the sample plants at 20 days interval from 20 DAS to harvest. The details of data recording are given below:

#### 3.12.1 Plant height (cm)

Plant height was considered as the height from ground level to the tip of the largest leaf of the plants. The plant height was recorded at 20, 40, 60, 80, 100 days after sowing (DAS) and at harvest. Plant height of five randomly sampled plants were recorded and mean was calculated in centimeter (cm).

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

The number of branches of five randomly selected plants from each plot at different days after sowing. Number of branches plant$^{-1}$ was recorded at 20, 40, 60, 80, 100 DAS and harvest.

#### 3.12.3 Leaf dry matter plant$^{-1}$ (g)

The number of leaves of five randomly selected plants was counted from each unit plot at 20 days interval from 20 DAS to at harvest and collected leaves were oven dried at 70°C for 72 hours until a constant weight was obtained and then averaged to record data.

#### 3.12.4 Stem dry matter plant$^{-1}$ (g)

After removing of leaves, stems from 5 selected plants were collected from each plot and were placed in oven maintained at $70^{0}$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded in gram.

#### 3.12.5 Pods plant$^{-1}$ (no)

Number of pods from five randomly selected plants was counted and their mean values were calculated.

### 3.12.6 Seeds pod$^{-1}$(no)

Number of seeds pod$^{-1}$ was recorded from 20 randomly selected mature pods from five plants and the mean value was calculated.

### 3.10.7 Thousand seed weight (g)

Thousand seeds were randomly taken from the harvest of each plot. The seeds were weighted at about 12% moisture level using an electric balance.

### 3.12.8 Grain yield (t ha$^{-1}$)

Seed were harvested from each unit plot and their weight was recorded and expressed in gram (g). The grain yield plot$^{-1}$ was finally converted to yield hectare$^{-1}$ and expressed in t ha$^{-1}$

### 3.12.9 Straw yield (t ha$^{-1}$)

Straw of each harvested area was sun dried for three consecutive days and was measured and converted to t ha$^{-1}$.

### 3.12.10 Biological yield (t ha$^{-1}$)

Biological yield was calculated using the following formula

Biological yield = Grain yield + Straw yield

### 3.12.11 Harvest index (%)

Harvest index was determined by the following formula

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

### 3.13 Statistical analysis

The recorded data on different parameters were statistically analyzed using Statistix 10. The analysis of variance for the characters under study were performed by ‘F’ variance test. Treatment means was compared using least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted on '**Approach to higher production of grasspea through manipulating its canopy structure**' and the results on effectiveness of various treatments for the management of grasspea production have been described and discussed below in detail under the following heading:

## 4.1 Growth parameters

### 4.1.1 Plant height (cm)

**Effect of variety**

Non-significant variation on plant height was observed among the varieties at all growth stages except 60 DAS and at harvest where $V_2$ is superior than $V_1$ (Fig. 1 and Appendix V). However, the highest plant height (11.05, 19.99, 35.50, 41.36, 46.32 and 46.49 cm at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_2$ (BARI Khesari-4) and the lowest plant height (10.92, 19.66, 29.96, 38.34, 44.22 and 43.98 cm at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_1$ (BARI Khesari-3).

**Effect of shoot clipping**

Significant variation was observed on plant height at different growth stages influenced by different shoot clipping treatments (Fig. 2 and Appendix V). The highest plant height (11.52, 21.21, 35.38, 44.02, 47.80 and 47.08 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from $C_0$ (No shoot clipping) which was significantly identical with $C_1$ and similar with $C_5$ at 20 DAS; $C_4$ at 40, 60, 100, 60 DAS and at harvest. The lowest plant height (10.54, 18.96, 30.45, 38.22, 43.43 and 43.38 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the shoot clipping treatment $C_2$ (Shoot clipping at 15 cm plant height) which was statistically identical with the $C_3$

(Shoot clipping at 20 cm plant height) at 20, 60 DAS and at harvest; $C_5$ at 40 DAS; all clipping treatment except $C_0$ at 80 and 100 DAS.

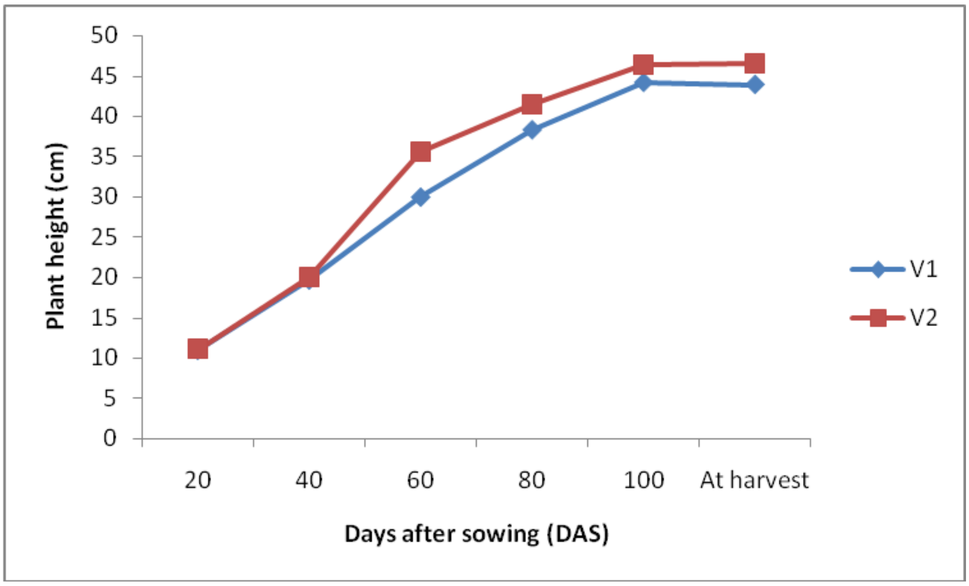


Fig. 1. Effect of variety on plant height of grasspea at different days after sowing

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

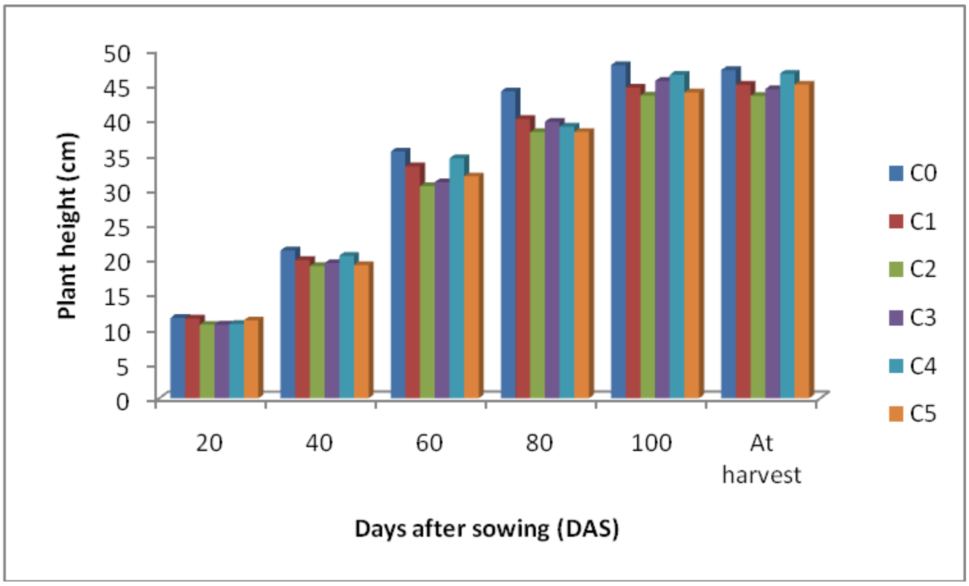


Fig. 2. Effect of shoot clipping on plant height of grasspea at different days after sowing

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## Combined effect of variety and shoot clipping

Plant height was significantly varied due to combined effect of variety and shoot clipping at 40, 60 DAS and at harvest but at 20, 80 and 100 DAS it was not significant (Table 1 and Appendix V).The highest plant height (11.79, 22.04, 39.54, 46.60, 50.91 and 50.75 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the treatment combination of $V_2C_0$. This treatment combination ($V_2C_0$) was statistically identical with $V_2C_1$ at 60 DAS and with $V_2C_4$ at harvest. The lowest plant height (10.12, 17.41, 28.10, 35.73, 40.76 and 41.73 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the treatment combination of $V_1C_2$ which was statistically similar with the treatment combination of $V_1C_1$, $V_1C_3$, and $V_2C_5$ at 40 DAS and with $V_1C_0$, $V_1C_1$, $V_1C_3$, and $V_1C_5$ at 60 DAS and with $V_1C_0$, $V_1C_3$, $V_1C_4$, $V_1C_5$ and $V_2C_1$ at harvest.

Table 1. Combined effect of variety and shoot clipping on plant height (cm) of grasspea at differentdays after sowing

| Treatment | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|
| | 20 | 40 | 60 | 80 | 100 | At harvest |
| $V_1C_0$ | 10.53 | 19.91 b-e | 29.99 c-e | 41.43 | 44.68 | 42.99 de |
| $V_1C_1$ | 10.81 | 19.06 c-f | 31.22 b-e | 40.67 | 43.28 | 45.95 bc |
| $V_1C_2$ | 10.12 | 17.41 f | 28.10 e | 35.73 | 40.76 | 41.73 e |
| $V_1C_3$ | 10.47 | 18.67 ef | 28.46 de | 38.70 | 44.25 | 42.98 de |
| $V_1C_4$ | 11.26 | 20.38 a-e | 32.67 b-d | 36.57 | 46.02 | 43.40 c-e |
| $V_1C_5$ | 11.16 | 19.44 b-e | 29.30 de | 36.97 | 40.99 | 43.53 c-e |
| $V_2C_0$ | 11.79 | 22.04 a | 39.54 a | 46.60 | 50.91 | 50.75 a |
| $V_2C_1$ | 11.62 | 20.61 a-c | 38.85 a | 39.47 | 45.89 | 44.05 b-e |
| $V_2C_2$ | 11.26 | 20.51 a-d | 33.91 bc | 40.97 | 46.09 | 45.03 b-d |
| $V_2C_3$ | 10.97 | 20.15 b-e | 32.44 b-d | 40.63 | 46.80 | 45.75 bc |
| $V_2C_4$ | 10.64 | 20.96 ab | 33.89 bc | 39.87 | 46.78 | 50.14 a |
| $V_2C_5$ | 11.19 | 18.87 d-f | 34.37 b | 40.63 | 46.77 | 46.49 b |
| $LSD_{0.05}$ | NS | 1.78 | 4.07 | NS | NS | 2.81 |
| CV(%) | 4.19 | 5.27 | 7.74 | 4.93 | 4.56 | 3.64 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

### 4.1.2 Number of branches plant$^{-1}$

**Effect of variety**

There was a significant variation on number of branches plant$^{-1}$was which found at 20 and 60 DAS but at 40, 80, 100 DAS and at harvest non-significant variation was observed among two varieties of grasspea (Fig. 3 and Appendix VI). However, the highest number of branches plant$^{-1}$ (4.00, 5.58, 7.22, 6.37, 6.21, and 5.57 at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_2$ (BARI Khesari-4) and the lowest number of branches plant$^{-1}$ (3.06, 5.57, 5.97, 5.58 5.77 and 5.42 at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_1$ (BARI Khesari-3).

**Effect of shoot clipping**

Significant variation was observed on number of branches plant$^{-1}$ at 20, 60, 100 DAS and at harvest but non-significant variation was observed at 40 and 80 DAS among the treatments influenced by different shoot clipping treatments (Fig. 4 and Appendix VI). At 20, 60, 100 DAS and at harvest, the highest number of branches plant$^{-1}$ (3.80, 7.10, 6.63 and 5.93, respectively) was obtained from the treatment $C_3$ (Shoot clipping at 20 cm plant height). The effect of this treatment $C_3$ (Shoot clipping at 20 cm plant height) was statistically identical with $C_4$ (Shoot clipping at 25 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height) at 20 DAS, and also statistically identical with $C_2$ (Shoot clipping at 15 cm plant height) and $C_4$ (Shoot clipping at 25 cm plant height) at 60 DAS. At 100 DAS and at the time of harvest, statistically similar result was also observed at all treatment except clipping treatment $C_0$ (No shoot clipping) . As a result in brief, the highest number of branches plant$^{-1}$ (3.80, 5.87, 7.10, 6.37, 6.63 and 5.93 at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height). The lowest number of branches plant$^{-1}$ (3.17, 5.33, 6.03, 5.87, 5.48, 5.07 at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping) which was statistically identical with $C_2$ (shoot clipping at 15 cm plant) and similar with , $C_1$ (shoot clipping at 10 cm plant height) at 20 DAS; identical with $C_5$ (Shoot clipping at 30 cm plant height) and similar with $C_1$ (shoot clipping at 10 cm plant height) at 60 and similar with all treatment except $C_3$ (Shoot clipping at 20 cm plant height).

**Combined effect of variety and shoot clipping**

Number of branches plant$^{-1}$was significantly varied due to combined effect of variety and shoot clipping at all growth stages except at 80 DAS and at harvest (Table 2 and Appendix V). The highest number of branches plant$^{-1}$ (4.53, 6.13, 8.13 and 7.27 at 20, 40, 60 and 100 DAS, respectively) was obtained from the treatment combination of $V_2C_3$ which was statistically similar with the treatment combination of $V_1C_2$, and $V_2C_0$ at 20 DAS; $V_2C_2$ and $V_2C_4$ at 60 and at 100 DAS with all treatment combination except $V_1C_0$, $V_1C_1$ and $V_1C_5$. The lowest number of branches plant$^{-1}$ at 20, 40, 60 and 100 DAS (2.40, 4.93, 5.40 and 4.83, respectively) was obtained from the treatment combination of $V_1C_0$ which was statistically identical with the treatment combination of $V_1C_1$ and similar with $V_1C_5$ at 20, 40, 60 and 100 DAS. However, it was summarized that, the highest number of branches plant$^{-1}$ (4.53, 6.13, 8.13, 6.40, 7.27 and 6.67 at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the treatment combination of $V_2C_3$ and the lowest number of branches plant$^{-1}$ (2.40, 4.93, 5.40, 4.73, 4.83 and 4.40 at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the treatment combination of $V_1C_0$

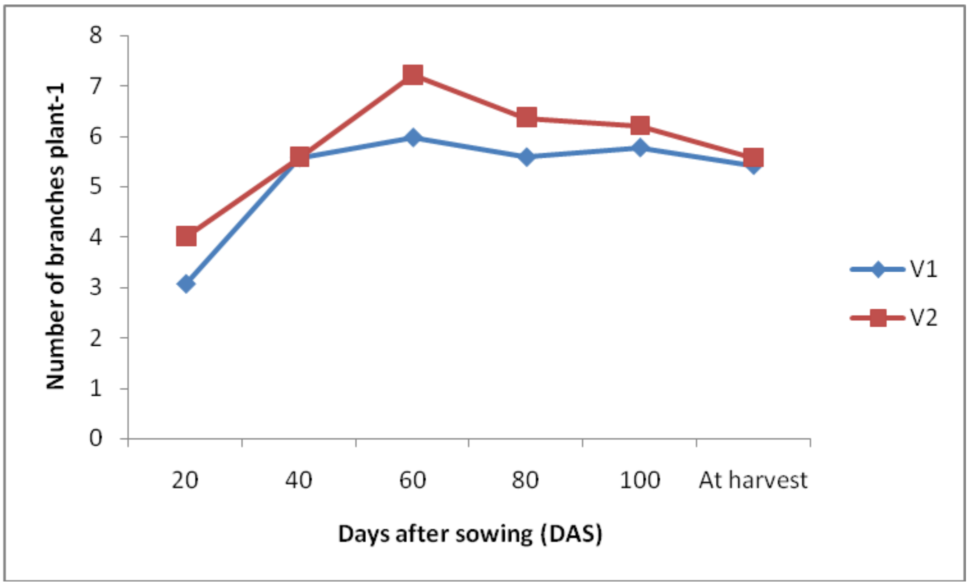


Fig. 3. Effect of variety on number of branches plant$^{-1}$ of grasspea at different days after sowing

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

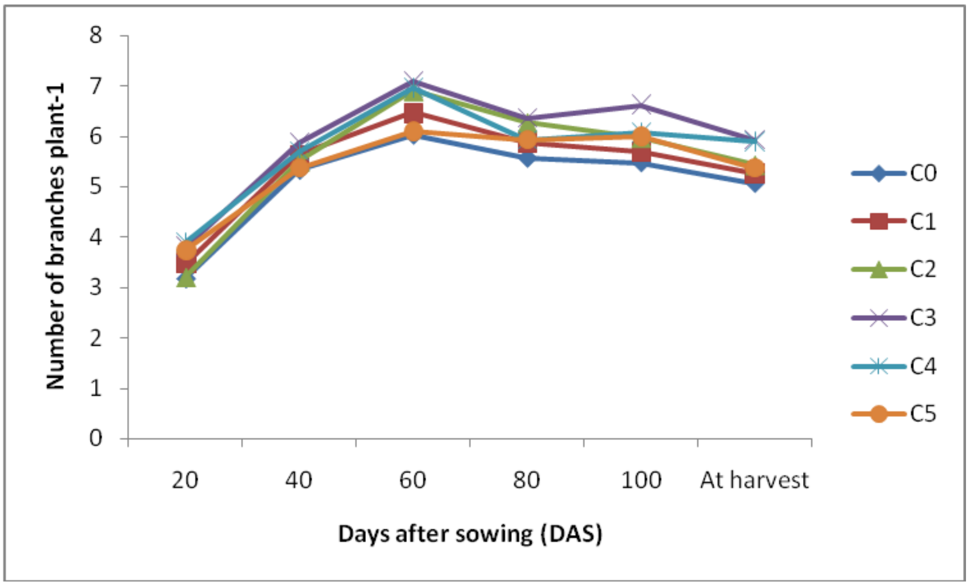


Fig. 4. Effect of shoot clipping on number of branches plant$^{-1}$ of grasspea at different days after Sowing

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

Table 2. Combined effect of variety and shoot clipping on number of branches plant$^{-1}$ of grasspea at different days after sowing

| Treatment | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|
| | 20 | 40 | 60 | 80 | 100 | At harvest |
| $V_1C_0$ | 2.40 f | 4.93 c | 5.40 g | 4.73 | 4.83 c | 4.40 |
| $V_1C_1$ | 2.47 f | 5.67 a-c | 6.00 d-g | 5.53 | 5.80 bc | 5.07 |
| $V_1C_2$ | 3.93 a-c | 5.47 a-c | 6.87 b-e | 6.33 | 6.00 a-c | 6.33 |
| $V_1C_3$ | 3.07 de | 5.47 a-c | 6.07 d-g | 6.20 | 5.53 bc | 5.33 |
| $V_1C_4$ | 3.80 bc | 5.93 ab | 5.80 e-g | 5.87 | 6.00 a-c | 5.47 |
| $V_1C_5$ | 2.60 ef | 5.27 bc | 5.67 fg | 5.93 | 5.33 bc | 5.60 |
| $V_2C_0$ | 4.33 ab | 5.73 a-c | 6.67 b-f | 5.93 | 6.07 a-c | 5.26 |
| $V_2C_1$ | 3.87 bc | 5.60 a-c | 6.93 b-d | 6.20 | 6.13 a-c | 5.47 |
| $V_2C_2$ | 3.80 c | 5.27 bc | 7.73 ab | 6.53 | 6.40 ab | 4.80 |
| $V_2C_3$ | 4.53 a | 6.13 a | 8.13 a | 6.40 | 7.27 a | 6.67 |
| $V_2C_4$ | 3.93 bc | 5.60 a-c | 7.33 a-c | 6.20 | 6.17 a-c | 5.20 |
| $V_2C_5$ | 3.53cd | 5.80 ab | 6.53 c-f | 6.00 | 6.20 ab | 6.33 |
| $LSD_{0.05}$ | 0.49 | 0.86 | 1.09 | NS | 1.25 | NS |
| CV(%) | 8.20 | 9.02 | 9.69 | 16.96 | 12.24 | 12.81 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

### 4.1.3 Leaf dry matter plant$^{-1}$ (g)

### Effect of variety

The recorded data on leaf dry matter plant$^{-1}$ was significant at 40 and 60 DAS but at 20, 80, 100 DAS and at harvest was not significant influenced by varietal difference (Fig. 5 and Appendix VI). However, the highest leaf dry matter plant$^{-1}$ (0.23, 1.46, 4.22, 4.61, 5.88 and 5.46 g at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_2$ (BARI Khesari-4). The lowest leaf dry matter plant$^{-1}$ (0.18, 1.02, 6.08, 4.00, 5.86 and 5.36 g at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the variety $V_1$ (BARI Khesari-3).

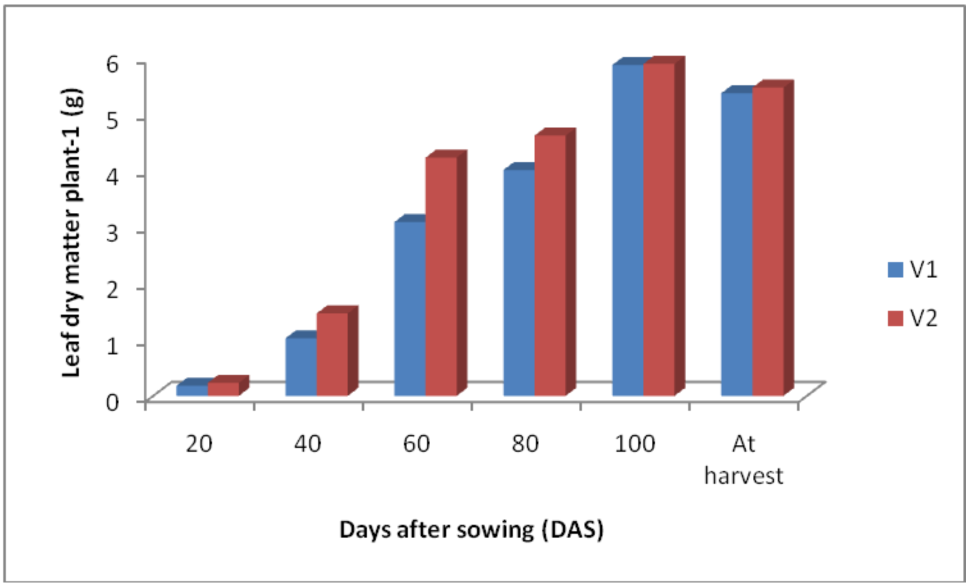


Fig. 5. Effect of variety on leaf dry matter (g) of grasspea at different days after sowing

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

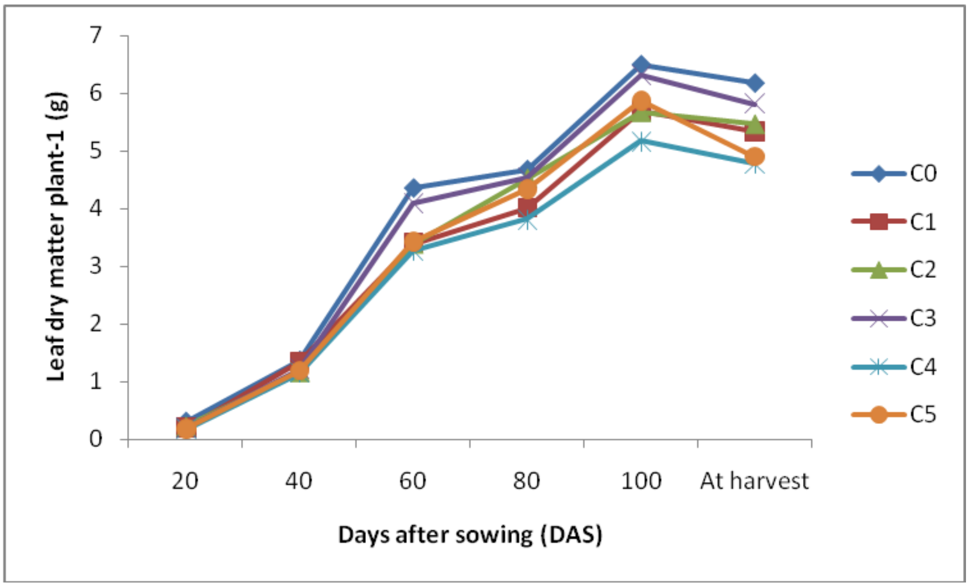


Fig. 6. Effect of shoot clipping on leaf dry matter (g) of grasspea at different days after sowing

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

**Effect of shoot clipping**

Significant variation was observed for leaf dry matter plant$^{-1}$ at 20, 60 and 100 DAS and at harvest but it was not differed significantly at 40 and 80 DAS among the treatments affected by different shoot clipping treatments (Fig. 6 and Appendix VI). At 20 DAS, the highest leaf dry matter plant$^{-1}$ (0.30 g) was found from $C_0$ (No shoot clipping) where the lowest (0.17 g) was found from $C_4$ (Shoot clipping at 25 cm plant height) which was statistically identical with the treatment $C_1$ (Shoot clipping at 10 cm plant height), $C_2$ (Shoot clipping at 15 cm plant height), $C_3$ (Shoot clipping at 20 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height). At 60 DAS, the highest leaf dry matter plant$^{-1}$ (4.35 g) was found from $C_0$ (No shoot clipping) which was statistically similar with the treatment $C_3$ (Shoot clipping at 20 cm plant height) where the lowest (3.27 g) was found from $C_4$ (Shoot clipping at 25 cm plant height). At 100 DAS, $C_0$ (No shoot clipping) showed the highest leaf dry matter plant$^{-1}$ (6.49 g) which was statistically identical with $C_3$ (Shoot clipping at 20 cm plant height) and closely followed by $C_1$ (Shoot clipping at 10 cm plant height), $C_2$ (Shoot clipping at 15 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height) where the lowest (5.17 g) was found from $C_4$ (Shoot clipping at 25 cm plant height). At the time of harvest, $C_0$ (No shoot clipping) also showed the highest leaf dry matter plant$^{-1}$ (6.17 g) which was statistically similar with the $C_3$ (Shoot clipping at 20 cm plant height) where the lowest (4.78 g) was found from $C_4$ (Shoot clipping at 25 cm plant height) which was statistically similar with the treatment $C_5$ (Shoot clipping at 30 cm plant height).

As a result in brief, the highest leaf dry matter plant$^{-1}$ (0.30, 1.36, 4.35, 4.67, 6.49 and 6.17 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping). The lowest leaf dry matter plant$^{-1}$ (0.17, 1.15, 3.27, 3.81, 5.17 and 4.78 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the shoot clipping treatment $C_4$ (Shoot clipping at 25 cm plant height).

Table 3. Interaction of variety and shoot clipping on leaf dry matter (g) of grasspea at different days after sowing

| Treatment | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|
| | 20 | 40 | 60 | 80 | 100 | At harvest |
| $V_1C_0$ | 0.24 | 1.47 a | 3.93 | 4.61 | 5.21 | 5.42 |
| $V_1C_1$ | 0.13 | 1.29 a-c | 2.75 | 3.61 | 5.43 | 5.14 |
| $V_1C_2$ | 0.17 | 1.01 cd | 3.80 | 4.29 | 6.14 | 5.27 |
| $V_1C_3$ | 0.11 | 0.98 cd | 3.49 | 4.43 | 5.20 | 5.70 |
| $V_1C_4$ | 0.10 | 0.82 d | 2.31 | 3.04 | 5.15 | 4.37 |
| $V_1C_5$ | 0.22 | 1.01 b-d | 3.30 | 4.43 | 5.94 | 5.21 |
| $V_2C_0$ | 0.35 | 1.71 a | 5.20 | 5.06 | 6.57 | 7.29 |
| $V_2C_1$ | 0.25 | 1.40 a-c | 3.80 | 4.41 | 5.96 | 4.41 |
| $V_2C_2$ | 0.17 | 1.33 a-c | 4.39 | 4.79 | 6.17 | 5.00 |
| $V_2C_3$ | 0.27 | 1.45 ab | 4.47 | 4.58 | 6.47 | 6.90 |
| $V_2C_4$ | 0.23 | 0.98 cd | 2.83 | 4.27 | 6.41 | 4.80 |
| $V_2C_5$ | 0.25 | 1.36 a-c | 3.56 | 4.24b | 5.79 | 5.46 |
| $LSD_{0.05}$ | NS | 0.40 | NS | NS | NS | NS |
| CV(%) | 26.90 | 19.22 | 18.53 | 21.92 | 15.54 | 9.88 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## Combined effect of variety and shoot clipping

Combined effect of variety and shoot clipping showed non-significant variation on leaf dry matter plant$^{-1}$ at 20, 60, 80, 100 DAS and at harvest but at 40 DAS it was found significant among the treatment combinations (Table 3 and Appendix V). At 40 DAS, the highest leaf dry matter plant$^{-1}$ (1.71 g) was obtained from the treatment combination of $V_2C_0$ which was statistically identical with the treatment combination of $V_1C_0$ where the lowest (0.82 g) was found from $V_1C_4$ (0.82 g) which was statistically similar with the treatment combination of $V_1C_2$, $V_1C_3$ and $V_2C_4$. Similar trend was also observed by the advancement of the growth stages but non-significant variation was found among the treatments. As a result in brief, the highest leaf dry matter plant$^{-1}$ (0.35, 1.71, 5.20, 5.06, 6.57 and 7.29 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the treatment combination of $V_2C_0$ and the lowest leaf dry matter plant$^{-1}$ (0.10, 0.82, 2.31, 3.04, 5.15 and 4.37g at

20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the treatment combination of $V_1C_4$.

### 4.1.4 Stem dry matter plant$^{-1}$ (g)

**Effect of variety**

Significant variation was observed on stem dry matter plant$^{-1}$ at all growth stages except at 20 DAS and at the time of harvest it was influenced by different varieties of grasspea (Fig. 7 and Appendix VI). The highest stem dry matter plant$^{-1}$(0.18, 1.04, 4.04, 5.40, 8.14 and 6.94 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the variety $V_2$ (BARI Khesari-4). The lowest stem dry matter plant$^{-1}$(0.15, 0.70, 2.49, 4.45, 6.69 and 6.32 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the variety $V_1$ (BARI Khesari-3).

**Effect of shoot clipping**

Stem dry matter plant$^{-1}$ was significantly influenced by different shoot clipping treatments at different growth stages (Fig. 8 and Appendix VI). It was found that the highest stem dry matter plant$^{-1}$(0.20, 0.96, 4.02, 5.52, 8.78 and 8.15 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height). At 60 and 100 DAS it was significantly similar with $C_2$ (Shoot clipping at 15 cm plant height) but significantly same with $C_4$ (Shoot clipping at 25 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height) at 80 DAS. At the time of harvest it was significantly similar with $C_5$ (Shoot clipping at 30 cm plant height). The lowest stem dry matter plant$^{-1}$(0.12, 0.77, 2.74, 4.12, 6.01 and 6.02 g at 20, 40, 60, 80, 100 and at harvest, respectively) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping) which was statistically identical with the treatment $C_1$ (Shoot clipping at 10 cm plant height), $C_2$ (Shoot clipping at 15 cm plant height) and $C_4$ (Shoot clipping at 25 cm plant height) at the time of harvest.

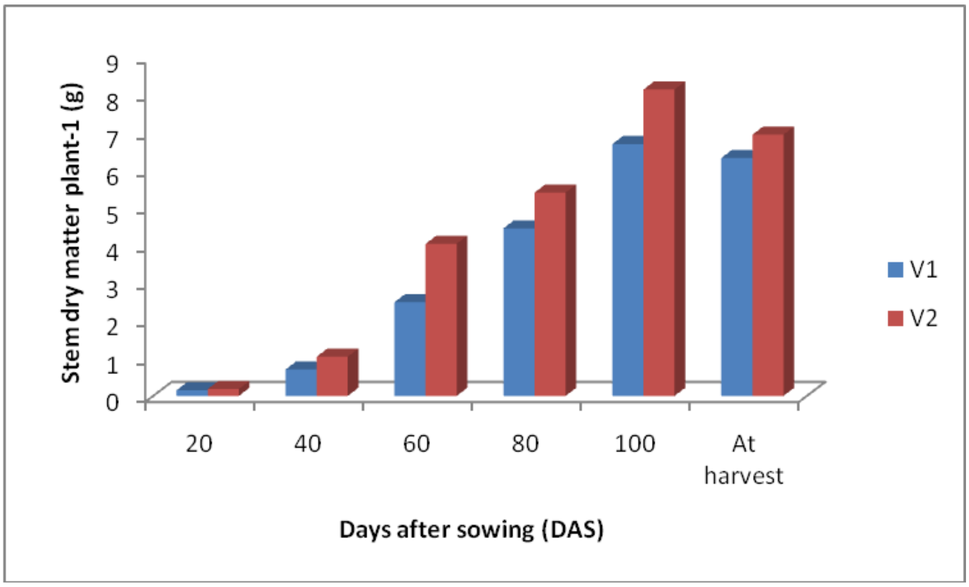


Fig. 7. Effect of variety on stem dry matter (g) of grasspea at different days after sowing

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

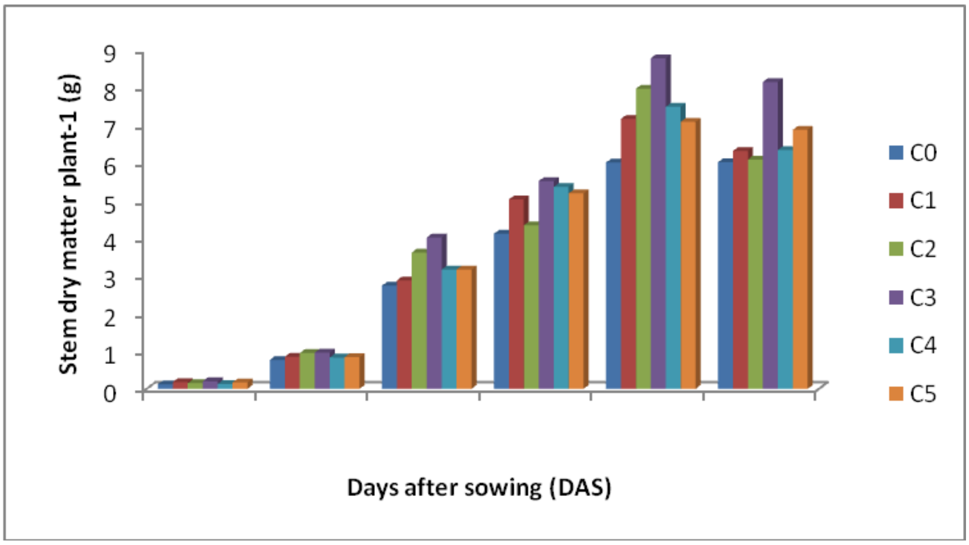


Fig. 8. Effect of shoot clipping on stem dry matter (g) of grasspea at different days after sowing

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## Combined effect of variety and shoot clipping

At the time of harvest, treatment combination of $V_2C_3$ showed non-significant difference on stem dry matter plant$^{-1}$ but at 20, 40, 60, 80 DAS it was significant among the treatments affected by combined effect of variety and shoot clipping at all growth stages (Table 4 and Appendix V). Result revealed that the highest stem dry matter plant$^{-1}$(0.21, 1.28, 4.88, 6.01, 8.99 and 8.46 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from the treatment combination of $V_2C_3$. The lowest stem dry matter plant$^{-1}$(0.09, 0.57, 1.65, 2.87, 5.49 and 5.30 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was observed from the treatment combination of $V_1C_0$.

Table 4. Interaction of variety and shoot clipping on stem dry matter (g) of grasspea at different days after sowing

| Treatment | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|
| | 20 | 40 | 60 | 80 | 100 | At harvest |
| $V_1C_0$ | 0.09 b | 0.57 f | 1.65 g | 2.87 e | 5.49 d | 5.30 |
| $V_1C_1$ | 0.19 a | 0.68 ef | 1.86 fg | 4.18 d | 6.12 d | 5.35 |
| $V_1C_2$ | 0.10 b | 0.63 f | 3.68 b-d | 4.51 cd | 6.94 b-d | 6.19 |
| $V_1C_3$ | 0.16 ab | 0.73 d-f | 2.37 e-g | 4.72 b-d | 6.44 cd | 6.67 |
| $V_1C_4$ | 0.20 a | 0.66 ef | 2.54 e-g | 5.67 a | 6.57 cd | 5.98 |
| $V_1C_5$ | 0.14 ab | 0.87 c-e | 2.84 d-f | 4.75b-c | 8.60 ab | 7.33 |
| $V_2C_0$ | 0.17 a | 0.97 b-d | 2.93 de | 5.38 a-c | 8.96 a | 7.84 |
| $V_2C_1$ | 0.16 ab | 1.02 bc | 3.62 cd | 5.87 a | 8.22 ab | 6.69 |
| $V_2C_2$ | 0.17 a | 1.18 ab | 4.35 a-c | 4.18 d | 8.52 ab | 5.99 |
| $V_2C_3$ | 0.21 a | 1.28 a | 4.88 a | 6.01 a | 8.99 a | 8.46 |
| $V_2C_4$ | 0.19 a | 1.00 bc | 4.68 ab | 5.36 a-c | 6.53 cd | 6.70 |
| $V_2C_5$ | 0.19 a | 0.81 c-f | 3.80 b-d | 5.62 ab | 7.61 a-c | 7.10 |
| $LSD_{0.05}$ | 0.07 | 0.21 | 0.47 | 0.91 | 1.69 | NS |
| CV(%) | 24.30 | 13.47 | 17.66 | 10.16 | 12.53 | 15.09 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## 4.2 Yield contributing parameters

### 4.2.1 Number of pods plant$^{-1}$

### Effect of variety

Number of pods plant$^{-1}$was not significantly varied due to varietal difference of grasspea (Table 5 and Appendix IX). But the highest number of pods plant$^{1}$

(23.52) was obtained from the variety $V_2$ (BARI Khesari-4) and the lowest number of pods plant$^{-1}$ (22.10) was obtained from the variety $V_1$ (BARI Khesari-3). Similar result was also observed by Laghari *et al*. (2016) and Rahman *et al*. (2015).

**Effect of shoot clipping**

Remarkable variation was observed on number of pods plant$^{-1}$ influenced by different shoot clipping treatments (Table 6 and Appendix IX). The highest number of pods plant$^{-1}$ (27.20) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) which was significantly different from all other treatments . The lowest number of pods plant$^{-1}$ (20.20) was obtained from the shoot clipping treatment $C_4$ (Shoot clipping at 25 cm plant height) which was statistically similar with the treatment $C_5$ (Shoot clipping at 30 cm ) and $C_0$ (No shoot clipping).

**Combined effect of variety and shoot clipping**

Significant influence was noted on number of pods plant$^{-1}$ affected by combined effect of variety and shoot clipping (Table 7 and Appendix IX). It was found that the highest number of pods plant$^{-1}$ (28.10) was obtained from the treatment combination of $V_2C_3$ which was closely followed by the treatment of $V_1C_3$ and $V_2C_2$. The lowest number of pods plant$^{-1}$ (19.10) was obtained from the treatment combination of $V_1C_5$ which was statistically similar with the treatment of $V_1C_4$ , $V_1C_0$, $V_2C_1$, $V_2C_4$ and $V_2C_5$.

### 4.2.2 Number of seeds pod$^{-1}$

**Effect of variety**

Number of seeds pod$^{-1}$ was not significantly different due varietal difference of grasspea (Table 5 and Appendix IX). However, numerically the highest number of seeds pod$^{-1}$(3.17) was obtained from the variety $V_2$ (BARI Khesari-4) and the lowest number of seeds pod$^{-1}$(3.15) was obtained from the variety $V_1$

(BARI Khesari-3). Laghari *et al*. (2016) also found similar result with the present study.

**Effect of shoot clipping**

Number of seeds pod$^{-1}$ was found significant with different shoot clipping treatments (Table 5 and Appendix IX). Results revealed that the highest number of seeds pod$^{-1}$ (3.66) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) which was statistically similar with the treatment of $C_2$ (Shoot clipping at 15 cm plant height). The lowest number of seeds pod$^{-1}$ (2.86) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping) which was statistically similar with the treatment of $C_1$ (Shoot clipping at 10 cm plant height) and $C_5$ (Shoot clipping at 30 cm plant height).

**Combined effect of variety and shoot clipping**

The recorded data on number of seeds pod$^{-1}$ was significantly influenced by combined effect of variety and shoot clipping (Table 7 and Appendix IX). It was observed that the highest number of seeds pod$^{-1}$ (3.70) was obtained from the treatment combination of $V_2C_3$ which was statistically similar with the treatment combination of $V_1C_3$ followed by $V_1C_2$, $V_1C_4$ and $V_2C_2$. The lowest number of seeds pod$^{-1}$ (2.80) was obtained from the treatment combination of $V_1C_0$ which was statistically similar with the treatment combination of $V_2C_0$ and $V_2C_1$.

### 4.2.3 Weight of 1000 seeds (g)

**Effect of variety**

No significant differencewas observed on 1000 seed weight due variety of grasspea (Table 5 and Appendix IX). However, numerically the highest 1000 seed weight (51.29g) was obtained from the variety $V_1$ (BARI Khesari-3) and the lowest 1000 seed weight (50.92g) was obtained from the variety $V_2$ (BARI Khesari-4).

Table 5. Effect of varieties on phonological characters and yield attributes of grasspea

| Treatment | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | 1000 seed weight (g) |
|---|---|---|---|
| $V_1$ | 22.10 | 3.15 | 51.29 |
| $V_2$ | 23.52 | 3.17 | 50.92 |
| $LSD_{0.05}$ | NS | NS | NS |
| CV(%) | 5.53 | 9.85 | 9.43 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

Table 6. Effect of shoot clipping on phonological characters and yield attributes of grasspea

| Treatment | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | 1000 seed weight (g) |
|---|---|---|---|
| $C_0$ | 21.25 cd | 2.86 d | 48.24 |
| $C_1$ | 23.10 bc | 2.91 cd | 51.02 |
| $C_2$ | 24.50 b | 3.35 ab | 53.24 |
| $C_3$ | 27.20 a | 3.66 a | 53.39 |
| $C_4$ | 20.20 d | 3.20 bc | 50.88 |
| $C_5$ | 20.60 d | 3.01 cd | 49.89 |
| $LSD_{0.05}$ | 2.17 | 0.32 | NS |
| CV(%) | 7.89 | 8.40 | 13.38 |

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## Effect of shoot clipping

Considerable influence was not observed on 1000 seed weight persuated by different shoot clipping treatments (Tabl and Appendix IX). However, numerically the highest 1000 seed weight (53.39g) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) and the lowest 1000 seed weight (48.24g) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping).

**Combined effect of variety and shoot clipping**

The recorded data on 1000 seed weight was not statistically significant with the function of variety and shoot clipping treatments (Table 7 and Appendix IX). However, numerically the highest 1000 seed weight (55.53g) was obtained from the treatment combination of $V_1C_3$ and the lowest 1000 seed weight (47.25g) was obtained from the treatment combination of $V_2C_0$.

Table 7. Interaction of variety and shoot clipping on phonological characters and yield attributes of grasspea

| Treatment | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | 1000 seed weight (g) |
|---|---|---|---|
| $V_1C_0$ | 20.00 ef | 2.80 e | 48.83 |
| $V_1C_1$ | 24.10 b-d | 2.95 c-e | 49.91 |
| $V_1C_2$ | 23.90 b-d | 3.30 a-d | 52.52 |
| $V_1C_3$ | 26.30 ab | 3.61 ab | 55.53 |
| $V_1C_4$ | 19.20 f | 3.30 a-d | 51.57 |
| $V_1C_5$ | 19.10 f | 3.07 c-e | 50.95 |
| $V_2C_0$ | 22.50 c-e | 2.91 de | 47.25 |
| $V_2C_1$ | 22.10 c-f | 2.87 de | 52.13 |
| $V_2C_2$ | 25.10 a-c | 3.40 a-c | 53.96 |
| $V_2C_3$ | 28.10 a | 3.70 a | 51.25 |
| $V_2C_4$ | 21.20 d-f | 3.10 b-e | 50.18 |
| $V_2C_5$ | 22.10 c-f | 2.95 c-e | 49.23 |
| $LSD_{0.05}$ | 3.06 | 0.45 | NS |
| CV(%) | 7.89 | 8.40 | 13.38 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

## 4.3 Yield parameters

### 4.3.1 Grain yield (t ha$^{-1}$)

**Effect of variety**

Non-significant variation was observed on grain yield between two varieties of grasspea (Table 8 and Appendix X). The highest grain yield (1.36t ha$^{-1}$) was obtained from the variety $V_2$ (BARI Khesari-4) where the lowest grain yield (1.35t ha$^{-1}$) was obtained from the variety $V_1$ (BARI Khesari-3). Similar result was also observed by Kalita and Chakrabarty (2017) and Laghari *et al*. (2016).

**Effect of shoot clipping**

Significant influence was noted on grain yield affected by different levels of shoot clipping (Table 9 and Appendix X).The highest grain yield (1.58 t ha$^{-1}$) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) which was significantly different from all other treatments followed by $C_2$ (Shoot clipping at 15 cm plant height). The lowest grain yield (1.24 t ha$^{-1}$) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping) which was statistically identical with the treatment of $C_5$ (Shoot clipping at 30 cm plant height) and closely followed by $C_1$ (Shoot clipping at 10 cm plant height) and $C_4$ (Shoot clipping at 25 cm plant height). Similar result was also observed by Pathirana *et al*. (2014) and Vasconcelos and Castagnoli (2000).

**Combined effect of variety and shoot clipping**

Grain yield of grasspea varied significantly due to the combined effect of variety and shoot clipping (Table 10 and Appendix X). Results indicated that the highest grain yield (1.64 t ha$^{-1}$) was obtained from the treatment combination of $V_2C_3$ which was closely followed by the treatment of $V_1C_3$, $V_1C_2$ and $V_2C_2$. The lowest grain yield (1.21 t ha$^{-1}$) was obtained from the treatment combination of $V_1C_0$ which was statistically similar with the treatment combination of $V_1C_1$, $V_1C_4$, $V_1C_5$, $V_2C_0$ and $V_2C_1$.

### 4.3.2 Straw yield (t ha$^{-1}$)

**Effect of variety**

Straw yield was found non-significant due to different varieties of grasspea (Table 8 and Appendix X). But numerically the highest straw yield (1.58 t ha$^{-1}$) was obtained from the variety $V_1$ (BARI Khesari-3) where the lowest straw yield (1.51 t ha$^{-1}$) was obtained from the variety $V_2$ (BARI Khesari-4).

**Effect of shoot clipping**

Variation on straw yield was found significant due to different shoot clipping treatments (Table 9 and Appendix X).The highest straw yield (1.80 t ha$^{-1}$) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) which was significantly different from all other treatments. The lowest straw yield (1.39 t ha$^{-1}$) was obtained from the shoot clipping treatment $C_5$ (Shoot clipping at 30 cm plant height) which was statistically identical with the treatment, $C_0$ (No shoot clipping), $C_1$ (Shoot clipping at 10 cm plant height), $C_2$ (Shoot clipping at 15 cm plant height) and $C_4$ (Shoot clipping at 25 cm plant height).

**Combined effect of variety and shoot clipping**

Straw yield of grasspea affected by combined effect of variety and shoot clipping was significant (Table 10 and Appendix X). Results revealed that the highest straw yield (1.89 t ha$^{-1}$) was obtained from the treatment combination of $V_1C_3$ which was statistically similar with the treatment combination of $V_2C_3$, $V_1C_2$ and $V_1C_4$. The lowest straw yield (1.38 t ha$^{-1}$) was obtained from the treatment combination of $V_2C_5$ which was statistically identical with the treatment combination of $V_1C_5$.

### 4.3.3 Biological yield (t $ha^{-1}$)

**Effect of variety**

The recorded data on biological yield was not significantly influenced by different varieties of grasspea (Table 8 and Appendix X). But it was observed that numerically the highest biological yield (2.94 t $ha^{-1}$) was obtained from the variety $V_1$ (BARI Khesari-3) whereas the lowest biological yield (2.87 t $ha^{-1}$) was obtained from the variety $V_2$ (BARI Khesari-4).Tickoo *et al*. (2006) also found similar result with the present study.

**Effect of shoot clipping**

Considerable influence was observed on biological yield persuaded by different shoot clipping treatments (Table 9 and Appendix X). Results revealed that the highest biological yield (3.37 t $ha^{-1}$) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) which was significantly different from all other treatments. The lowest biological yield (2.66 t $ha^{-1}$) was obtained from the shoot clipping treatment $C_5$ (Shoot clipping at 30 cm plant height) which was statistically similar with the treatment of $C_0$ (No shoot clipping), $C_1$ (Shoot clipping at 10 cm plant height) and $C_4$ (Shoot clipping at 25 cm plant height).

**Combined effect of variety and shoot clipping**

Significant variation was remarked as influenced by combined effect of variety and shoot clipping (Table 10 and Appendix X).The highest biological yield (3.44 t $ha^{-1}$) was obtained from the treatment combination of $V_1C_3$ which was statistically similar with the treatment combination of $V_2C_3$. Again, the lowest biological (2.64 t $ha^{-1}$) was obtained from the treatment combination of $V_2C_5$ which was statistically identical with the treatment combination of $V_1C_5$ and closely followed by the treatment combination of $V_1C_0$, $V_1C_1$, $V_2C_0$, $V_2C_1$, $V_2C_2$ and $V_2C_4$.

### 4.3.4 Harvest index (%)

**Effect of variety**

Significant influence was not found on harvest index affected by different varieties of grasspea (Table 8 and Appendix X). But the highest harvest index (46.84%) was obtained from the variety $V_2$ (BARI Khesari-4) and the lowest harvest index (46.24%) was obtained from the variety $V_1$ (BARI Khesari-3). Birari *et al*. (1993) also observed similar result with the present study.

**Effect of shoot clipping**

Non-significant variation was observed on harvest index of grasspea influenced by different shoot clipping treatments (Table 9 and Appendix X). The highest harvest index (47.58%) was obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height) and the lowest harvest index (45.07%) was obtained from the shoot clipping treatment $C_0$ (No shoot clipping).

**Combined effect of variety and shoot clipping**

The recorded data on harvest index was not significantly influenced by combined effect of variety and shoot clipping (Table 10 and Appendix X). However, numerically the highest harvest index (49.39%) was obtained from the treatment combination of $V_2C_3$ and the lowest harvest index (44.57%) was obtained from the treatment combination of $V_1C_0$.

Table 8. Effect of variety on Yields and harvest index of grasspea

| Treatment | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $V_1$ | 1.35 | 1.58 | 2.94 | 46.24 |
| $V_2$ | 1.36 | 1.51 | 2.87 | 46.84 |
| $LSD_{0.05}$ | NS | NS | NS | NS |
| CV(%) | 8.84 | 8.86 | 4.13 | 10.04 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

Table 9. Effect of shoot clipping on yields and harvest index of grasspea

| Treatment | Grain yield ($t\ ha^{-1}$) | Straw yield ($t\ ha^{-1}$) | Biological yield ($t\ ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $C_0$ | 1.24 c | 1.51 b | 2.75 bc | 45.07 |
| $C_1$ | 1.31 bc | 1.47 b | 2.78 bc | 47.13 |
| $C_2$ | 1.42 b | 1.58 b | 2.99 b | 45.99 |
| $C_3$ | 1.58 a | 1.80 a | 3.37 a | 47.58 |
| $C_4$ | 1.34 bc | 1.55 b | 2.88 bc | 46.39 |
| $C_5$ | 1.27 c | 1.39 b | 2.66 c | 47.18 |
| $LSD_{0.05}$ | 0.14 | 0.19 | 0.25 | NS |
| CV(%) | 8.74 | 10.56 | 7.01 | 7.46 |

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

Table 10. Interaction of variety and shoot clipping on Yields and harvest index of grasspea

| Treatment | Grain yield ($t\ ha^{-1}$) | Straw yield ($t\ ha^{-1}$) | Biological yield ($t\ ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $V_1C_0$ | 1.21 d | 1.52 bc | 2.79 cd | 44.57 |
| $V_1C_1$ | 1.31 cd | 1.42 bc | 2.73 cd | 47.96 |
| $V_1C_2$ | 1.41 a-d | 1.62 a-c | 3.03 bc | 46.55 |
| $V_1C_3$ | 1.55 ab | 1.89 a | 3.44 a | 44.96 |
| $V_1C_4$ | 1.32 cd | 1.65 a-c | 2.97 b-d | 45.52 |
| $V_1C_5$ | 1.29 cd | 1.39 c | 2.68 d | 47.86 |
| $V_2C_0$ | 1.27 cd | 1.49 bc | 2.70 cd | 44.61 |
| $V_2C_1$ | 1.31 cd | 1.51 bc | 2.82 cd | 46.29 |
| $V_2C_2$ | 1.42 a-c | 1.52 bc | 2.94 cd | 45.24 |
| $V_2C_3$ | 1.61 a | 1.70 ab | 3.30 ab | 49.39 |
| $V_2C_4$ | 1.35 b-d | 1.45 bc | 2.80 cd | 48.22 |
| $V_2C_5$ | 1.25 cd | 1.38 c | 2.64 d | 47.31 |
| $LSD_{0.05}$ | 0.20 | 0.28 | 0.35 | NS |
| CV(%) | 8.74 | 10.56 | 7.01 | 7.46 |

$V_1$ = BARI Khesari-3, $V_2$ = BARI Khesari-4

$C_0$ = No clipping, $C_1$ = shoot clipping at 10 cm plant height, $C_2$ = shoot clipping at 15 cm plant height, $C_3$ = shoot clipping at 20 cm plant height, $C_4$ = shoot clipping at 25 cm plant height and $C_5$ = shoot clipping at 30 cm plant height

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Experiment was executed during the period of November 2017 to February 2018 to study the approach to higher production of grasspea through manipulating its canopy structure. The experiment was consisted of two factors. Factor A: two grasspea variety, *viz*. $V_1$ =BARI Khesari-3 and $V_2$ =BARI Khesari-4 and Factor B: six levels of shoot clipping, *viz*. $C_0$ =No shoot clipping, $C_1$ = Shoot clipping at 10 cm plant height, $C_2$ = Shoot clipping at 15 cm plant height, $C_3$= Shoot clipping at 20 cm plant height, $C_4$ = Shoot clipping at 25 cm plant height and $C_5$ = Shoot clipping at 30 cm plant height. The experiment was laid out in a Split Plot Design with three replications. Data on different growth and yield parameters were recorded and statistically analyzed.

In terms of growth parameters regarding varietal performance, plant height was significant at the time of harvest but number of branches plant$^{-1}$, leaf dry matter plant$^{-1}$ and stem dry matter plant$^{-1}$ was not significant at harvesting period. However, results revealed that the highest plant height (11.05, 19.99, 35.50, 41.36, 46.32 and 46.49 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively), number of branches plant$^{-1}$ (4.00, 5.58, 7.22, 6.21, 6.37 and 5.57 at 20, 40, 60, 80, 100 DAS and at harvest, respectively), leaf dry matter plant$^{-1}$ (0.23, 1.46, 4.22, 4.61, 5.88 and 5.46 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and stem dry matter plant$^{-1}$ (0.18, 1.04, 4.04, 5.40, 8.14 and 6.94 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were obtained from the variety $V_2$ (BARI Khesari-4) where the lowest plant height (10.92, 19.66, 29.96, 38.34, 44.22 and 43.98 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively), the lowest number of branches plant$^{-1}$ (3.06, 5.57, 5.97, 5.77, 5.58 and 5.42 at 20, 40, 60, 80, 100 DAS and at harvest, respectively), The lowest leaf dry matter plant$^{-1}$ (0.18, 1.02, 6.08, 4.00, 5.86 and

5.36 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and the lowest stem dry matter plant$^{-1}$ (0.15, 0.70, 2.49, 4.45, 6.69 and 6.32 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were obtained from the variety $V_1$ (BARI Khesari-3). Regarding yield and yield contributing parameters, the recorded data were not significantly differed due to varietal difference. Although, the highest number of pods plant$^{-1}$ (23.52), number of seeds pod$^{-1}$ (3.17), grain yield (1.36 t ha$^{-1}$) and harvest index (46.84%) were obtained from the variety $V_2$ (BARI Khesari-4) and the highest 1000 seed weight (51.29g), straw yield (1.58 t ha$^{-1}$) and biological yield (2.94 t ha$^{-1}$) were obtained from the variety $V_1$ (BARI Khesari-3). Similarly, the lowest number of pods plant$^{-1}$ (22.10), number of seeds pod$^{-1}$ (3.15), grain yield (1.35 t ha$^{-1}$) and harvest index (46.24%) were obtained from the variety $V_1$ (BARI Khesari-3) and the lowest 1000 seed weight (50.92), straw yield (1.51 t ha$^{-1}$) and biological yield (2.87 t ha$^{-1}$) were obtained from the variety $V_2$ (BARI Khesari-4).

Regarding shoot clipping treatments, all the growth parameters influenced significantly. Results revealed that the highest plant height (11.52, 21.21, 35.38, 44.02, 47.80 and 47.08 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) ware obtained from the treatment $C_2$ (Shoot clipping at 15 cm plant height) but the highest leaf dry matter plant$^{-1}$ (0.30, 1.36, 4.35, 4.67, 6.49 and 6.17 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) ware obtained from $C_0$ (No shoot clipping). Again, the highest number of branches plant$^{-1}$ (3.80, 5.87, 7.10, 6.37, 6.63 and 5.93 at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and stem dry matter plant$^{-1}$ (0.20, 0.96, 4.02, 5.52, 8.78 and 8.15 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were recorded from $C_3$ (Shoot clipping at 20 cm plant height) treatment. Similarly, the lowest plant height (10.58, 18.96, 30.45, 38.22, 43.43 and 43.38 cm at 20, 40, 60, 80, 100 and at harvest, respectively) ware obtained from $C_2$ (Shoot clipping at 15 cm plant height) but the lowest leaf dry matter plant$^{-1}$ (0.17, 1.15, 3.27, 3.81, 5.17 and 4.78 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) was obtained from $C_4$ (Shoot clipping at 25 cm plant height) treatment. Again, the lowest number of branches plant$^{-1}$ (3.17, 5.33, 6.03, 5.87, 5.48, 5.07 at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and stem dry matter plant$^{-1}$ (0.12, 0.77, 2.74, 4.12, 6.01 and 6.02 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were obtained $C_0$ (No shoot clipping). Shoot clipping treatment influenced all the yield and yield contributing parameters except 1000 seed weight. The highest number of pods plant$^{-1}$ (27.20), number of seeds pod$^{-1}$ (3.66), 1000 seed weight (53.39g), grain yield (1.58 t ha$^{-1}$), straw yield (1.80 t ha$^{-1}$), biological yield (3.37 t ha$^{-1}$) and harvest index (47.58%) were obtained from the shoot clipping treatment $C_3$ (Shoot clipping at 20 cm plant height). Again, the lowest number of pods plant$^{-1}$ (26.60), straw yield (1.39 t ha$^{-1}$) and biological yield (2.66 t ha$^{-1}$) were obtained from the shoot clipping treatment $C_5$ (Shoot clipping at 30 cm plant height) but the lowest number of seeds pod$^{-1}$ (2.86), 1000 seed weight (48.24g), grain yield (1.24 t ha$^{-1}$) and harvest index (45.07%) were obtained from the shoot clipping treatment $C_0$ (No shoot clipping).

Considering combined effect of variety and shoot clipping, all the studied growth parameters were not significantly influenced at harvesting period except plant height at harvest. However, results showed that the highest plant height (11.79, 22.04, 39.54, 46.60, 50.91 and 50.75 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and leaf dry matter plant$^{-1}$ (0.35, 1.71, 5.20, 5.06, 6.57 and 7.29 g at 20, 40, 60, 80, 100 and at harvest, respectively) were obtained from the treatment combination of $V_2C_0$. But the highest number of branches plant$^{-1}$ (4.53, 6.13, 8.13, 6.40, 7.27 and 6.67 at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and stem dry matter plant$^{-1}$ (0.21, 1.28, 4.88, 6.01, 8.99 and 8.46 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were obtained from the treatment combination of $V_2C_3$. All the studied yield and yield contributing parameters were significantly influenced by combined effect of variety and shoot clipping except 1000 seed weight and harvest index. However, results indicated that the highest number of pods plant$^{-1}$ (28.10), number of seeds pod$^{-1}$ (3.70), grain yield (1.64 t ha$^{-1}$) and harvest index

(49.39%) were obtained from the treatment combination of $V_2C_3$ and the highest 1000 seed weight (55.53g), straw yield (1.89 t $ha^{-1}$) and biological yield (3.44 t $ha^{-1}$) were obtained from the treatment combination of $V_1C_3$. Similarly, the lowest plant height (10.12, 17.41, 28.10, 35.73, 40.76 and 41.73 cm at 20, 40, 60, 80, 100 DAS and at harvest, respectively) ware found from $V_1C_2$ and lowest leaf dry matter $plant^{-1}$ (0.10, 0.82, 2.31, 3.04, 5.15 and 4.37 g at 20, 40, 60, 80, 100 and at harvest, respectively) ware found from $V_1C_4$ treatment combination but the lowest number of branches $plant^{-1}$ (2.40, 4.93, 5.40, 4.73, 4.83 and 4.40 at 20, 40, 60, 80, 100 DAS and at harvest, respectively) and stem dry matter $plant^{-1}$ (0.09, 0.57, 1.65, 2.87, 5.49 and 5.30 g at 20, 40, 60, 80, 100 DAS and at harvest, respectively) were observed from the treatment combination of $V_1C_0$. Again, the lowest number of pods $plant^{-1}$ (19.10) was found from the treatment combination of $V_1C_5$ but the lowest number of seeds $pod^{-1}$ (2.80), grain yield (1.21 t $ha^{-1}$) and harvest index (44.57%) were found from the treatment combination of $V_1C_0$ but the lowest 1000 seed weight (47.25g) was obtained from the treatment combination of $V_2C_0$. The lowest straw yield (1.38 t $ha^{-1}$) and biological (2.64 t $ha^{-1}$) were obtained from the treatment combination of $V_2C_5$.

Considering the above fact, $V_2C_3$ (BARI Khesari-4 with shoot clipping at 20 cm plant height) performed the best in producing higher yield than other treatments comprised with other variety and shoot clipping treatments under the present study. So, this treatment combination considered as the best compared to all other treatment combinations.

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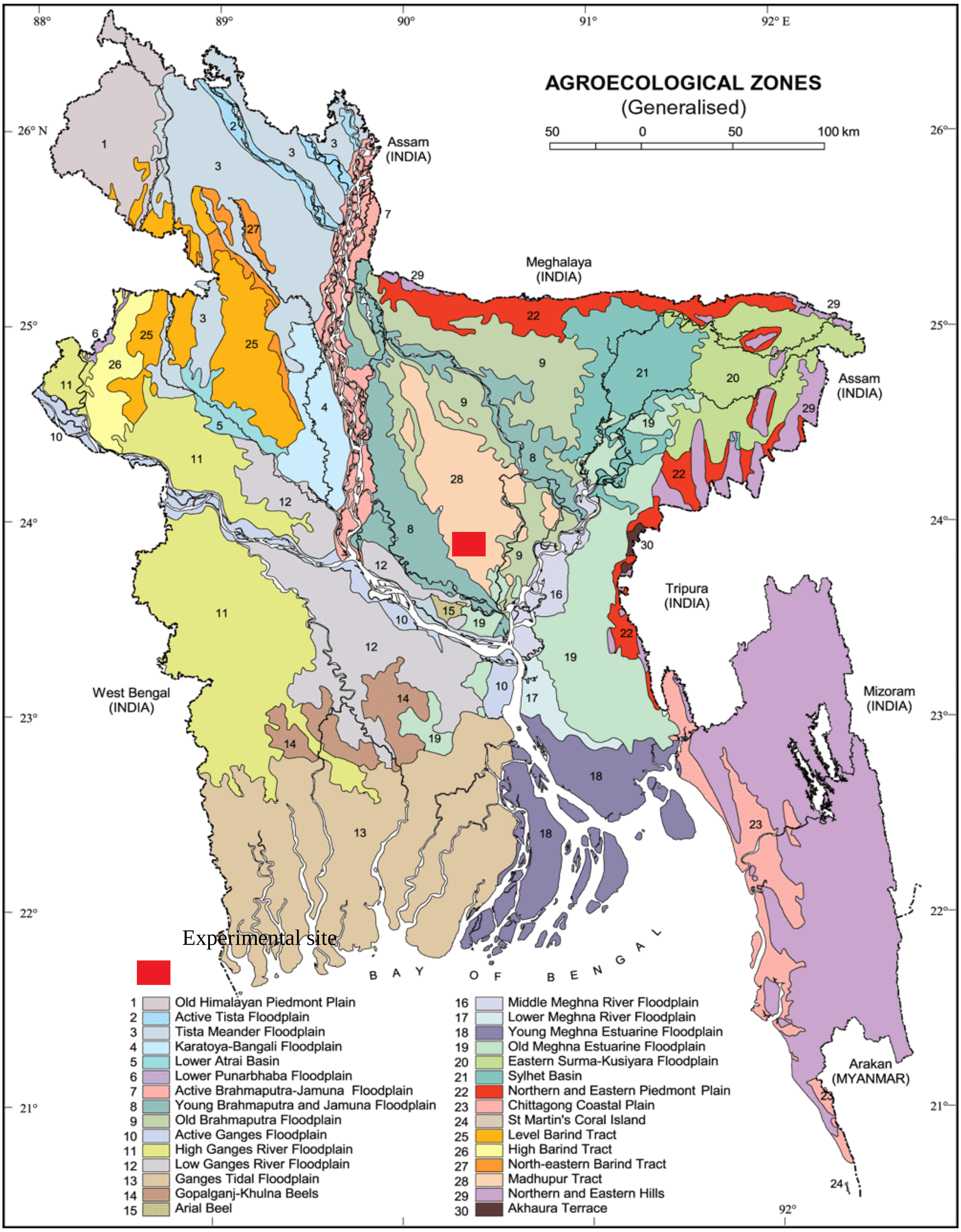
## APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2017 to February 2018.

| Year | Month | Air temperature (°C) | | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | *Max* | *Min* | *Mean* | | |
| 2017 | November | 28.60 | 8.52 | 18.56 | 56.75 | 14.40 |
| 2017 | December | 25.50 | 6.70 | 16.10 | 54.80 | 0.0 |
| 2018 | January | 23.80 | 11.70 | 17.75 | 46.20 | 0.0 |
| 2018 | February | 22.75 | 14.26 | 18.51 | 37.90 | 0.0 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Agronomy Farm, SAU, Dhaka |
| *AEZ* | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Not Applicable |

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam (ISSS) |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field

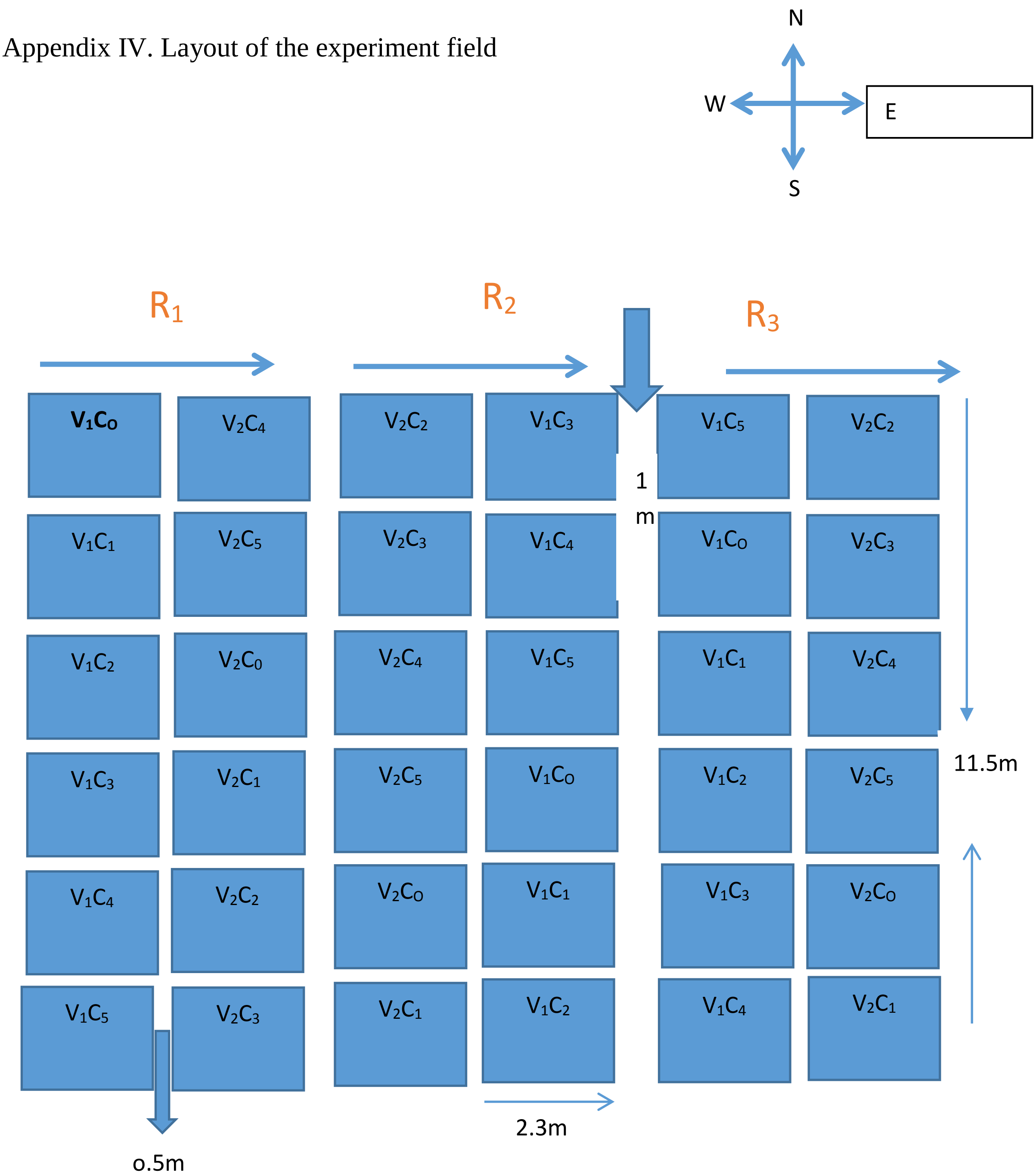



Fig. 8. Layout of the experimental plot

Appendix V. Combined effect of variety and shoot clipping on plant height (cm) of grasspea at different days after sowing

| Sources of variation | Degrees of freedom | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 5.06 | 5.37 | 6.20 | 5.77 | 4.77 | 4.23 |
| Factor A | 1 | 0.16 | 0.98 | 76.61 | 81.90 | 39.69 | 56.60 |
| Error | 2 | 0.75 | 0.36 | 0.51 | 11.33 | 11.63 | 0.38 |
| Factor B | 5 | 1.20 | 4.47 | 23.02 | 28.40 | 16.24 | 11.34 |
| AB | 5 | 0.34 | 5.35 | 11.99 | 8.45 | 26.44 | 29.56 |
| Error | 20 | 0.21 | 1.09 | 6.419 | 3.85 | 4.25 | 2.71 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Combined effect of variety and shoot clipping on plant branch (no.) of grasspea at different days after sowing

| Sources of variation | Degrees of freedom | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 1.21 | 2.53 | 7.16 | 9.014 | 6.88 | 2.937 |
| Factor A | 1 | 8.02 | 0.001 | 14.18 | 1.777 | 5.601 | 0.187 |
| Error | 2 | 0.10 | 0.057 | 0.067 | 0.521 | 0.351 | 2.137 |
| Factor B | 5 | 0.51 | 0.235 | 1.27 | 0.503 | 0.915 | 0.734 |
| AB | 5 | 1.22 | 0.454 | 0.662 | 0.655 | 0.311 | 2.121 |
| Error | 20 | 0.08 | 0.252 | 0.408 | 1.031 | 0.535 | 0.495 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Interaction of variety and shoot clipping on leaf dry matter (g) of grasspea at  differentdays after sowing

| Sources of variation | Degrees of freedom | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 0.034 | 0.430 | 3.76 | 6.118 | 8.006 | 9.456 |
| Factor A | 1 | 0.026 | 1.742 | 11.74 | 3.246 | 0.004 | 0.089 |
| Error | 2 | 0.004 | 0.036 | 0.39 | 1.040 | 0.845 | 0.254 |
| Factor B | 5 | 0.014 | 0.045 | 1.20 | 0.676 | 1.373 | 1.734 |
| AB | 5 | 0.017 | 0.079 | 0.73 | 0.531 | 0.385 | 3.409 |
| Error | 20 | 0.003 | 0.056 | 0.45 | 0.893 | 0.832 | 0.286 |

NS = Non-significant  * = Significant at 5% level     ** = Significant at 1% level

Appendix VIII. Interaction of variety and shoot clipping on stem dry matter (g) of grasspea at different days after sowing

| Sources of variation | Degrees of freedom | At different days after sowing (DAS) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 6.71 | 0.43 | 4.44 | 3.693 | 16.88 | 30.24 |
| Factor A | 1 | 7.22 | 1.12 | 21.76 | 8.141 | 18.87 | 3.434 |
| Error | 2 | 6.33 | 0.01 | 0.143 | 0.214 | 0.032 | 1.677 |
| Factor B | 5 | 3.97 | 0.03 | 1.358 | 1.921 | 5.190 | 3.874 |
| AB | 5 | 4.59 | 0.08 | 1.854 | 1.901 | 0.813 | 1.431 |
| Error | 20 | 1.54 | 0.013 | 0.332 | 0.250 | 0.863 | 1.001 |

NS = Non-significant  * = Significant at 5% level     ** = Significant at 1% level

Appendix IX. Interaction of variety and shoot clipping on phenologicalcharacters and yield attributes ofgrasspea

| Sources of variation | Degrees of freedom | Pods plant$^{-1}$ (No.) | Seeds pod$^{-1}$ (No.) | 1000 seed weight (g) |
|---|---|---|---|---|
| Replication | 2 | 32.38 | 2.74 | 3.278 |
| Factor A | 1 | 18.06 | 0.002 | 1.983 |
| Error | 2 | 1.59 | 0.097 | 8.551 |
| Factor B | 5 | 43.61 | 0.553 | 7.571 |
| AB | 5 | 4.76 | 0.026 | 3.004 |
| Error | 20 | 3.23 | 0.070 | 1.933 |

NS = Non-significant  * = Significant at 5% level     ** = Significant at 1% level

Appendix X. Interaction of variety and shoot clipping on Yields and harvest index of grasspea

| Sources of variation | Degrees of freedom | Grain yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| Replication | 2 | 0.103 | 0.015 | 0.171 | 3.990 |
| Factor A | 1 | 3.255 | 0.045 | 0.048 | 3.300 |
| Error | 2 | 0.014 | 0.018 | 0.014 | 21.823 |
| Factor B | 5 | 0.092 | 0.115 | 0.391 | 5.321 |
| AB | 5 | 2.940 | 0.019 | 0.012 | 10.895 |
| Error | 20 | 0.014 | 0.026 | 0.041 | 12.057 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level