International Research Journal of Biological Sciences ISSN 2278-3202
Vol. 2(9), 48-53, September (2013) Int. Res. J. Biological Sci.

# Biomass productivity of Green Manure crop *Sesbania cannabina* Poir (Dhaincha) in different Planting Density Stress

**Srivastava Nitisha* and Kumar Girjesh**
Plant Genetics Laboratory, Department of Botany, University of Allahabad, Allahabad-211002, UP, INDIA

**Available online at: www.isca.in**
Received 30th May 2013, revised 18th June 2013, accepted 18th July 2013

## Abstract

*The present world is facing an acute shortage of biomass and developing countries require increase mass of firewood, fodder and fibres. In view of filling these requirements an increased investigation into fast growing, nitrogen fixing and fibre obtaining plant species has been required. Thus present study is an attempt to envisage the biomass productivity of Sesbania cannabina Poir. in different planting densities. Sesbania cannabina Poir. is a multipurpose leguminous crop with many unexplored economic uses. Environmental factors such as planting density greatly affect the biomass production of a plant species. Plant products such as leaves, fibres etc. are directly correlated with the biomass production of a plant species. Therefore it is important to study the effect of planting density on the biomass production of a plant. Planting densities affect various parameters of plants such as germination percentage, survival percentage, plant height, stem breadth, number of leaves, leaf length, pod length etc. Therefore present study is an attempt correlates the different planting densities with these morphological parameters. The present study was conducted at Department of Botany, University of Allahabad, India. The experiment was based on complete randomized block design with three replicates using five different planting densities viz. 1, 10, 25, 50 and 100. Means study showed that highest biological yield was achieved under plants within lowest density set. The results of this experiment showed that planting density is an important effective factor on quantity and morphological characteristics of plants that they can greatly affect yield of Sesbania cannabina Poir.*

**Keywords:** Germination, morphological characteristics, planting densities, *Sesbania cannabina,* survival.

## Introduction

*Sesbania cannabina* Poir. is a multipurpose leguminous crop and is widely used as green manure crop to increase the yield of rice, wheat and maize etc. Due to vigorous growth and high potential to increase their biomass during rainy season, it is used as green manure for many important food crops. *Sesbania* seed contains 30-36% crude protein and is at present not being used for other agricultural or industrial purposes. A very little attention has been paid for this crop which may lead into its widespread use among fodders and food resources. It may be a potential source of nitrogen for other plants and proteins for cattle as being a leguminous plant. It is grown during the summer season and is widely adaptable to different adverse climatic conditions like drought, waterlogging, soil salinity, etc[1].

Planting density is among the most important factors influencing the yield and yield components of crops. The increasing cost of crop planting has resulted in increase in determining optimal planting densities for various crops. However, manupulation of planting density greatly affects the growth and growth parameters of crops. Population density or the number of adults in an environment related to the limiting resources may have important long and short-term consequences for the longevity of organisms. Plant density has been recognized as a major factor determining the degree of competition between plants. Yield per plant decreases as the density per unit area increases. High planting density results in intra-specific competition among population for various resources. The net productivity of plants will also be affected by incresing planting densities as it affects light penetration and increases competition for various nutrients present in soil. If the planting density is lower than its optimum value then total production will be lower and weeds will be higher[2]. Higher the planting density, higher will be the canopy, which results in increased solar radiation capture. In addition, increasing planting density will also increase intra-specific competition among the plants which affects the vegetative and reproductive growth of plants[3]. Higher planting density also increases the relative humidity within canopy and leaf wetness by reducing air movement and sunlight penetration within canopy[4-5]. Thus plant density could have significant impact on plant disease incidence[4,6]. Reduction in seed yield may be the result of lower number of pods, lower seed weight or a combination of these components. In dense populations, many seeds may not develop. Jettner et al. stated that increasing yields at high sowing rate could be directly attributed to large plant population[7]. Regan et al. concluded that there was strong relationship between economic optimum plant density and seed yield potential[8]. Increasing planting density is negatively correlated with fresh weight/plant, the marketable fresh weight/plant and head size of the plants. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yields, for which it is important to know the effect of increasing planting densities on plant yield and biomass production. The present study was undertaken to study the effect of increasing planting densities on germination, survival and different morphological characteristics of *Sesbania cannabina*.

## Material and Methods

**Procurement of seeds:** Seeds of *Sesbania cannabina* variety ND-1 were obtained from Sunn Hemp Research Station, Pratapgarh, Uttar Pradesh, India.

**Sowing of seeds:** The experiment was conducted as a pot experiment in a randomized block design with three replicates. Weather conditions of experimental site were hot and dry during sowing period (May). The five plant densities (1, 10, 25, 50 and 100) were applied. Dry and healthy seeds were soaked in water for 14 hr and were used for sowing in large cement made pots.

**Field study and scoring of data:** Data for germination percentage and survival percentage were taken after 15 and 30 days of sowing, respectively. In order to determine the yield and other characters under varying plant densities data for plant height was taken twice (after 30 days and 45 days) and data for stem girth, number of leaves, leaf length, internode length and pod length were taken after 45 days of sowing.

**Statistical Analysis:** All statistical analyses including One-way Anova were performed using SPSS 11.0 software.

## Results and Discussion

**Germination and survival percentages:** The germination and survival in seeds of density stress sets of *S. cannabina* were evaluated and have been presented in table-1. The overall estimation of germination and survival percentages illustrated that these parameters were greatly affected by increasing plant densities. The maximum germination and survival percentage among all the five density sets was observed in case of 1 plant/pot set which was noted to be 100%. It shows that this set caused no inhibition on seedling germination and survival. The density sets with increasing numbers of seeds were affected and germination and survivability percentages lowered to a greater extent at 100 seeds/pot. The germination was found to decrease from 100% at 10-plants/pot set to percentage of 70.29% at 100-plants/pot set. While, the survivability was observed to fall off from 93.33% (10-plants/pot set) to 70.29% (100-plants/pot set). Thus, the two lower densities of 10-plants/pot and 25-plant/pot do not significantly affect the germination and survival percentages.

**Table-1**
**Effect of different planting densities on germination and survival percentages of Sesbania pea**

| Planting densities | Germination % (mean) | Survival % (mean) |
|---|---|---|
| 1 | 100 | 100 |
| 10 | 100 | 93.33 |
| 25 | 89.32 | 88.15 |
| 50 | 88 | 74.12 |
| 100 | 83 | 70.29 |

**Morphological parameters:** The morphological parameters (figure-1 and 2) such as plant height, stem girth, number of leaves per plant, leaf length, pod length of each density set were evaluated and result showed that planting density significantly affected plant height, stem girth, number of leaves/plant, leaf length and pod length (table-2 to 7). The range (Max. and Min.), general mean, standard error and standard deviation have been calculated for each parameter of all the density sets. A wide spectrum of variability was encountered in each case. A density dependent increase in plant height at certain level was observed in each set. Comparative description of these has been discussed below.


**Figure-1**
**Plant experimental set after 30 days of sowing**

**Figure-2**
**Plant experimental set after 45 days of sowing**

**Table-2**
**Plant height after 30 days (cm)**

| Planting Densities | *Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 35.0000 | . | . | 35.00 | 35.00 |
| 10plants /pot | 37.3000$^{ab}$ | 3.19896 | 1.01160 | 32.00 | 42.00 |
| 25plants/pot | 39.7000$^{ab}$ | 4.71522 | 1.49108 | 29.00 | 45.00 |
| 50plants/pot | 44.6000$^{ab}$ | 6.97933 | 2.20706 | 32.00 | 52.00 |
| 100plants/pot | 33.6000$^{ab}$ | 3.20416 | 1.01325 | 28.00 | 39.00 |

**Table-3**
**Plant height after 45 days (cm)**

| Planting Densities | **Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 102.0000 | . | . | 120.00 | 120.00 |
| 10plants /pot | 106.9000$^{ab}$ | 8.90006 | 2.81445 | 89.00 | 120.00 |
| 25plants/pot | 107.1000$^{ab}$ | 9.88208 | 3.12499 | 95.00 | 120.00 |
| 50plants/pot | 111.6000$^{ab}$ | 6.51835 | 2.06128 | 105.00 | 125.00 |
| 100plants/pot | 93.4000$^{ab}$ | 8.89694 | 2.81346 | 80.00 | 110.00 |

**Table-4**
**Stem girth (cm)**

| Planting Densities | *Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 3.5000 | . | . | 3.50 | 3.50 |
| 10plants /pot | 2.2300$^{ab}$ | .12042 | .05385 | 2.10 | 2.40 |
| 25plants/pot | 1.8800$^{ab}$ | .08367 | .03742 | 1.80 | 2.00 |
| 50plants/pot | 1.6400$^{ab}$ | .11402 | .05099 | 1.50 | 1.80 |
| 100plants/pot | 1.3800$^{ab}$ | .13509 | .06042 | 1.25 | 1.60 |

**Table-5**
**Number of leaves/ plant**

| Planting Densities | *Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 28.0000 | . | . | 28.00 | 28.00 |
| 10plants /pot | 22.6000$^{ab}$ | 2.88097 | 1.28841 | 19.00 | 27.00 |
| 25plants/pot | 19.4000$^{ab}$ | 1.51658 | .67823 | 17.00 | 21.00 |
| 50plants/pot | 17.2000$^{ab}$ | 2.38747 | 1.06771 | 14.00 | 20.00 |
| 100plants/pot | 15.4000$^{ab}$ | 2.07364 | .92736 | 12.00 | 17.00 |

**Table-6**
**Leaf length (cm)**

| Planting Densities | *Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 29.8000 | 1.48324 | .66332 | 28.00 | 32.00 |
| 10plants /pot | 21.2000 [ab] | 1.64317 | .73485 | 19.00 | 23.00 |
| 25plants/pot | 19.0000 [ab] | 1.58114 | .70711 | 17.00 | 21.00 |
| 50plants/pot | 17.4000 [ab] | 1.51658 | .67823 | 15.00 | 19.00 |
| 100plants/pot | 14.4000 [ab] | 1.14018 | .50990 | 13.00 | 16.00 |

**Table-7**
**Pod Length (cm)**

| Planting Densities | **Mean | Std. Deviation | Std. Error of Mean | Minimum | Maximum |
|---|---|---|---|---|---|
| Control | 24.3000 | 1.35810 | .42947 | 22.00 | 26.00 |
| 10plants /pot | 20.9500 [ab] | 1.23491 | .39051 | 19.00 | 23.00 |
| 25plants/pot | 18.7200 [ab] | .94962 | .30030 | 17.00 | 20.00 |
| 50plants/pot | 18.3000 [ab] | 1.45678 | .46068 | 16.50 | 21.00 |
| 100plants/pot | 16.1900 [ab] | 2.07335 | .65565 | 11.00 | 18.00 |

*Mean value of 5 plants at each density level, **Mean value of 10 plants at each density level, Means in each row followed by unlike letters shows that difference compared to control values are significant at $p \leq 0.05$ = a, at $p \leq 0.01$= b.

**Plant height after 30 days (table-2):** The mean height of the plant of the lowest density has been recorded as 35 cm. The plants of subsequent densities exhibited an increase in height upto the density level of 50 plants/ pot, and reduced very much at the highest density level of 100 plants/ pot. The maximum plant height was observed at 50 plants/ pot and was observed to be 44.60 cm which was much higher than the control value.

**Plant height after 45 days (table-3):** The mean height of control plant after 45 days was observed to be 102cm, which increases upto planting density of 50 plants/ pot and reduced much as compared to control at 100plants/pot density level. The maximum plant height was observed to be 111.60cm at the density level of 50 plants/ pot.

**Stem girth after 45 days (table-4):** The mean value of stem girth of different planting density levels shows a linear decrease in stem diameter with increase in planting densities. The mean values for maximum and minimum stem girth were observed to be 3.5cm and 1.38cm at planting densities of 1 plant/pot and 100 plants/ pot, respectively. Thus increasing planting density negatively affects the stem girth.

**Number of leaves per plant after 45 days (table-5):** Evaluation of number of leaves/plant for lowest to highest density set displayed a wide spectrum of variation. The lowest density set exhibited number of leaves per plant as mean of 28.0. However, subsequent sets exhibited lower mean values of total number of leaves/plant than the lowest density set. The maximum reduction in number of leaves/plant was observed in case of 100 plants/pot set where a severe decline from 28 leaves (at lowest density set) to 15.40 (at highest density set) was registered.

**Leaf length after 45 days (table-6):** Estimation of mean values of leaf length was observed to be maximum at the planting density of I plant/pot and it showed a linear decrease in leaf length with increasing planting densities. The maximum and minimum mean values for leaf length were observed to be 29.80cm and 14.40cm at the planting densities of 1 plant/pot and 100 plants/ pot, respectively.

**Pod length (table-7):** The mean values for pod length showed a linear decrease with increasing planting densities. The mean values for maximum and minimum pod length were observed to be 24.30cm and 16.19cm at the planting densities of 1 plant/pot and 100 plants/ pot, respectively.

**Discussion:** Competitive stresses among plants pose a serious limitation on crop yield and yield parameters. Competition among plants occurs when plants require similar nutrients or factor and that nutrient or factor have limited supply below the combined demands of the plants[9-10]. These necessary factors may be water, nutrients, sunlight, carbon dioxide or oxygen. Plants exhibit extreme plasticity by responding in size and form to the available space[9]. Donald emphasized the importance of measuring the three parameters: density, yield of dry matter and seed yield, together[9]. These results have agricultural implications. Furthermore, higher plant density is desirable so that the crop can compete successfully with weeds at the beginning of the growing season. Increasing planting density lead to growth competition for achieving more spacing, this inhibits underground growth but enhances the stem growth[11-13]. Thus, planting density has significant effect on plant growth.

In some cases, higher planting densities may be used to compensate lower germination. Norton et al. reported that growers in northern Arizona increase seeding rates to ensure sufficient plant germination[14]. However, this strategy can prove detrimental if germination is not hindered. In contrast to previous information, Heitholt , Silvertooth and Bednarz et al. provided evidence that increased plant densities can negatively affect crop yield[15-17]. Jones and Wells reported that lower densities result in more light penetration and lower plant competition, causing a shift in sink/source ratios[18].

The results showed that plant density stress had significantly affected on biological yield, leaf number, leaf length, pod number and stem girth however plant height had not been negatively affected with plant density stress (table-2 and 3). As it was shown in the results of this study, stress had a negative effect on most of the Sesbania pea characteristics under study. Plant height showed an increasing trend with increasing planting densities. Similar results have been reported by Zhang et al.[3] in maize hybrids and Mobasser et al.[19] in rice cultivars. The increase of planting density causes increase in plant height and debilitates stems by decrease of stem diameter. Environmental conditions during stem elongation pose a serious limitation on stem diameter. Konuskan[20] and Mobaser et al.[19] reported that stem diameter was lower in higher plant densities as a consequence of inter plant competition. Our study depicts that the pod length was significantly affected by the planting densities and pod length tend to decrease with increasing planting densities. Similar trend was also reported by Zhang et al.[3]

## Conclusion

Present investigation showed that planting density is an important and effective factor affecting quantity and quality of plants. Plants susceptibility to variation in planting densities generated intense effort to understand how it affect yield of crop plant and also to decide optimum density for the species. There has been much theoretical speculation about the possible impact of population density on the evolution of longevity but little experimental evidence has been gathered to test these ideas. Our study is a little contribution towards this field of work.

## Acknowledgement

Nitisha Srivastava is thankful to University Grant Commission, New Delhi for UGC D.Phil. fellowship. Authors are also thankful to Sunn Hemp Research Station, Pratapgarh, India for providing seeds of *Sesbania cannabina* Poir.

## References

1. Kumar G. and Srivastava N., Gamma rays induced cytomorphological variations in *Sesbania cannabina* Poir, *Cytologia,* **76(4)**, 375-380 **(2011)**
2. Allard R.W., History of plant population genetics, *Annual of Review of Plant Genetics*, **33**, 1-27 **(1999)**
3. Zhang W., Zhang H., Wang H. et al., Effects of spacings and planting densities on agronomic traits and yield in high-oil soybeans (J), *Soybean Science (in Chinese),* **25**, 283- 287 **(2006)**
4. Burdon J.J. and Chilvers G.A., Host density as a factor in plant diseased ecology, *Annual Review of Phytopathology*, **20**, 143-166 **(1982)**
5. Tu J.C., An integrated control of white mold (*Sclerotinia sclerotiorum*) of beans, with emphasis on recent advances in biological control, *J. Bot*., **38**, 73- 76 **(1997)**
6. Copes W.E. and Scherm H., Plant spacing effects on microclimate and *Rhizoctonia* web blight development in container-grown Azalea, *Hortic. Sci*., **40**, 1408-1412 **(2005)**
7. Jettner R.J., Siddique K.H., Loss S.P. and French R.J., Optimum plant density of desi chickpea (*Cicer arietinum* L.) increase with increasing yield potential in south western Australia, *Australian J. of Agricultural Research,* **50(6)**, 1017 – 1026 **(1999)**
8. Regan K.L., Siddique K.H. and Martin L.D., Response of Kabuli chickpea (*Cicer artietinum*) to sowing rate in Mediterranean – type environments of southwestern, *Australia. J. of Experimental Agriculture,* **43 (1)**, 87-97 **(2003)**
9. Donald C. M., Competition among crop and pasture plants, *Adv. Agron*., **159**, 1 - 118 **(1963)**
10. Milthorpe F. L. and Moorby J., An Introduction to Crop Physiology. 1st edn., Cambridge University Press, London, **(1974)**
11. Degenhardt D.E. and Kondra Z.P., The influence of seeding date and seeding rate on seed yield and yield components of five genotypes of *Brassica napus* [J], *Canadian Journal of Plant Science*, **61**, 175-183 **(1981)**
12. Rao R.C.N., Simmonds L.P., Azam-Ali S.N. and Williams J.H., Population, growth, and water use of groundnut maintained on stored water. I. Root and shoot growth, *Exp. Agric*., **25**, 51–61 **(1989)**
13. Morrisson J., Mcvetty E.B.E. and Scarth R., Effect of altering plant density on growth characteristics of summer rape [J], *Canadian Journal of Plant Science,* **70,** 13-49 **(1990)**

14. Norton E.R., Clark L.J. and Carpenter E.W., Planting date evaluation in Graham County. In Cotton, Univ. of Arizona Rep. P-130, pp, 5-12 **(2002)**

15. Heitholt J.J., Canopy characteristics associated with deficient and excessive cotton plant population densities, *Crop Sci.,* **34**, 1291-1297 **(1994)**

16. Silvertooth J.C., Row spacing, plant population, and yield relationships. [Online]. Availableathttp://cals.arizona.edu/crops/cotton/comments/april1999cc.html (accessed 7 March, 2004; verified 2 Nov. 2004) University of Arizona, Tucson, AZ. **(1999)**

17. Bednarz C.W., Bridges D.C. and Brown S.M., Analysis of cotton yield stability across population densities, *Agron. J.,* **92**, 128-135 **(2000)**

18. Jones M.A. and Wells R., Fiber yield and quality of cotton grown at two divergent population densities, *Crop Sci*., **38**, 1190-1195 **(1998)**

19. Mobasser H.R., Delarestaghi Khorgami M.M., Tari A. and Pourkalhr D.B., Effect of planting density on agronomical characteristics of rice (Oryza sativa L.) varieties in north of Iran, *Pak. J. Biol. sci*., **10** (**18**), 3205-3209 (**2007**)

20. Konuskan O., Effect of plant density on yield and yield related characters of some maize hybrids grown in hatay conditions as 2nd crop, M.Sc. Thesis, Science Institute, M.K.U., 71 (**2000**)