The Asian and Australasian Journal of Plant Science and Biotechnology ©2009 Global Science Books

Impact of Removal of Shoot Tips on Productivity of Greengram (*Vigna radiata* L.)

Thayamini H. Seran* • Krishanthy

Department of Crop Science, Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka

Corresponding author: * thayaseran@yahoo.com

ABSTRACT

This experiment was carried out in 2007/2008 cropping seasons at the Agronomy farm of Eastern University, Sri Lanka to study the effect of decapitation on yield of greengram (*Vigna radiata* L.) 'MI 5'. In the control treatment (T_1), removal of the apical portion (1 cm long) of greengram plants was not practice while in other treatments (T_2, T_3, T_4 and T_5), apical portions of main stems were removed 3, 4, 5 and 6 weeks after planting respectively. Several morphological features were measured at regular intervals to evaluate the effect of decapitation while other parameters were measured at harvesting time. There were significant ($P<0.01$) differences between treatments in the number of pods per plant, dry weight of pods per plant and 1000-seed weight. Higher yield (2585 kg/ha) was obtained in T_2 than other treatments and T_1 gave the lowest yield (1687 kg/ha). In the present study, removal of the apical portion of the main stem at the 3rd week (T_2) would be most effective practice to obtain a high yield of greengram in sandy Regosol.

Keywords: branches, decapitation, harvest index, leaf area, yield
Abbreviations: HI, Harvest Index; **LAI**, Leaf Area Index

INTRODUCTION

Greengram (*Vigna radiata*) is one of the important pulse crops grown and consumed in Sri Lanka. It is a leguminous species grown principally for its protein-rich edible seeds and also has potential as a green manure and as a forage crop. Crop residues are important feed resources for ruminants (Reddy *et al*. 2003). Greengram, also known as *mung* in Hindi, is cultivated mostly in developing countries. Low income groups depend on grain legumes to substitute for the expensive meat and fish products. Greengram is adapted in multiple cropping systems in the drier and warmer climates of tropics and sub-tropics due to its rapid growth, short duration and wide adaptability. The optimum temperature for seed germination and subsequent plant growth is 28-33°C. Greengram grows in a wide range of soil types, but thrives best on deep loam or sandy loam soil. Green gram is one of the six major grain legumes successfully cultivated in dry and intermediate zones in Sri Lanka. However, one of the major problems of agriculture in third world countries is low crop productivity. One way of addressing population growth is by increasing the productivity of crops by expanding the cropping area, although this is not possible because cultivated land area is limited. On the other hand, raising productivity per unit area becomes only possible when planting high yielding varieties, increasing the number of crops grown per year and applying some agronomic practices such as decapitation, hormone application, fertilizer application, etc.

Decapitation means removal of the apex which may result in production of a greater number of inflorescences due to more extensive branching (Carl and Paul 1975), thus increasing crop fruit and seed production. Decapitation has many advantages in legumes. In cowpea, decapitation at the 5th leaf stage resulted in an increase in branching components, yield and harvest indices (Argall and Stewart 1984). Apex removal from inoculated legume plants prior to transition to flowering resulted in increased vegetative growth and nitrogenase (acetylene reduction) activity, delayed leaf and nodule senescence, and a greater accumulation of nitrogen in shoots (Gautam *et al.* 1983). In soybean, removing the apex during the early flowering stage increased yield by 10-15% (Greer and Anderson 1956). In groundnut, the number of seed set per plant was increased by 24% when the apical dominant shoot of the plant was removed (Andrea *et al.* 2006). Therefore an attempt was made to study the effect of decapitation on productivity of greengram to identify the suitable stage of vegetative growth to practice decapitation so as to achieve optimum yield in the Eastern region of Sri Lanka.

MATERIALS AND METHODS

Experimental site

This experiment was conducted in the 2007/2008 cropping seasons at the Agronomy farm of Eastern University in the Eastern Province of Sri Lanka to study the effect of removal of shoot tips on yield of greengram. The soil at the experimental site is sandy Regosol. The altitude of the site is about 100 m above mean sea level and falls into the agro-ecological zone of Low Country Dry Zone. The mean temperature ranges from 28 to 32°C and mean annual rainfall is about 1500 mm.

Experimental design

The experiment was laid out in a Randomized Complete Block Design with five treatments, each replicated four times. The size of each plot was 90 cm × 70 cm. The treatments were as follows:

T_1 - No removal of apical portion of main stem
T_2 - Removal of apical portion at 3rd week after planting
T_3 - Removal of apical portion at 4th week after planting
T_4 - Removal of apical portion at 5th week after planting
T_5 - Removal of apical portion at 6th week after planting.

Received: 4 November, 2008. Accepted: 17 January, 2009.

Original Research Paper

Agronomic practices

The area was ploughed and leveled and then plots were arranged according to the experimental design. Greengram cv. 'MI 5' seeds obtained from the Agronomy farm, Eastern University of Sri Lanka were soaked for 1 h and then treated with captan 50% wettable powder (fungicide; Harrisons Chemical (Pvt.) Ltd., Colombo, Sri Lanka) at a rate of 0.25% (w/w) before planting. At each planting hole in an individual plot, three seeds were planted at a spacing of 30 cm between rows and 10 cm within plants and also seeds were planted at the border of the plot to prevent the border effect to the experimental plants. Plants were thinned out after two weeks of planting; vacant hills were planted with seedlings and maintained at one plant per hill. Fertilizer was applied at the time of planting as basal application at a rate of 35 kg/ha urea, 140 kg/ha triple super phosphate and 75 kg/ha muriate of potash. Further, urea at the rate of 30 kg/ha was applied as top dressing during the flowing stage. Watering was done twice a day until germination and then once a day for a month. After one month, watering was done at 2-3 day intervals. There was no pest attack during this experimental period. Hand weeding was done two times during the first month of planting and continued periodically as when necessary.

Measurements

Numbers of leaves and branches were counted at regular intervals. Leaf area was measured using a portable leaf area meter. Leaf Area Index (LAI) was then calculated by dividing the leaf area by canopy area. Number of days from planting to first flowering, days to 50% flowing and days to maturity were also recorded in each treatment. Pods were separately harvested from each plant in each plot. Four pickings were done at the 35th, 45th, 55th and 65th days after planting. The number of pods per plant and the number of seeds per pod were counted. The grain yield per plot was evaluated.

Statistical analysis

Statistical analysis (S.A.S. software package, USA) was used for data analysis. All data were analyzed by analysis of variance and the significance of difference between means was then estimated using Duncan's Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

Leaf Area Index (LAI)

There were no remarkable differences (P>0.05) between treatments in the LAI until the 5th week of planting, thereafter significant variations were noted (**Table 1**). LAI was remarkably high (7.24) in T_2 at the 8th week. It would have been due to decapitation which was practiced in T_2 at the 3rd week after planting. Vegetative growth is normally rapid during that period. It was also noted that the numbers of branches and leaves in T_2 significantly (P<0.01) were higher than other treatments except T_3. Removal of the apical portion of the main stem would have caused auxiliary bud growth which leads to an increase in the number of leaves and branches. Greer and Anderson (1956) reported that removing the apex during the early flowering stage facilitated branching and increased leaf number in soybean.

Table 1 Leaf Area Index (LAI) at two week intervals.

Treatments	LAI at 4th week	LAI at 6th week	LAI at 8th week
T1	2.20 ± 0.16	4.40 ± 0.36 a	4.05 ± 0.32 c
T2	1.92 ± 0.12	4.50 ± 0.28 a	7.24 ± 0.28 a
T3	2.50 ± 0.19	3.89 ± 0.25 ab	5.92 ± 0.34 b
T4	2.45 ± 0.10	3.62 ± 0.16 b	3.05 ± 0.22 c
T5	2.42 ± 0.09	4.52 ± 0.22 a	3.80 ± 0.38 c
F-test	ns	*	**

Values represent means ± standard error.
F-test: * : P< 0.01; ** : P<0.05; ns: not significant
Means followed by the same letter in each column are not significantly different from each other according to Duncan's Multiple Range Test at the 5% level.

Leyser (2005) mentioned that the plant hormone, auxin synthesized in the shoot apex moves down the stem and inhibits lateral branching. This finding is supported for the induction of the lateral branches when removing the apex from the stem.

The optimal LAI differs among species. It changes during the growth of a crop and can also differ greatly in nature from values of 2-12 in stands of trees in tropical and mountainous rain forests (Stephens and Waggoner 1970). The optimum LAI may not be the same for varieties within a species and it may also depend on the light intensity. Jeffers and Shibles (1969) reported that the highest rate of photosynthesis occurred with full sunlight with an LAI > 8, and as the light intensity decreased net assimilation was diminished and the optimum LAI decreased. Therefore, it is necessary for expanding the leaf area to reach its optimal LAI in order to obtain maximum crop productivity. A large LAI value is related to greater productivity (Loomis and Williams 1969).

Number of flowers

The numbers of flowers per plant varied significantly (P<0.05) among the treatments at the 4th and 5th week after planting. The average number of flowers ranged from 9.75-21.25 at the 5th week (**Table 2**).

The average number of flowers in T_2 was high (21.25) at the 5th week but very low at the 4th week. This would be due to decapitation that was practiced in T_2 and T_3 at the 3rd and 4th week after planting, respectively. Decapitation may induce active vegetative growth and reduce reproductive growth. Therefore, the number of flowers decreased in T_2 at the 4th week. However, at the 5th week, the average number of flowers in T_2 was higher than at other weekly intervals, which would have been due to the removal of the apical portion of the main stem that enhanced vegetative proliferation and generated multiple site branches for flower formation. Keller *et al.* (1988) mentioned that decapitation resulted in less abscission among distal flowers and young pods from the nodes of *Vicia faba* L.

Days to 50% flowering

In this experiment, 25 to 27 days were taken for first flowering, 32 to 39 days for 50% flowering and 36 and 40 days for 100% flowering. T_2 (27 days) and T_3 (26 days) took a long time for 1st flowering than other treatments. All treatments showed 50 and 100% flowering within 15 days

Table 2 The average number of flowers per plant at weekly intervals.

Treatments	At 4th week	At 5th week	At 6th week	At 7th week
T_1	4.00 ± 0.81 a	15.25 ± 1.70 ab	3.75 ± 0.25	1.00 ± 1.00
T_2	0.75 ± 0.75 b	21.25 ± 4.62 a	3.75 ± 1.43	0.50 ± 0.50
T_3	2.00 ± 0.00 ab	14.75 ± 3.70 ab	5.75 ± 1.49	0.00 ± 0.00
T_4	4.00 ± 0.70 a	9.75 ± 1.79 b	6.25 ± 2.59	1.25 ± 1.25
T_5	2.25 ± 0.85 ab	11.50 ± 1.32 b	4.50 ± 1.04	0.00 ± 0.00
F-test	*	*	ns	ns

Values represent means ± standard error.
F-test: * : P< 0.05; ns: not significant
Means followed by the same letter are not significantly different in each column according to Duncan's Multiple Range Test at the 5% level.

after the appearance of first flowers. In greengram, flowering is an indeterminate type growth habit and may continue over a period of several weeks if the plant remains healthy (Poehlman 1991) and could increase seed yield in greengram. Chandel *et al.* (1973) reported that in greengram, days to flowering have a direct positive co-relation with seed yield.

Days to maturity

The first matured pods were harvested in T_2 at 35 days after the appearance of the first flower. The matured pods had short hairs and were brown to black. Poehlman (1991) reported that pods mature about 20 days after flowering.

Number of pods

The average number of matured pods per plant in each treatment is shown in **Table 3**. There was a significant difference (P<0.01) between treatments. T_2 produced the maximum number of pods while T_5 formed the least. The average number of pods varied from 16.12 to 29.62. T_2 had more branches and pods. In T_2, removal of the apical portion was done at the 3rd week after planting. This practice at an early vegetative stage may be attributed to the induction of the lateral buds that would grow and develop into branches, supported by Leyser (2005) who reported that the plant hormone, auxin synthesized in the shoot apex moves down the stem and inhibits lateral branching. The number of pods per plant may be related to the number of branches per plant. Singh and Malhotra (1970) reported that pods per plant make the greatest direct contribution to seed yield.

Weight of pods

There were significant differences in dry weights of pods and seeds among treatments (**Table 4**). However, no difference was noted between T_2 and T_3, both of which had more branches that led to the production of more pods per plant. Therefore, the average dry weights of pods and seeds were significantly high in T_2 and T_3 as compared to T_1 (control).

Table 3 The average number of pods per plant in each treatment.

Treatments	Number of pods per plant
T_1	18.00 ± 1.20 c
T_2	29.62 ± 1.46 a
T_3	22.12 ± 0.85 b
T_4	17.62 ± 0.65 c
T_5	16.12 ± 1.31 c
F value	**

Value represents mean ± standard error.
F test: ** : P<0.01
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 4 The average dry weight of pods per plant in each treatment at the time of harvest.

Treatment	Weight of pods per plant (g)	Shelling %
T_1	12.41 ± 1.01 b	57.00
T_2	18.81 ± 0.83 a	57.68
T_3	16.05 ± 0.85 a	56.88
T_4	12.79 ± 0.68 b	59.85
T_5	12.86 ± 1.47 b	58.47
F value	**	ns

Value represents mean ± standard error.
F test: ** P< 0.01; * P< 0.05; ns: not significant.
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Number of nodules

There was no significant (P>0.05) difference between treatments in the number of nodules per plant until the 4th week after planting. Remarkable variations were then noted after the 5th week (**Table 5**). The average number of nodules ranged from 12-34 at the 6th week after planting and was higher in the decapitated plants than in the control. T_2 and T_3 significantly (P<0.01) differed from other treatments and no significant difference (P>0.05) was noted between T_2 and T_3 after the 4th week of planting.

The removal of the apex from inoculated legume plants prior to the transition to flowering resulted in increased vegetative growth and nitrogenous (acetylene reduction) activity, delayed nodule senescence and a greater accumulation of nitrogen in shoots of beans (Gautam *et al.* 1983). This may explain the high number of nodules that formed in T_2 where decapitation was practiced before the flowering stage.

Table 5 The number of nodules per plant in each treatment.

Treatment	Number of nodules per plant	
	At 6th week	At 8th week
T_1	12.0 ± 1.08 c	38.00 ± 1.08 b
T_2	34.0 ± 1.82 a	51.25 ± 3.49 a
T_3	31.0 ± 1.29 a	50.25 ± 1.79 a
T_4	16.5 ± 1.25 b	23.25 ± 0.85 d
T_5	18.0 ± 1.08 b	31.75 ± 1.25 c
F value	**	**

Value represents mean ± standard error.
F test: ** P< 0.01
Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Table 6 The average number of seeds per pod in each treatment.

Treatments	Number of seeds per pod
T_1	8.39 ± 0.31 a
T_2	6.94 ± 0.24 b
T_3	7.11 ± 0.37 b
T_4	8.18 ± 0.24 a
T_5	8.21 ± 0.22 a
F value	*

Value represents mean ± standard error.
F test: * : P<0.05
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 7 **The 1000-seed weight of greengram in each treatment.**

Treatment	1000-seed weight
T_1	55.06 ± 0.31 b
T_2	53.80 ± 0.59 c
T_3	54.80 ± 0.40 c
T_4	59.40 ± 0.42 a
T_5	60.00 ± 0.32 a
F value	**

Value represents mean ± standard error.
F test: ** P< 0.01
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Number of seeds

In the present study, there was a significant difference in the number of seeds per pod between treatments (**Table 6**). T_2 and T_3 significantly differed (P<0.05) from other treatments. T_2 and T_3 produced of the fewest seeds per pod but more pods.

Seed weight

In this experiment, T_4 and T_5 significantly differed (P<0.01) from other treatments in 1000-seed weight and there was no remarkable difference between T_2 and T_3 (**Table 7**). Iqbal (1989) reported that the 1000-seed weight of 'MI 5' was 56 g.

Table 8 Economic yield in each treatment.

Treatment	Yield (kg/ha)
T_1	1687.46 b
T_2	2584.92 a
T_3	2174.28 ab
T_4	1839.68 b
T_5	1792.38 b
F value	*

Value represents mean ± standard error.
F test: * P< 0.05
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 9 Harvest Index in each treatment.

Treatment	Harvest index
T_1	34.59 ± 1.21 c
T_2	40.11 ± 1.04 a
T_3	36.36 ± 1.28 b
T_4	36.01 ± 1.01 b
T_5	34.57 ± 1.02 c
F value	*

Value represents mean ± standard error.
F test: * P< 0.05
Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Economic yield

There was a significant difference (P<0.05) in yield among the treatments and highest seed yield (2585 kg/ha) was obtained in T_2 (**Table 8**). The number of branches per plant, number of seeds per pod and number of pods per plant were the important characteristics contributing towards seed yield. In greengram, seed yield is positively correlated with the number of branches per plant, 1000-seed weight, number of pods per plant and number of seeds per pod (Yohe and Poehlman 1975). Pods per plant make highest direct contribution to seed yield (Singh and Malhotra 1970) and seeds per pod and height of plant have positive contribution to seed yield (Poehlman 1991). In soybean, removing the apex during early flowering stage increased yield by 10-15% (Greer and Anderson 1956).

Green gram is usually determinate type growth habit (Lawn 1979). Therefore, formation of new leaves effectively ceases at flowering. One third of the total dry matter accumulated during seed filling may be partitioned into non-reproductive structures (Muchow *et al.* 1982) and in greengram, flowering is restricted to the uppermost 4 or 5 nodes on the stem and branches (Poehlman 1991). Therefore, decapitation at an early vegetative stage increases the production of branches, multiple side branches for flower production and also increases the chances of producing more leaves before flower initiation. This may increase the accumulation of dry matter for seed filling. In the present study, high seed yield was obtained in T_2 where decapitation was practiced at an early vegetative stage.

Harvest index

Harvest index reflects the physiological capacity of a crop to mobilize and translocate photosynthates (sink capacity) to organs having economic value (Rao 2003). In the present study, significantly highest harvest index value of 40.11% was recorded in T_2 followed by T_3 and T_4 (**Table 9**). These results indicate that removal of the apex at an early stage of vegetative growth (T_2) significantly increased seed yield in greengram. Hay (1995) mentioned that the value for modern varieties of most intensively cultivated grain crops falls within the range 0.4 to 0.6. Similar findings regarding harvest index have been reported by Ghafoor *et al*. (2000) who reported that accessions of mungbean with a harvest index of 35.01-40.10% gave good average values for most values i.e. days to maturity, number of branches, pods/plant, seeds per pod and grain yield.

CONCLUSION

This study revealed that most agronomic parameters (LAI, number of flowers and pods as well as fresh and dry weights of pods and seeds) were favourably achieved in T_2 among the tested treatments. Decapitation in greengram at the 3rd week after planting would be more effective to obtain high yield (2585 kg/ha) among the treatments. Greengram is usually determinate growth type and decapitation at an early vegetative growth period effectively increases the number of branches and produces multiple side branches for flower production. This ultimately increases seed yield. However, decapitation at a late vegetative or flowering period did not form effective branches. Therefore, the vegetative growth of greengram plant is stopped after the initiation of flowers.

REFERENCES

Argall JF, Stewart KA (1984) Effects of decapitation and benzyladenine on growth and yield of cowpea (*Vigna unguiculata* (L.) Walp.). *Annals of Botany* **54**, 439-444

Andrea LM, Kenton ED, Hassan AM (2006) Removal of apical dominant shoot for disease resistance screening increases seed yield of container-grown plants. *Crop Science* **46**, 2013-2014

Carl LA, Paul EK (1975) Plant Growth and Development, Tata Mcgraw. pp 266-276

Chandel KPS, Joshi BS, Pant KC (1973) Yield in green gram and its components. *Indian Journal of Genetics and Plant Breeding* **33 (2)**, 271-276

Gautam, S, Lisa MB, Barbara DW (1983) Effects of prevention of flowering on the growth of bean plants inoculated with an ineffective strain of *Rhizobium phaseoli*. *Botanical Gazette* **144**, 225-230

Ghafoor A, Zahib MA, Ahmad Z, Afzal M, Zubair M (2000) Selecting superior mungbean lines on the basis of genetic diversity and harvest index. *Pakistan Journal of Biological Science* **3 (8)**, 1270-1273

Greer HAL, Anderson I.C (1956) Response of soyabean to triodobenzoic acid under field condition. *Crop Science* **5**, 229-232

Hay RKM (1995) Harvest index: a review of its use in plant breeding and crop physiology. *Annals of Applied Biology* **126 (1)**, 197-216

Iqbal YB (1989) Varietal evaluation of improved greengram cultivars of the National Coordinated Varietal Trial in Maha-Illuppalama. BSc thesis in Agriculture, Eastern University of Sri Lanka, pp 34-44

Jeffers DL, Shibles RM (1969) Some effects of leaf area, solar radiation air temperature and variety on net photosynthesis in field grown soybeans. *Crop Science* **9**, 762-764

Keller ER, Diethelm R, Bangerth F (1988) Auxins, ABA and gibberellin-like activity in abscising and non-abscising flowers and pods of *Vicia faba* L. *Journal of Plant Growth Regulation* **10**, 75-90

Lawn RJ (1979) Agronomic studies on *Vigna* spp. in south-eastern Queensland. II. Vegetative and reproductive response of cultivars to sowing date. *Australian Journal of Agricultural Research* **30**, 871-882

Leyser O (2005) The fall and rice of apical dominance. *Current Opinion in Genetics and Development* **15 (4)**, 468-471

Muchow RC, Charles EDA (1982) An analysis of the growth of mung beans at a range of plant densities in tropical Australia. I. Dry matter production Australian. *Journal of Agricultural Research* **33**, 41-51

Poehlman JM (1991) *The Mung Bean*, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, pp 5-10

Rao GR (2003) Effect of certain growth regulars on growth and yield of greengram. *Madras Agricultural Journal* **90 (7-9)**, 547-549

Reddy BVS, Reddy PS, Bidinger F, Elummel M (2003) Crop management factors influencing yield and quality of crop residue. *Field Crops Research* **84 (1-2)**, 57-77

Singh KB, Malhotra RS (1970) Interrelationship between yield and yield components. *Indian Journal of Genetics and Plant Breeding* **30**, 244-250

Stephens GN, Waggoner PE (1970) Carbon dioxide exchange of a tropical ran forest part. *Bioscience* **20**, 1050-1053

Yohe JM, Poehlman JM (1975) Regression, correlations and combining ability in mungbean (*Vigna radiata* L.). *Tropical Agriculture* (Trinidad) **52**, 343-352