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Foliar Nutrition of Different Sources of Phosphorus on Yield and Economics of Greengram (*Vigna radiata.L.)* in North Eastern Zone of Tamil Nadu

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***Abstract:** Nutrient management is an important cultural operation in increasing the productivity of pulses. It is closely related to availability of nutrients and also mobilization absorption, and utilization of nutrient from the soil. Foliar nutrition to pulse crops is very essential at flowering stage to arrest the flower dropping and also to induce the flowering. Accordingly, the field experiment was conducted in greengram variety VRM (Gg) - 1 at Agricultural College and Research Institute, Vazhavachanur during summer season, 2019 with different sources of phosphorus as foliar spray in greengram. The study revealed that the application of Mono Ammonium Phosphate (MAP) as foliar spray @ 1.0 per cent at flower initiation stage (First spray) and 15 days after first spray (second spray) has recorded the highest seed yield of 1161 kg ha^{-1} and mean haulm yield of 1929.12 kg ha^{-1} in addition to the gross monetary returns of Rs. 57,541 ha^{-1}, net monetary returns of Rs. 36,989 ha^{-1} with B: C ratio of 2.79 when compared to other sources of phosphorus at different concentrations in green gram cultivation.*
***Keywords:** Greengram, phosphorus, Mono ammonium phosphate, DAP, 19:19:19, foliar spray, flowering, yield, economics*

Introduction

Green gram is an important pulse crop occupies an area of 34.5 million hectares, production of 15.91 million tonnes and productivity of 461 kg ha $^{-1}$. The crop occupies an area of 1.18 lakh hectares, production of 1.21 lakh tonnes and productivity of 640 kg ha$^{-1.}$ in Tamil Nadu. The major green gram cultivating states are Maharashtra, Orissa, Andhra Pradesh, Karnataka, Gujarat, Rajasthan, Madhya Pradesh, Uttarpradesh and Tamil Nadu. Among the states, Orissa ranks first in area and production, whereas Punjab is first in productivity. It contains 51 per cent of carbohydrate, 24-2 per cent of protein, 4 per cent of minerals and 3 per cent of vitamins. It enriches the soil fertility through association with symbiotic rhizobial bacterial microorganisms in the roots and then fixes atmospheric nitrogen for its growth and development and further uses as manure crop, green fodder and involves in multiple intercropping system. Phosphorus fertilization is very crucial for seed formation in all the crops. The uptake of phosphorus nutrition will be less than 20 percent by crops, which will be improved through addition application of phosphorus inputs. Generally, the concentration of available phosphorus in the soil is insufficient due to fixation, which demands the addition of soluble phosphorus either inorganic or organic form to support the phosphorus requirement of the crop (Tisdale *et al*., 2010). The pulse crops increases nodules in the root through nitrogen fixation which increases the productivity (Prasad et al., 2014). The adequate amount phosphorus is very important for legume crops is more important for cell division followed by root development, nodulation, growth and yield than nitrogen because it involves in energy transfer reactions and oxidation-reduction processes. Phosphorus is a key single factor for increasing productivity of pulses (Deo and Khaldelwal, 2009). The functions of phosphorus in the plant cannot be substituted by other nutrients and also one of the most essential elements because of its multiple effects for growth and development of the crop. Phosphorus is important for photosynthesis, nutrient translocation, transformation of starches and sugars in the plant system and transfer of genetic traits from one generation to another. The role of phosphorus for physiological responses in green gram was reported by Sukalu Kachlam (2018). The limitation in phosphorus availability results in reduction in crop growth and adequate supply of phosphorus is inevitable at the early stage of the crop (Bertrand *et al.*, 2003).The foliar application of di ammonium phosphate (DAP) and superphosphate was found to be beneficial because it eliminates fixation of insoluble triphosphates in soil.

Nowadays, application of water soluble fertilizers in the form of foliar spray is getting importance to enhance the yield. There is a need to improve the economy of country through increasing the yield of pulses by eliminating the constraints like inadequate nutrient uptake by greengram plants. The water soluble source of phosphorous and nitrogen like Mono Ammonium phosphate (MAP) contains 12 per cent N and 61 per cent P_2O_5 which serves as high quality source of phosphorus during different stages of the growth cycle. MAP is an ideal fertilizer for fertigation and foliar application due to easy water solubility nature when compared to DAP which further facilitates uptake of natural phosphorus present in the soil. The available ammonium ($NH4^+$) in MAP lowers the pH in the root zone soil which enhances the phosphorus uptake by the plant. The concentration of 0.5% MAP is recommended as foliar spry in most of the crops, whereas 1.0% for more tolerant crops MAP is compatible with most commonly used pesticides and fertilizers. Foliar application of DAP and MAP at different concentrations produced significantly increased the grain yield in greengram.

Generally, 2.0 per cent DAP foliar spray is recommended for pulse crops to prevent flower drop and better seed set in crops. Several demonstrations were conducted on the effect of 2.0 % DAP spray and boosted the yield in greengram. Inspite of that farmers are failing to adopt for the following reasons due to its time consumption in dissolving capacity and filtering of supernants, incompatible with plant protection chemicals and phytotoxicity effect of its solid deposition on the leaf surface.

Materials and Methods

The field experiment was conducted in greengram variety VRM (Gg) - 1 at Agricultural College and Research Institute, Vazhavachanur during summer season, 2019. The experiment was laid out on Randomized Block Design with three replications. The treatments were allotted randomly to each replication by keeping the gross plot size as 2.3x2.3 m^2 and net plot size as 2x2 m^2 respectively. The treatments are Control (water spray) (T_1),0.5,1.0,2.0 % MAP at flower initiation & 15 days after first spray (T_3,T_4,T_5) and 0.5,1.0, 2.0 % 19:19:19 at flower initiation & 15 days after first spray (T_6,T_7,T_8).

Height of the randomly selected three plants was measured from ground level to the base of last fully opened leaf at various dates of observation starting from 15 DAS upto harvest with 15 days interval. The number of pods was counted from 3 randomly selected plants from net plots and then the average was worked out. One representative plant from each net plot was selected randomly and uprooted carefully at each observation date for dry matter studies. Roots were discarded and plants were kept for sun drying in well labelled brown paper bags. Initially plant samples were sundried upto two days followed by oven drying at a constant temperature of $65^0 + 2^0$ C until constant dry weight was obtained. Total number of pods from three selected plants was counted and an average number of pods plant^{-1} was worked out. Number of seeds pod^{-1} was recorded from three randomly selected plants from each net plot at the time of harvesting and average is worked out. Hundred seeds were counted from each net plot seed yield and its weight was recorded. The plants from each net plot were harvested and seeds were separated by threshing. The sun dried seed yield obtained in each net plot were weighed in kg and presented as kg ha^{-1}. Haulm yield was obtained by deducting the seed yield from the weight of total dry produce (biological yield) of respective net plot in kg and given as kg ha^{-1}. The figures of biological yield were calculated by summing seed yield, and halum yield of net plots. Finally it was converted on hectare basis.

The harvest index was calculated by using formula,

$$\text{Harvest index (\%)} = \frac{\text{Total seed yield (kg ha}^{-1}\text{)}}{\text{Total biological yield (kg ha}^{-1}\text{)}} \times 100$$

Where,

Biological yield = seed yield + haulm yield

The cost of cultivation for raising the crop in each treatment was worked out. Similarly, the gross returns were calculated as per prevailing market prices of economic produce of each treatment and there after the net returns were worked out. The data was subjected to “F” test and inferences were drawn. The B:C ratio will be calculated by dividing gross monetary returns with cost of cultivation. The statistical analysis of the data was carried out by the standard statistical method ‘Analysis of Variance’ (Panse and Sukhatme, 1967). The null hypothesis was tested by F at significance in order to ascertain whether treatment effects were real or not. From the data, in which the treatment

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effects were significant, the appropriate standard error (SE) and critical difference (CD) at 5 per cent level of significance were worked out.

Results and Discussion

The rate of plant height increase was slow from 0 to 15 days after sowing (DAS) days then fast from 15 to 30 days and very fast between 30 and 45 days, it was slowed down from 45 to 60 days and very slow from 60 days to harvest. The data presented in Table - 1 revealed that the mean plant height was increased from 10 DAS to harvest and reached to maximum (40.26 cm) at harvest for spraying of 0.5% MAP at flower initiation and 15 days after first spray (T_4).

Table 1: Plant height (cm) as influenced by various treatments at various growth stages of greengram

Treatments	Plant height (cm)					
	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1- Control (water spray)	7.86	15.76	21.36	25.70	29.26	31.00
T_2 - 2% DAP at flower initiation & 15 days after first spray	7.73	16.23	22.46	27.36	31.46	32.66
T_3 - 0.5% MAP at flower initiation & 15 days after first spray	7.03	15.30	22.20	30.80	35.40	38.90
T_4 - 1% MAP at flower initiation & 15 days after first spray	7.13	14.66	21.85	31.70	36.36	40.26
T_5 - 2% MAP at flower initiation & 15 days after first spray	7.53	16.36	22.70	28.03	33.13	34.36
T_6 - 0.5% 19:19:19 at flower initiation &15days after first spray	7.83	15.80	22.00	29.23	33.9	36.63
T_7 - 1% 19:19:19 at flower initiation & 15 days after first spray	7.33	14.93	22.33	30.40	34.43	37.76
T_8 -2% 19:19:19 at flower initiation & 15 days after first spray	7.36	14.86	14.86	26.90	30.06	32.40
SED	0.56	1.57	0.95	0.36	0.45	0.43
CD(p=0.05)	1.17	3.31	2.01	0.76	0.95	0.90

The observations for T_5 (2% MAP at flower initiation & 15 days after first spray) was 31.7, 36.36, 40.26 cm respectively for 40th, 50th 60th DAS followed by the plot sprayed with T_3 (0.5% MAP at flower initiation and 15 days after first spray) recorded as 30.8, 35.4, 38.9 cm. The lowest plant height was observed under the control plot. Shinde and Bhilare (2003) also observed similar results with regard to growth parameters.

The leaf area index increased continuously up to 45 DAS and then slow increase from 45 to 60 days and then very slow from 60 days to harvest (Table -2 and Fig: 1). At 15 and 30 DAS the leaf area index was not significant .At 45th and 60th DAS the leaf area index was a significant differences in different treatments.

Table -2: Effect of different sources of phosphorus on leaf area index of greengram

Treatments	Leaf Area Index			
	15 DAS	30 DAS	45 DAS	60 DAS
T_1- Control (water spray)	0.039	0.35	1.23	1.10
T_2 - 2% DAP at flower initiation & 15 days after first spray	0.038	0.38	1.3	1.17
T_3 - 0.5% MAP at flower initiation & 15 days after first spray	0.037	0.38	1.43	1.28
T_4 - 1% MAP at flower initiation & 15 days after first spray	0.034	0.35	1.47	1.32
T_5 - 2% MAP at flower initiation & 15 days after first spray	0.036	0.38	1.34	1.20
T_6 - 0.5% 19:19:19 at flower initiation & 15 days after first spray	0.040	0.38	1.37	1.23
T_7 - 1% 19:19:19 at flower initiation & 15 days after first spray	0.038	0.38	1.38	1.24
T_8 -2% 19:19:19 at flower initiation & 15 days after first spray	0.042	0.39	1.28	1.15
SED	0.0017	0.019	0.011	0.021
CD(p=0.05)	0.0037	0.041	0.024	0.045

The data pertaining to leaf area index of greengram was significantly influenced due to application of 1% MAP at flower initiation & 15 days after first spray (T_4) recorded higher leaf area index of 1.47 at 45 DAS and then decreased at harvest, which was followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3). Among 19:19:19 spray, application of 1% 19:19:19 at flower initiation and 15 days after first spray (T_7) recorded higher leaf area index of 1.38 followed by application of 0.5% 19:19:19 at flower initiation and 15 days after first spray (T_6). Control (water spray) (T_1) recorded lower leaf area index of 1.23.(fig.1).

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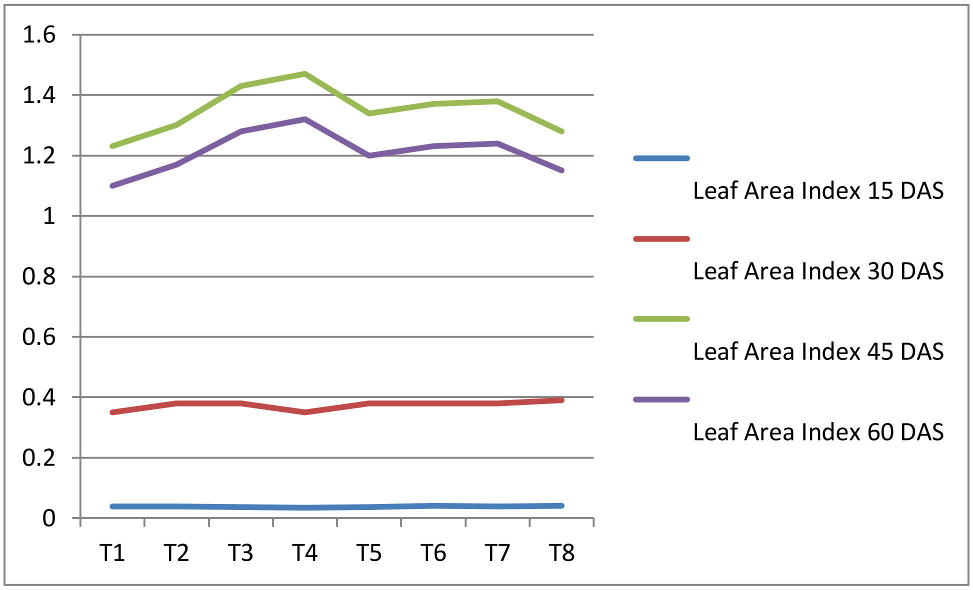
Figure 1: Effect of different treatments on leaf area index at different stages of crop growth



The dry matter production (g m^{-2}) of greengram was significantly influenced due to application of 1% MAP at flower initiation & 15 days after first spray (T_4) (Table 4) , which has recorded higher dry matter of 247.72 (g m^{-2}) followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3). Application of 1% 19:19:19 at flower initiation & 15 days after first spray (T_7) recorded higher dry matter of 239.23 (g m^{-2})) followed by application of 0.5% 19:19:19 at flower initiation + 15 days after first spray (T_6). Whereas the control (water spray) (T_1) recorded lower dry matter of 221.61 (g m^{-2})**.** The first flower initiation started at 28 DAS. After flower initiation, application of 1% MAP at flower initiation &15 days after first spray (T_4) recorded higher flower count of 56 followed by application of 0.5% MAP at flower initiation +15 days after first spray (T_3) recorded as 54 (Table - 4).

Table 4: Effect of different sources of phosphorus on flower count, no. of pods plant^{-1}, fertility ratio and yield parameters

Treatments	Flower count(No.)	No of pods plant^{-1}	Fertility ratio	No. of pods plant^{-1}	No of seeds Pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest Index (%)
T_1	38	8	4.7:1	8.0	6.6	3.11	660	1485	24.90
T_2	42	10	4.2:1	10.0	8.0	3.22	814	1621	27.36
T_3	54	14	3.8:1	14.3	10.3	3.41	1093	2293	32.16
T_4	56	15	3.7:1	15.3	11.6	3.47	1161	2757	33.33
T_5	46	11	4.1:1	11.0	9.3	3.27	969	1713	28.16
T_6	48	12	4.0:1	12.0	9.3	3.31	1009	1952	28.93

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T_7	50	13	3.8:1	13.0	10.0	3.33	1065	2069	30.30
T_8	40	9	5.0:1	8.6	8.3	3.18	775	1543	26.33
SED	-	-	-	0.76	0.64	0.020	15.7	69.52	0.39
CD(p=0.05)	-	-	-	1.60	1.34	0.043	33.1	146.07	0.82

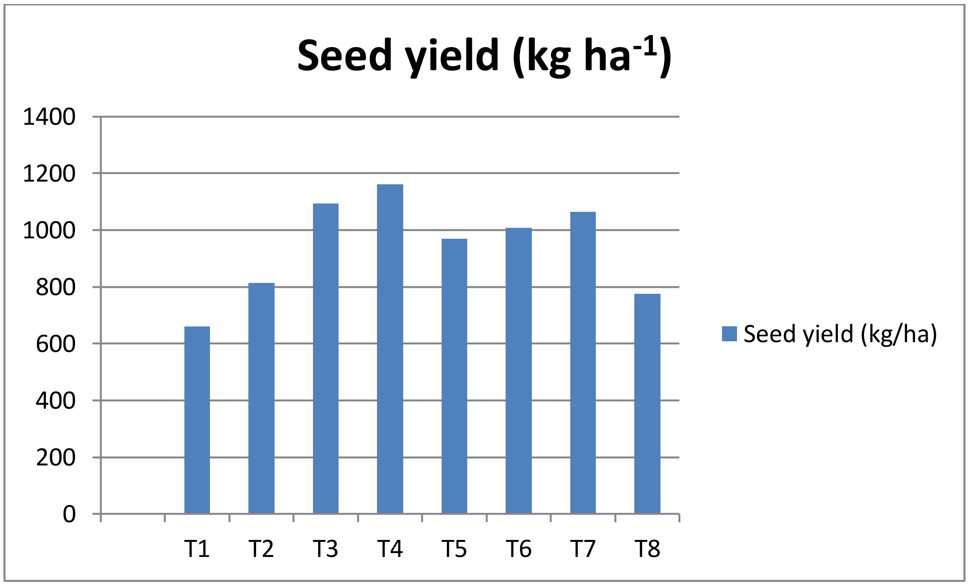
T_1 - Control (water spray), T_2 - 2% DAP at flower initiation & 15 days after first spray, T_3 - 0.5% MAP at flower initiation & 15 days after first spray, T_4 - 1% MAP at flower initiation & 15 days after first spray, T_5 - 2% MAP at flower initiation & 15 days after first spray,, T_6 - 0.5% 19:19:19 at flower initiation & 15 days after first spray, T_7 - 1% 19:19:19 at flower initiation & 15 days after first spray,, T_8 -2% 19:19:19 at flower initiation & 15 days after first spray

Application of 1% MAP at flower initiation & 15 days after first spray (T_4) recorded higher no of pods plant^{-1} 15 followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3). Application of 1% 19:19:19 at flower initiation & 15 days after first spray (T_7) recorded higher no of pods plant^{-1} of 13 followed by application of 0.5% 19:19:19 (T_6) The control (water spray) (T_1) recorded lower no of pods plant^{-1} of 8.0 in greengram(Table -4). The no. of seeds pod^{-1} was maximum sprayed with 1% MAP at flower initiation stage and 15 days after flowering recorded as 11.66 (T_4) followed by the plot sprayed with 0.5% MAP recorded as 10.33(T_3). The lowest number will be observed under the control plot as 6.66(Table -4). Singh and Singh (1991) has observed higher yield parameters due to soil application P_2O_5.

There is no significant difference in test weight. The table -4 indicates that the higher test weight of 3.47 g was recorded under the plot sprayed with 1% MAP (T_4) followed by sprayed with 0.5% MAP (T_3) recorded as 3.41g. The lowest test weight was observed under the control plot recorded as 3.11 g(Table -4). The data on seed yield, haulm yield, biological yield and harvest index as influenced by different treatments were presented in Table 4 and depicted in fig. 2. The seed yield of green gram (kg ha^{-1}) was significantly influenced due to application of 1% MAP at flower initiation & 15 days after first spray (T_4), recorded higher seed yield of 1161 kg ha^{-1}(Table -5) and Fig :1 followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3). Application of 1% 19:19:19 at flower initiation & 15 days after first spray (T_7) recorded higher seed yield of 1065 kg ha^{-1} followed by application of 0.5% 19:19:19 at flower initiation & 15 days after first spray (T_6). Control (water spray) (T_1) recorded lower seed yield of 660 kg ha$^{-1.}$ The similar results were observed by Tank *et al.* (1992), Ardeshna *et al.* (1993), Ghuge (1993) and Gopal Rao *et al.* (1993).

The haulm yield of green gram (kg ha^{-1}) was significantly influenced due to application of 1% MAP (T_4) at flower initiation & 15 days after first spray(Table -5). Application of 1% MAP at flower initiation & 15 days after first spray (T_4) recorded higher seed yield of 2757 kg ha^{-1} followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3).Both treatments are significantly different from other treatments. Among 19:19:19 spray, application of 1% 19:19:19 at flower initiation & 15 days after first spray (T_7) recorded higher haulm yield of 2069 kg ha^{-1} followed by application of 0.5% 19:19:19 (T_6). Both treatments are significantly different from other treatments. The haulm yield of 2%DAP was recorded as 1621 kg ha^{-1} control (water spray) (T_1) recorded lower haulm yield of 1485 kg ha^{-1}. Harvest index as influenced by application of different treatments were presented in Table -4. The ratio between economic yield to biological yield was influenced by various treatments. The harvest index among various treatments varied from 33.33% - 32.16% compared to control recorded as 24.9%. Among highest harvest index was recorded the application of 1% MAP (T_4) treatment. Sharma *et al.* (1993) reported similar results with regard to yield.

Figure 2: Effect of different sources of phosphorus on Seed yield (kg ha^{-1})



The gross monetary returns (Rs 57,541 ha^{-1}), net monetary returns (Rs 36,989 ha^{-1}) and B: C ratios (2.79:1) were highest for application of 1% MAP foliar nutrition at flower initiation and 15 days after first spray (T_4). The control (water spray) (T_1) were recorded lowest gross monetary returns, net monetary returns and B: C ratio among all the treatments.

The Benefit cost ratio of green gram was significantly influenced due to application of 1% MAP (T_4) at flower initiation & 15 days after first spray (Table - 5). Application of 1% MAP at flower initiation & 15 days after first spray (T_4) recorded higher benefit cost ratio of 2.79 followed by application of 0.5% MAP at flower initiation & 15 days after first spray (T_3). Both treatments are significantly different from other treatments. Among 19:19:19 spray, application of 1% 19:19:19 at flower initiation & 15 days after first spray (T_7) recorded higher Benefit cost ratio of 2.46 followed by application of 0.5% 19:19:19 (T_6). Both treatments are significantly different from other treatments. The control (water spray) (T_1) recorded lower benefit cost ratio of 1.73. Patel *et al.* (1992) have recorded similar results in economics.

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Table 5: Effect of different sources of phosphorus on Cost of cultivation (Rs ha^{-1}), Gross return (Rs ha^{-1}), Net return (Rs ha^{-1}) and B: C ratio

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B : C ratio
T_1 - Control (water spray)	18802	32587	13785	1.73
T_2 - 2% DAP at flower initiation & 15 days after first spray	20302	39875	19573	1.96
T_3 - 0.5% MAP at flower initiation & 15 days after first spray	20052	53717	33665	2.67
T_4 - 1% MAP at flower initiation & 15 days after first spray	21302	57541	36239	2.70
T_5 - 2% MAP at flower initiation & 15 days after first spray	23802	47143	23341	1.98
T_6 - 0.5% 19:19:19 at flower initiation & 15 days after first spray	20177	49342	29165	2.44
T_7 - 1% 19:19:19 at flower initiation & 15 days after first spray	21552	53093	30541	2.46
T_8 -2% 19:19:19 at flower initiation & 15 days after first spray	24302	37964	13662	1.56

CONCLUSION

The growth attributes such as plant height, leaf area index and the total dry matter m^{-2} were even upto 30 DAS. After 30 DAS, foliar application of different phosphorus sources has increased the plant biometric traits compared to without foliar application of different levels of phosphorus. In case of plant height, 1% MAP of foliar application at 30 and 45 DAS was found to better reached to maximum (40.26 cm) at harvest. The leaf area index and total dry matter increased continuously up to 45 days and then decreased due to leaf senescence. Application of 1.0 % MAP as foliar spray at flower initiation and 15 days after first spray has recorded the maximum leaf area index at 45 DSA and maximum total dry matter production m^{-2} at harvest. The number of pods (15.33) and number of seeds pod^{-1} (11.66) was significantly increased for 1% MAP of foliar nutrition at flower initiation and 15 days after first spray with test weight (100 seed weight) was 3.47 g in greengram.

The highest seed yield of 1161 kg ha^{-1} was recorded by the application of 1% MAP foliar application at flower initiation and 15 days after first spray (T_4) with haulm yield (1929.12 kg ha-1), with the net return of Rs.36239 and B:C ratio of 2.70. Which was significantly superior over rest of the treatments.

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