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Response of Physiological Parameters in Greengram (*Vigna radiata* L. Wilckzek) *cv.* GAM-5 to Source Manipulation, Plant Growth Regulators and Chemical

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ABSTRACT

Background: Among the pulse crops mungbean is one of the richest sources of protein. There is great loss in the yield of mungbean due to various reasons may be biotic or abiotic constraints. To overcome the yield loss various physiological activities are studied. Physiological activities of the plant are greatly influenced by the source manipulation, plant growth regulators and chemical in mungbean. In correspondence to this, an experiment was conducted to study the physiological parameters in greengram.

Methods: A factorial randomized block design in two respective years, *i.e.* 2016 and 2017 to study the response of source manipulation (nipping, 25% defoliation and 50% defoliation), plant growth regulators (GA_3 and NAA at 25 and 50mg/l respectively) and chemical (Thiourea 500 and 1000mg/l) on the physiological parameters like Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area (LA) in greengram at 30, 45, 60 and 75 DAS/harvest at Regional Research Station, Anand Agricultural University, Anand.

Result: From the obtained results it can be proposed that the physiological parameters like crop growth rate, relative growth rate and net assimilation rate increased with the increasing phase and decreased at harvesting stage. While leaf area increased significantly at each growth phase. The treatment of nipping M_2 was noted significantly higher value for CGR *i.e.*, 8.42, 16.17 and 11.48 g/cm^2/day/10, for RGR *i.e.*, 0.544, 2.967 and 1.290 g/day, for NAR *i.e.*, 0.466, 2.959 and 1.484 mg/cm^2/day and for LA *i.e.* 96.87, 218.94, 381.88 and 588.78 cm^2. While the treatment S_2 GA_3 25 mg/l was noted significantly higher value for CGR *i.e,* 8.60, 16.67 and 11.69 g/cm^2/day/10, for RGR *i.e.*, 0.568, 2.938 and 1.202 g/day, for NAR *i.e.*, 0.372, 3.043 and 1.529 mg/cm^2/day and for LA *i.e.*, 96.61, 224.75, 382.20 and 580.42 cm^2 contributing to the higher seed yield under M_2 nipping treatment *i.e.*, (1719.7 kg/ha) and S_2 treatment *i.e.*, GA_3 25 mg/l (1714.1 kg/ha). Thus, GAM-5 had a better source-sink partitioning efficiency.

Key words: Crop growth rate, Greengram, Nipping, Plant growth regulators, Relative growth rate.

INTRODUCTION

The mungbean (*Vigna radiata* L. Wilczek) belongs to Fabaceae family with the chromosome number 2n= 22. This family occupies the third largest family of flowering plants, having 650 genera and 20,000 plant species (Doyle, 1994). Mungbean is a short duration leguminous crop which is mainly cultivated for the use of dry seeds. There are various factors affecting the seed yield of the crop like the interaction of the external environmental factors with physiological processes of the plant. The diversity of various physiological components of growth and development is possible through the source manipulations or exogenous application of plant growth regulators, which ultimately enhancing or modifying the physiological processes in plants or tissue levels. Thus, manipulation of source may provide opportunity for increasing yield in plants with excessive leaf development habit. Sink in mungbean is determined by the number of pods per plant (Mackenzie *et al*., 1975), number of seeds per pod and weight of an individual seed (AVRDC, 1976). Removal of apical shoot above node 5 or removal of inflorescence or axillary bud at nodes 1-4 together with the apical shoot greatly increased pod number and seed weight of mungbean (Clifford, 1979). The leaves at flowering nodes are the major contributors for seed filling and development (AVRDC, 1974). The use of plant growth regulators are known to improve the physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yields. The PGRs are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, thereby increasing the productivity (Taiz and Zeiger, 2003). No detail information is available in mungbean about source-sink relationships under discriminated source levels. These aspects need investigation in mungbean genotypes to develop high yielding variety/crop management under sub-tropical

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condition. Hence, the present study was undertaken for studying the effect on physiological parameters by manipulating source through nipping and artificially removal of selective leaves and also the use of plant growth regulators and chemical (GA3, NAA and Thiourea) using factorial randomized block design in two respective years 2016 and 2017.

MATERIALS AND METHODS

The study was carried out at Regional Research Station, Anand Agricultural University, Anand during summer in the year 2016 and 2017 on "Effect of source manipulation, plant growth regulators and chemical on physiological parameters of green gram (*Vigna radiata* L. Wilckzek.) *cv*. GAM-5". The factorial randomized block design was applied using twenty eight treatment combinations The source manipulation treatments were M1-Control, M2-Nipping at 30 DAS, M3-25% defoliation and M4- 50% defoliation and seven subplot PGR's treatments were given along with control *i.e.*, S1-Water spray (Control), S2- GA3 25 mg/l, S3-GA3 50 mg/l, S4-NAA 25 mg/l, S5-NAA 50 mg/l, S6-Thiourea 500 mg/l and S7-Thiourea 1000 mg/l. Five plants in each treatment were uprooted randomly at 30, 45, 60 and 75 DAS/harvest and used for recording crop growth rate, relative growth rate and net assimilation rate as described below.

Crop growth rate (CGR) (g cm^{-2} day^{-1})

Crop growth rate is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the following formula and expressed as g cm^{-2} day^{-1}.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,

W_1 = Dry weight of the plant (gm^{-2}) at time t_1.
W_2 = Dry weight of the plant (gm^{-2}) at time t_2.
t_2-t_1 = Time interval in days.
A = Unit land area (cm^2).

Relative growth rate (RGR) (g day^{-1})

It is rate of increase in dry weight per unit dry weight already present and is expressed in g day^{-1}. Relative growth rate at various stages was calculated as suggested by Radford (1967).

$$RGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

Where,

W_1 = Dry weight of plants (g) at time t_1.
W_2 = Dry weight of plants (g) at time t_2.

Net assimilation rate (NAR) (mg/cm^2/day)

It is a measure of the average efficiency of leaves on a plant or dry matter accumulation rate per unit of leaf area. It is expressed as mg/cm^2/day and calculated by using the following formula:

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{\text{Loge } LA_2 – \text{Loge } LA_1}{(LA_2 - LA_1)}$$

Where,

LA_1 and W_1 = Leaf area (dm$^{2)}$ and dry weight of the plant (g), respectively at time t_1.
LA_2 and W_2= Leaf area (dm^2) and dry weight of the plant (g), respectively at time t_2. It is expressed as g cm^{-2} day^{-1}.

RESULTS AND DISCUSSION

Crop growth rate (g/cm^2/day)

The data on crop growth rate at 30-45, 45-60 and 60-75 DAS/harvest as influenced by source manipulation and plant growth regulators for the year 2016, 2017 and in pooled analysis are represented in Table 1. Significant differences were observed for the crop growth rate recorded at 30-45 DAS of time interval in both the respective years and pooled analysis. Significantly the higher CGR was observed by the nipping treatment M_2 *i.e.,* 8.51, 8.33 and 8.42 g/cm^2/day, which was statistically at par with the treatment M_3 *i.e.*, 8.48, 8.10 and 8.29 g/cm^2/day and M_4 *i.e.*, 8.10, 7.75 and 7.93 g/cm^2/day respectively. Similarly CGR at the interval of 45-60 DAS, the treatments had significant differences in the both the year as well as pooled analysis. Significantly, higher CGR was noted by the treatment of nipping (M_2) *i.e.*, 16.11, 16.23 and 16.17 g/cm^2/day, which was statistically at par with the treatment M_3 25% defoliation *i.e.*, 15.83, 16.03 and 15.93 g/cm^2/day respectively. Similarly at last phase *i.e.*, 60-75 DAS, significant differences were observed for CGR during both the years as well as pooled analysis. Significantly the higher CGR was recorded by 25% defoliation treatment (M_3) *i.e.,* 11.81 and 11.80 g/cm^2/day during 2016 and pooled respectively while in 2017 it was recorded by M_2 (11.82g/cm^2/day). It was remained at par with each other in respective growth stage respectively. On the other hand significantly minimum CGR was noted under the control treatment compared to other source manipulation in both the years as well as pooled analysis. The perusal of the data revealed that the effect of different treatments of plant growth regulators and chemical on CGR recorded at 30-45 DAS were significant in both the respective years and in pooled analysis. Significantly higher CGR was recorded under the treatment GA_3 25mg/l (S_2) *i.e.*, 8.87, 8.33 and 8.60 g/cm^2/day which was at par with the treatment S_3 *i.e.*, 8.62, 8.09 and 8.35 g/cm^2/day. Similarly at juvenial phases results showed significant differences for CGR under both the years and pooled. Significantly the higher crop growth rate was noted in the treatment GA_3 25 mg/l (S_3: 16.68, 16.66 and 16.67 g/cm^2/day) compared to other treatments which was remained at par with the treatment GA_3 50 mg/l (S_3) *i.e.*, 16.46, 16.01 and 15.46 during both the respective years and pooled analysis. Similar trends was also observed for crop growth rate at 60-75 DAS during the years 2016, 2017 and pooled analysis under various treatment of PGR's. The treatment of GA_3 25 mg/l (S_2) was registered significantly higher crop growth rate (11.93, 11.44 and 11.69 g/cm^2/day) which was significantly at par with the treatment S_3 *i.e.*, 11.68, 11.89 and 11.79 g/cm^2/day respectively. While, the minimum

Table 1: Influence of source manipulation and plant growth regulators and chemical treatments on crop growth rate ($g/cm^2/day/10$) at 30-45, 45-60 and 60-75 DAS.

Treatments	Crop growth rate (g/cm²/day/10)								
	30-45 DAS			45-60 DAS			60-75 DAS		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Source manipulation (M)									
M_1-Control	8.00	7.70	7.85	14.47	14.55	14.51	11.03	10.86	10.95
M_2-Nipping at 30 DAS	8.51	8.33	8.42	16.11	16.23	16.17	11.15	11.82	11.48
M_3-25% defoliation	8.48	8.10	8.29	15.83	16.03	15.93	11.81	11.79	11.80
M_4-50% defoliation	8.10	7.75	7.93	15.01	15.35	15.18	11.46	11.11	11.28
S. Em.+	0.09	0.09	0.07	0.18	0.26	0.17	0.19	0.27	0.17
C.D. @5%	0.27	0.26	0.20	0.51	0.73	0.47	0.55	0.76	0.49
PGR's and chemical application (S)									
S_1-Control	7.88	7.80	7.84	14.27	14.45	14.36	11.36	11.12	11.24
S_2-GA_3 25mg/l	8.87	8.33	8.60	16.68	16.66	16.67	11.93	11.44	11.69
S_3-GA_3 50mg/l	8.62	8.09	8.35	16.46	16.46	16.46	11.68	11.89	11.79
S_4-NAA 25mg/l	8.19	7.93	8.06	16.01	16.02	16.02	11.16	11.20	11.18
S_5-NAA 50mg/l	8.18	7.89	8.03	15.64	15.80	15.72	11.51	10.67	11.09
S_6-Thiourea 500mg/l	8.15	7.88	8.01	14.27	14.74	14.50	11.11	12.33	11.72
S_7-Thiourea 100mg/l	8.04	7.87	7.95	14.17	14.65	14.41	10.78	11.11	10.94
S. Em.+	0.12	0.12	0.09	0.24	0.34	0.22	0.26	0.35	0.23
C.D. @5%	0.35	0.34	0.26	0.67	0.96	0.62	0.73	1.00	0.65
Interactions									
M×S									
S. Em.+	0.25	0.24	0.18	0.47	0.68	0.44	0.51	0.71	0.46
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y×M									
S. Em.+			0.098			0.234			0.25
C.D. @5%			NS			NS			NS
Y×S									
S. Em.+			0.130			0.310			0.33
C.D. @5%			NS			NS			NS
Y×M×S									
S.Em.+			0.260			0.619			0.65
C.D. @5%			NS			NS			NS
CV%	5.20	5.21	5.18	5.33	7.54	6.49	7.79	10.75	9.29

CGR was noted in every growth stages in individual years as well as pooled analysis. The treatments had significant differences for CGR. Crop growth rate is influenced by LAI, photosynthetic rate and leaf angle and is an index of amount of radiation energy intercepted. Crop growth rate (CGR) increased upto 45-60 DAS and declined thereafter. The present data also revealed that the application of GA_3 increased CGR and was due to increased dry matter partitioning in reproductive parts with time course (Brar and Singh, 1983) in cotton. Similar increase of CGR was reported at all the treatments over control (Katiyar, 1980) in cotton. The results were in agreement with the findings of Reddy (2005) in cowpea.

Relative growth rate (g/day)

The data recorded on relative growth rate (g/day) at 30-45, 45-60, 60-75 DAS as influenced by source manipulation and plant growth regulators and chemical for the year 2016, 2017 and in pooled analysis are represented in Table 2. Differences among the various treatments of source manipulation for relative growth rate (g/day) at 30-45 DAS were found significant in the year 2016, 2017 and pooled analysis. Significantly the higher RGR at the interval of 30-45 DAS was registered in the treatment M_2 *i.e.*, 0.558, 0.529 and 0.544 g/day during both the respective year as well as pooled analysis, which was at par with the treatment M_3 *i.e.*, 0.533, 0.487 and 0.520 g/day respectively. Similarly during 45-60 DAS the treatment of M_2 showed significant differences for relative growth rate and registered 2.957, 2.978 and 2.967 g/day higher compared to other treatment during the years 2016, 2017 as well as in pooled analysis. It was remained at par with the treatment of M_3 *i.e.*, 2.905, 2.942 and 2.924 g/day in respective years and pooled analysis. Similarly, at 60-75 DAS the significant differences were noted

Table 2: Influence of source manipulation and plant growth regulators and chemical treatments on relative growth rate (g/day) at 30-45, 45-60and 60-75 DAS.

Treatments	Relative growth rate (g/day)								
	30-45 DAS			45-60 DAS			60-75 DAS		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Source manipulation (M)									
M_1-Control	0.464	0.413	0.438	2.658	2.672	2.665	1.203	1.227	1.215
M_2-Nipping at 30 DAS	0.558	0.529	0.544	2.957	2.978	2.967	1.274	1.307	1.290
M_3-25% defoliation	0.553	0.487	0.520	2.905	2.942	2.924	1.242	1.245	1.244
M_4-50% defoliation	0.483	0.423	0.453	2.755	2.816	2.786	1.163	1.232	1.197
S. Em.+	0.007	0.006	0.005	0.039	0.048	0.032	0.025	0.022	0.018
C.D. @5%	0.018	0.017	0.013	0.110	0.135	0.091	0.070	0.062	0.049
PGR's and chemical application (S)									
S_1-Control	0.442	0.449	0.446	2.618	2.652	2.635	1.185	1.205	1.195
S_2-GA_3 25mg/l	0.623	0.514	0.568	3.061	3.021	2.938	1.298	1.249	1.202
S_3- GA_3 50mg/l	0.578	0.479	0.529	3.021	2.938	2.869	1.249	1.242	1.245
S_4-NAA 25mg/l	0.499	0.440	0.469	2.938	2.869	2.622	1.202	1.253	1.227
S_5-NAA 50mg/l	0.497	0.457	0.477	2.869	2.900	2.885	1.194	1.229	1.211
S_6-Thiourea 500mg/l	0.491	0.451	0.471	2.622	2.708	2.665	1.220	1.297	1.259
S_7- Thiourea 100mg/l	0.471	0.451	0.461	2.600	2.688	2.644	1.194	1.241	1.218
S. Em.+	0.009	0.008	0.006	0.051	0.063	0.043	0.033	0.029	0.023
C.D. @5%	0.024	0.022	0.018	0.145	0.179	0.121	NS	NS	0.065
Interactions									
M×S									
S. Em.+	0.017	0.016	0.013	0.102	0.126	0.086	0.066	0.058	0.046
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y×M									
S. Em.+			0.007			0.046			0.025
C.D. @5%			0.019			NS			NS
Y×S									
S. Em.+			0.009			0.061			0.033
C.D. @5%			0.025			NS			NS
Y×M×S									
S. Em.+			0.018			0.122			0.066
C.D. @5%			NS			NS			NS
CV%	5.79	5.82	5.91	6.27	7.65	6.98	9.33	7.99	8.64

for RGR due to source manipulation. The treatment of nipping (M_2) recorded significantly higher relative growth rate (1.274, 1.307, 1.290 g/day) as compared to the other treatments of leaf removal which was statistically at par with the treatment M_3 *i.e.*, 1.242, 1.245 and 1.244 g/day in the year 2016, 2017 and pooled analysis, respectively. At all the growth stages minimum RGR were noted under the control treatments in both the years and pooled analysis. The perusal of the data revealed that the effect of different treatments of plant growth regulators and chemical on RGR recorded at 30-45 DAS were significant in both the respective years and in pooled analysis. Significantly higher RGR was recorded under the treatment GA_3 25mg/l (S_2) *i.e.*, 0623, 0.514 and 0.568 g/day which was at par with the treatment S_3 *i.e.*, 0.578, 0.479 and 0.529 g/day respectively. Similar trend was observed under different treatments of plant growth regulators on relative growth rate at 45-60 DAS in the both the respective years as well as pooled analysis. Significantly the higher relative growth rate was noted in the treatment of GA_3 25 mg/l (S_2: 3.061, 3.021 and 2.938 g/day) which was remained at par with the treatment GA_3 50 mg/l (S_3) *i.e.*, 3.021, 2.938 and 2.869 g/day compared to other treatments during both the respective years and pooled analysis. However, the results were non-significant for relative growth rate at 60-75 DAS during the years 2016 and 2017, whereas significant differences were observed for pooled analysis. The treatment of Thiourea 500 mg/l (S_6) was recorded significantly higher relative growth rate (1.259 g/day), which was significantly at par with the treatment S_3 and S_4 *i.e.*, 1.245 and 1.227 g/day respectively. The relative growth rate (RGR) showed significant differences due to nipping and growth regulator treatments at 30-45 and 45-60 DAS. The present result also indicated that during early stages of crop growth, RGR was significantly higher with the treatment of growth regulator which declined during the last lag phase of growth. During early stage, *i.e.*, grand growth phase the treatments of nipping significantly increased as compared to other growth regulators and control. GA_3 can manipulate a variety of growth and development phenomena (Deotale *et al.*, 1998). Srivastava and Tiwari (1981) also indicated a positive association of RGR in seed yield in chickpea.

Net assimilation rate (mg/cm²/day)

The data on net assimilation rate at different growth stages is presented in Table 3. Significant differences were observed for the net assimilation rate recorded at 30-45 DAS of time interval in both the respective years and pooled analysis. Significantly the higher NAR was observed by the nipping treatment M_2 *i.e.,* 0.460, 0.472 and 0.466 mg/cm²/day, which was statistically at par with the treatment M_3 and M_4. Similarly NAR at the interval of 45-60 DAS, the treatments had significant differences in the both the year as well as pooled analysis. Significantly, higher NAR was noted by the treatment of nipping (M_2) *i.e.*, 2.956, 2.961 and 2.959 mg/cm²/day, which was statistically at par with the treatment (M_3) 25% defoliation *i.e.*, 2.937, 2.908 and 2.922 mg/cm²/day respectively. Significant differences were observed for NAR during both the years as well as pooled analysis at 60-75 DAS interval. Significantly, higher NAR was recorded by the nipping treatment (M_2) *i.e.,* 1.519 mg/cm²/day in 2016, 1.449 mg/cm²/day in 2017 and 1.484 mg/cm²/day in pooled. While, M_4 treatment registered significantly highest during 2017 and pooled *i.e.*, 1.520 and 1.501 mg/cm²/day. It was remained at par with M_3 and M_4 in respective growth stage respectively. On the other hand significantly minimum NAR was noted under the control treatment compared to other source manipulation in both the years as well as pooled analysis. The perusal of the

Table 3: Influence of source manipulation and plant growth regulators and chemical treatments on net assimilation rate (mg/cm²/day) at 30-45, 45-60 and 60-75 DAS.

Treatments	Net assimilation rate (mg/cm²/day)								
	30-45 DAS			45-60 DAS			60-75 DAS		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Source manipulation (M)									
M_1-Control	0.194	0.193	0.193	2.710	2.658	2.684	1.417	1.407	1.412
M_2-Nipping at 30 DAS	0.460	0.472	0.466	2.956	2.961	2.959	1.519	1.449	1.484
M_3-25% defoliation	0.338	0.351	0.344	2.937	2.908	2.922	1.451	1.409	1.430
M_4-50% defoliation	0.263	0.267	0.265	2.815	2.751	2.783	1.482	1.520	1.501
S. Em.+	0.008	0.007	0.006	0.056	0.084	0.054	0.026	0.027	0.020
C.D. @5%	0.024	0.020	0.017	0.160	0.238	0.151	0.075	0.078	0.057
PGR's and chemical application (S)									
S_1-Control	0.272	0.274	0.273	2.668	2.617	2.643	1.428	1.386	1.407
S_2-GA_3 25mg/l	0.368	0.376	0.372	3.026	3.060	3.043	1.537	1.522	1.529
S_3- GA_3 50mg/l	0.337	0.354	0.346	2.987	3.020	3.004	1.531	1.502	1.517
S_4-NAA 25mg/l	0.323	0.337	0.330	2.940	2.937	2.939	1.444	1.379	1.411
S_5-NAA 50mg/l	0.311	0.317	0.314	2.899	2.868	2.884	1.468	1.423	1.445
S_6-Thiourea 500mg/l	0.301	0.302	0.301	2.747	2.634	2.691	1.393	1.423	1.408
S_7- Thiourea 100mg/l	0.283	0.287	0.285	2.714	2.599	2.657	1.470	1.487	1.478
S. Em.+	0.011	0.009	0.008	0.074	0.111	0.071	0.035	0.036	0.027
C.D. @5%	0.032	0.027	0.022	0.211	0.315	0.199	0.099	0.103	0.075
Interactions									
M×S									
S. Em.+	0.022	0.019	0.016	0.149	0.222	0.142	0.070	0.073	0.053
C.D. @5%	NS	NS	0.044	NS	NS	NS	NS	NS	NS
Y×M									
S. Em.+			0.008			0.076			0.029
C.D. @5%			NS			NS			NS
Y×S									
S. Em.+			0.011			0.100			0.038
C.D. @5%			NS			NS			NS
Y×M×S									
S. Em.+			0.022			0.200			0.075
C.D. @5%			NS			NS			NS
CV%	12.33	10.12	11.30	9.03	13.62	11.43	8.21	8.68	8.39

data revealed that the effect of different treatments of plant growth regulators and chemical on NAR recorded at 30-45 DAS were significant in both the respective years and in pooled analysis. Significantly higher NAR was recorded under the treatment GA_3 25mg/l (S_2) *i.e.,* 0.368, 0.376 and 0.372 mg/cm^2/day, which was at par with the treatment S_3 and S_4 respectively. The data revealed that the effect of different treatments of plant growth regulators on net assimilation rate recorded at 45-60 DAS had significant differences in the both the respective years as well as pooled analysis. Significantly the higher net assimilation rate was noted in the treatment GA_3 25 mg/l (S_2: 3.026, 3.060 and 3.043 mg/cm^2/day) compared to other treatments which was remained at par with the treatment GA_3 50 mg/l (S_3) *i.e.*, 3.020, 3.060 and 3.043 mg/cm^2/day during both the respective years and pooled analysis. Similar trends was also observed for net assimilation rate at 60-75 DAS during the years 2016, 2017 and pooled analysis under various treatment of PGR's. The treatment of GA_3 25 mg/l (S_2) as registered significantly higher net assimilation rate (1.537, 1.522 and 1.529 mg/cm^2/day) which was significantly at par with the treatment S_3 *i.e.*, 1.531, 1.502 and 1.517 mg/cm^2/day respectively. While, the minimum NAR was noted in every growth stages in individual years as well as pooled analysis. The NAR decreased from 30 DAS to harvest. Thus, it appears that NAR possesses a direct positive association with seed yield. The results were in affirmation with the findings of Shah and Prathapasenan (1992) due to application of plant growth regulators in mungbean. Hoque and Hoque (2002) observed that in the foliar spray, the highest NAR was found with 200 ppm and control at 25 and 35 DAS, respectively and with 100 ppm at 45 and 55 DAS. According to Rahman *et al.*, (2004) NAR maximized at 80 DAS followed by a gradual decrease in all treatments. It

Table 4: Influence of source manipulation and plant growth regulators and chemical treatments on leaf area (cm^2) at 30, 45, 60 and 75 DAS.

Treatments	Leaf area (cm^2)											
	30 DAS			45 DAS			60 DAS			75 DAS/harvest		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Source manipulation (M)												
M_1-Control	97.61	95.42	96.52	213.82	201.36	207.59	345.00	363.03	354.02	549.71	567.02	558.37
M_2-Nipping at 30 DAS	92.02	101.72	96.87	224.98	212.91	218.94	379.49	384.27	381.88	585.11	592.45	588.78
M_3-25% defoliation	96.88	96.84	96.86	222.17	209.36	215.77	371.57	376.66	374.12	578.82	584.03	581.43
M_4-50% defoliation	90.06	94.62	92.34	217.26	206.38	211.82	356.17	372.14	364.15	556.28	577.38	566.83
S. Em.+	2.24	2.33	1.71	2.98	2.71	2.14	6.14	5.32	4.31	6.82	6.43	4.97
C.D. @5%	NS	NS	NS	8.46	7.70	6.01	17.42	15.08	12.11	19.36	18.25	13.98
PGR's and chemical application (S)												
S_1-Control	92.27	96.16	94.22	211.90	204.89	208.40	344.97	358.08	351.53	528.82	542.75	528.76
S_2-GA_3 25mg/l	94.45	98.78	96.61	229.35	220.16	224.75	379.74	384.66	382.20	582.24	592.65	580.42
S_3- GA_3 50mg/l	99.10	99.71	99.40	222.21	221.69	221.95	373.57	389.93	381.75	579.19	597.41	581.28
S_4-NAA 25mg/l	94.20	96.87	95.53	221.21	213.62	217.41	363.25	374.69	368.97	573.31	575.75	567.50
S_5-NAA 50mg/l	95.04	99.40	97.22	222.67	217.06	219.86	369.52	379.11	374.31	573.78	587.50	573.62
S_6-Thiourea 500mg/l	91.12	96.03	93.57	212.60	164.74	188.67	351.97	363.44	357.70	565.67	583.23	567.43
S_7- Thiourea 100mg/l	92.84	93.10	92.97	216.98	210.37	213.67	358.39	368.28	363.34	569.36	582.25	568.78
S. Em.+	2.96	3.08	2.27	3.94	3.59	2.83	8.12	7.03	5.70	9.03	8.51	6.58
C. D. @5%	NS	NS	NS	11.19	10.18	7.95	23.04	19.95	16.02	25.61	24.14	18.50
Interactions												
M×S												
S. Em.+	5.92	6.16	4.53	7.89	7.18	5.66	16.24	14.06	11.39	18.05	17.02	13.16
C.D. @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y×M												
S. Em.+			2.42			3.02			6.09			7.03
C.D. @5%			NS			NS			NS			NS
Y×S												
S. Em.+			3.21			4.00			8.06			9.30
C.D. @5%			NS			11.24			NS			NS
Y×M×S												
S. Em.+			6.41			8.00			16.11			18.61
C.D. @5%			NS			NS			NS			NS
CV%	10.89	10.98	10.85	6.22	5.99	6.11	7.75	6.51	7.13	5.51	5.08	5.29

was established that NAR became higher during vegetative stage and then declined rapidly as season progressed (Haloi and Baldev, 1986).

Leaf area per plant (cm^2)

The data on leaf area per plant at 30, 45, 60 and 75 DAS/ harvest as influenced by source manipulation and plant growth regulators and chemical for the year 2015-16, 2016-17 and in pooled analysis are represented in Table 4. The leaf area per plant recorded at 30 DAS was found to be non-significant in both the respective years and pooled analysis. The leaf area per plant had significant differences among the various treatments at 45 DAS in both the respective years as well as pooled analysis. Significantly higher leaf area per plant was recorded by nipping treatment M_2 *i.e.*, 224.98, 212.91 and 218.94 cm^2 which remained at par with M_3 (222.17, 209.36 and 215.77 cm^2) respectively. Similar trend was observed at 60 DAS the treatment of source manipulation was noted with significant differences in both the respective years and pooled analysis. Significantly the higher leaf area was recorded in the treatment M_2 *i.e.*, 379.49, 384.27 and 381.88 cm^2 which was found at par with the treatment M_3. Whereas the minimum leaf development was observed under control treatment under both the growth phases in individual year and pooled analysis. Similarly at 75 DAS/harvest leaf area was found significant under various treatments and significantly higher value of leaf area by nipping treatment (M_2) *i.e.,* 585.11, 592.45 and 588.78 cm^2, which remained at par with the treatment M_3 *i.e.*, 578.82, 584.03 and 581.43 cm^2 in both the respective years and pooled analysis. While, control treatment registered the minimum in both the year and pooled. Results of leaf area per plant showed non-significant differences in both the respective years as well as pooled analysis at 30 DAS due to the PGR's and chemical treatments. In case of 45 DAS PGR's and chemical treatment showed significant differences during both the years as well as pooled analysis. The treatment of GA_3 25mg/l (S_2) recorded significantly higher leaf area *i.e.,* 229.35, 220.16 and 224.75 cm^2 and remained at par with S_3 (222.21, 221.69 and 221.95 cm^2) and S_5 (222.67, 217.06 and 219.86 cm^2) respectively. However at 60 DAS influence of plant growth regulators and chemical showed significant differences for leaf development. The treatment GA_3 50 mg/l (S_3) recorded significantly higher leaf area *i.e.*, 373.57, 389.93 and 381.75 cm^2, which was found at par with the treatment S_2 and S_4. Whereas the minimum leaf area development were registered under the control treatment in respective manners for individual years as well as pooled analysis. In case of 75 DAS/harvest, the treatments showed significant difference for leaf area in both the respective years as well as pooled analysis. Significantly the maximum leaf area was observed in the treatment GA_3 25 mg/l (S_2) *i.e.*, 582.24, 592.65 and 580.42 cm^2, which was statistically at par with the treatment GA_3 50 mg/l (S_3) *i.e.*, 579.19, 597.41 and 581.28 cm^2 respectively. Leaf area had significant and positive correlation with bio-chemical and physiological processes governed under cell, tissue and organ levels that increased size of photosynthetic area in terms of dry matter assimilation rate which contributed for synthesis of higher biomass, number of pods per plant and number of seeds per plant as well as seed yield. This might be due to activation of enzymatic systems during its juvenile growth phases and stimulated various physiological forms and functions going in tissues levels and ultimately on growth and development of plants. The results found were in concurrence with the findings of Ganiger *et al*. (2002 b) in cowpea.

CONCLUSION

The effect of different source manipulation, Plant Growth Regulators and Chemical Treatments on Physiological Parameters *viz.* CGR, RGR and NAR were found significant at various growth phases at 30-45, 45-60 and 60-75 DAS. Crop growth rate (CGR) increased upto 45-60 DAS and declined there after. RGR was significantly higher with the treatment of growth regulator which declined during the last lag phase of growth. The NAR decreased from 30 DAS to harvest.

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