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GROWTH AND DEVELOPMENT IN FIVE *CLEOME* SPECIES WITH RESPECT TO LAR, NAR AND RGR

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ABSTRACT

Cleome is the largest genus from family Cleomaceae comprising 180 to 200 species of herbaceous annual or perennial plants and shrubs widely distributed in tropical and subtropical regions. Many of these species have wide medicinal importance. Here we tried to study ecophysiology of five species growing in our region. All selected species growing at different places at different situations and as fast growing weed in India. Some species are grown in Africa for its medicinal value or as edible food. Growth of a plant can be analyzed by measuring a variety of growth parameters. Growth and development of a plant can be studied or analyzed by making periodic observations of plant root length, shoot length, root to shoot ratio, number of leaves or leaflets, fresh weight, dry weight and leaf area per plant. From results in most of the *Cleome* species studied Net Assimilation Rate and therefore, photosynthesis appears to be an important component for the Relative Growth Rate observed.

Keywords: *Cleome, RGR, LAR, NAR, Growth Analysis and Biomass produtivity.*

Number of Tables: 10 **Number of Figures: 10** **Number of References: 10**

INTRODUCTION

Growth analysis is an important tool for studying very complex interaction between plant and the environment. This interaction helps understanding the critical phases in the life cycle of a plant. Usually growth of a plant is divided into three measure phases. The early or slow growing phase referred as initial or Lag phase, the second is Log phase or the phase of instantaneous or exponential growth. Usually during this phase the rate of growth with respect to increase in number of leaves, leaf area, fresh weight and dry weight is higher. Towards the end of this phase, initiation of flowering takes place and plant enters into the reproductive phase. The second phase including reproductive phase is ultimately followed by a phase of senescence where there is decline in the rate of increasing biomass production. Thus, when the growth of a plant is plotted against time, it gives a sigmoid curve of growth in plants (Anonymous 2013). Growth of a plant can be analyzed by measuring a variety of growth parameters. Growth and development of a plant can be studied or analyzed by making periodic observations of plant root length, shoot length, root to shoot ratio, number of leaves or leaflets, fresh weight, dry weight and leaf area per plant.From the above basic data the Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR) of whole plant can be computed and compared. Relative Growth Rate is an increase in size (biomass) per unit initial size of a plant per unit time. NAR and LAR are contributory components of RGR. NAR is defined as an increase in size per unit leaf area per unit time. Therefore, the rate of net photosynthesis is the deciding factor of NAR. LAR is a ratio of leaf area to biomass (fresh weight /dry weight). LAR represents the amount of plant or proportion of plant engaged in photosynthesis. Usually RGR of a plant is dependent either on NAR or LAR and sometimes depends on both NAR and LAR (Poorter and Werf, 1998). RGR, NAR and LAR can be easily computed with the help of measures of basic parameters namely fresh weight or more appropriately dry weight of a plant and leaf area per plant with their periodic records for a plant. Growth and development in Cleomaceae members with respect to their root length, shoot length, total length (linear growth), root to shoot ratio, leaf area per plant, biomass (fresh weight and dry weight) per plant and biomass produced by reproductive parts, that is pods, has been recorded in tables 1,3,5,7 and 9. For the above growth parameters, the periodic observations (per week) were made with first observation at about 27 days of age of the plant (*Cleome viscosa*-26, *C. simplisifolia*-24, *C. gynandra* -26, *C. chelidonii*-29 and *C. spesiosa*-30 days of age). The measurements were continued per week for consecutive 12 weeks that is up to about one hundred and ten day's growth. With the help of above parameters the growth and performance of *Cleome* species was further analyzed by determining Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR). The values of RGR, NAR, and LAR per week have been recorded in the tables 2,4,6,8 and 10 and represented graphically in figure 1-10. In these figures the RGR has also been compared with NAR

and LAR for deciding the major component of Relative Growth Rate in the species.

Materials & Methods

For current research, plants were collected from Shivaji University campus and identified with the help of standard floras and confirmed in taxonomist Prof. S. R. Yadav and herbarium deposited in Department of Botany, Shivaji University Kolhapur (Herbarium specimens *VTA01-VTA13*). After these plants were grown in plots and pots both. Five plants from the pot were carefully uprooted, washed thoroughly with water to remove any dirt and dust particles on the surface of the plant parts and blotted to surface dry. This plant material was used for analysis for growth and development of plants using various parameters such as Root length, Shoot length, Root to shoot ratio, Height of a plant, Number of leaves per plant, Leaf area per plant, Number of pods per plant, Fresh weight per plant, Dry weight per plant.

For determination of biomass production, fresh weight, dry weight and moisture content were recorded. These observations were statistically analyzed. From the above data Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR) were computed following the formulae (Patil and Dhopte, 1989).

$$RGR = \frac{2.303 \times (\log_{10} w_1 - \log_{10} w_0)}{t_1 - t_0}$$ $$NAR = \frac{2.303 \times (W_1 - W_0)(\log_{10} A_1 - \log_{10} A_0)}{(A_1 - A_0) \times (t_1 - t_0)}$$ $$LAR = \frac{(A_1 - A_0)(\log_{10} w_1 - \log_{10} w_0)}{(W_1 - W_0)(\log_{10} A_1 - \log_{10} A_0)}$$	Where W_0= Initial fresh/dry weight per plant W_1= Final fresh/dry weight per plant A_0= Initial leaf area per plant A_1= Final leaf area per plant t_0= Initial time (0d) t_1= Final time (7d)

The first set of observations was made after 24 days for *Cleome simplicifolia.* In case of *Cleome viscosa, C. gynandra, C. chelidonii* and *C. speciosa* these observation were recorded respectively after 26 days, 26 days, 29 days and 30 days after seedling growth. After these initial observations, the observations were recorded every week for all the species for additional 11 weeks. With the help of these observations the growth and development was analyzed for every stage of development (I,II,III,….IX stages) till the plant produced pods and reached

almost end of its life cycle.

RESULT AND DISCUSSION

It is evident from table 1 that root length, shoot length and total length of *C. viscosa* are increased linearly with the stages of growth and development. It can be noted that initially, that is up to IVth stage, the root length of plant is higher than the shoot length. However, with further growth of plant the growth of shoot is very rapid and it becomes more than that of root. It is observed that with increasing size of plant there is continuous decrease in root to shoot ratio. It implies that the growth of shoot is more vigorous than that of root. The biomass (fresh weight and dry weight per plant) is also increased with increase in the age of the plant. It is found that the average biomass produced (dry weight) by the plant per week is about 1.76 g. Similar trend has also been observed with respect to leaf area per plant. It can be seen that the leaf area increases from 14.63 cm^2 per plant during first week to 1788.22 cm^2 per plant after 12th stage of development. It is also noted that reproductive phase of growth begins after about 95-97 day of age of the plant.Relative Growth Rate, Net Assimilation Rate and Leaf Area Ratio at different developmental stages in *Cleome viscosa* have been recorded in table 2 and depicted in the form of curves in the fig 1 and 2. The Relative Growth Rate (RGR) of *C. viscosa* decreases up to IIIrd stage of growth. There is some improvement in it during IVth and Vth stages and again there is some decline during VIth and VIIth stages. After Xth stage there is sudden decline in RGR. The Net Assimilation Rate up to stage III is showing a pattern which differs from that of RGR. However, after this up to stage VIII the pattern of RGR and NAR are alike and latter even though their trend is similar, their magnitudes are quite different. The curve for LAR in *C. viscosa*, however, is quite different from that of RGR. Therefore, it appears that the curves of RGR and NAR are well correlating and hence Net Assimilation Rate appears to be the contributory component of RGR in the species.The growth and performance of *Cleome simplicifolia* with respect to some basic growth parameters at different developmental stages (Ist to XIIth) has been recorded in table 3. It is clear from the results recorded in table that there is continuous increase in both root length and shoot length of the plants up to XIth stage of development. It is interesting to find that the shoot growth of the plant is vigorous after VIIth stage of development. However, there is no such sudden change observed in the increase in the root length of the plants. It is also observed that after XIth stage, which falls in the reproductive phase there is decrease in the shoot length as well as root length at XIIth stage of development. It is also found that the root to shoot ratio is quite higher that is 3.05 to 5.84 up to VIIth stage of growth. However, there is drastic decline in it and further declines up to 0.56 during last stage studied. It clearly shows that the root part of *C. simplicifolia* is very strong up to VIIth stage and later shoot part grows vigorously. Inspite of differed root and shoot growth the total biomass (fresh weight as well as dry weight) goes on increasing with

age of the plant. It can be seen that per week, on an average, 0.69 g per plant dry matter is produced by the species, which appeared to be the lowest biomass produced among the *Cleome* species studied in the present investigation. The leaf area per plant also increases continuously with the advancement of the stage of development. The total leaf area produced per plant in the species is 610.44 cm^2 per plant. Relative Growth Rate, Net Assimilation Rate and Leaf Area Ratio at different developmental stages in *Cleome simplicifolia* have been recorded in table 4 and depicted in the form of curves in the fig 3 and 4. Figure no. 3 explains the pattern of NAR against that of RGR at different developmental stages. It is quite clear from the graph that both Net Assimilation Rate and Relative Growth Rate, follow identical pattern with continuous decrease up to $VIII^{th}$ stage followed by sudden increase which is continued upto X^{th} stage and then there is a decline. Besides, the curves for NAR and RGR are very near to each other. Contrarary to this, even though the patterns of LAR and RGR are nearly similar, from stage IV^{th} onwards there is a wide gap between the values of them which is continued up to XI^{th} stage. It can be suggested that in *C. simplicifolia* Net Assimilation Rate appears to be the major contributory component of Relative Growth Rate. Thus the mechanism of the growth in *C. simplicifolia* appears to be identical to that of *C. viscosa*.Table 5 depicts the growth and development of *Cleome chelidonii* with respect to root length, shoot length, root to shoot ratio, biomass (fresh weight and dry weight) and leaf area per plant. It is evident from the results recorded in the table that both root length and shoot length of the plants linearly increase with the age of the plant. Initially, the root to shoot ratio is 0.75 indicating shoot length of the plant is almost double that of root. As the plant grows further there is continuous decrease in this ratio up to V^{th} stage of development showing more linear growth of shoot. However, the root to shoot ratio does not change much up to the X^{th} stage of development and later again there is some decrease in the ratio. The rate of production of biomass (fresh as well as dry) increases at every developmental phase which is continued up to the last phase studied. It is evident that the average dry weight produced by the plant is 9.658 g per plant at the age of about 113 days. It is found that average dry matter produced by the plant per week is 3.73 g per plant. This biomass produced by *Cleome chelidonii* appears to be second that produced by *C. gynandra* (4.40g per plant), which is highest among all *Cleome* species studied. *C. chelidonii* appears to attain maturity relatively later than that by *C. gynandra* and other *Cleome* species. It can be seen that even though pod formation has been recorded at X^{th} stage of development the biomass of pod could not be measured even up to XII^{th} stage of development. Leaf area per plant in *C. chelidonii* also increases continuously as the size of plant increases even up to the last stage studied.The values for RGR, NAR and LAR at every developmental stage have been recorded in the table 6. The comparison of Net Assimilation Rate with Relative Growth Rate and that of Leaf Area Ratio and Relative Growth Rate in *C. chelidonii* has

been shown graphically in the fig 5and 6 respectively. It is quite clear that, initially, for few days that is up to IIIrd stage of development the relative growth rate is increased. However, a decreased Relative Growth Rate by the plant has been recorded during next consecutive stages and it is the lowest at Xth and XIth stages. The pattern shown by Net Assimilation Rate is almost different from that of RGR. It can be seen that NAR goes on increasing till VIth stage of development, which is maximum during this period (0.1181±0.027g per g per day). During the further growth, it declines and it is continued till the last stage. However, it can be seen that NAR is always higher than that during initial or first stage. It appears that there is no correlation between NAR and RGR. As against this some correlation can be seen between LAR and RGR. It is observed that except up to second stage there is continuous decline in both LAR and RGR and there seems to be relatively closer agreement between LAR and RGR. It can be concluded that Leaf Area Ratio appears to be the major contributory component of Relative Growth Rate in *Cleome chelidonii*. The size of root as well as shoot has increased linearly with an increase in the age of *Cleome gynandra* (Table 7). Interestingly, however, the root to shoot ratio has been slightly increased with almost the same magnitude up to the VIIIth stage of development (on an average 0.54 to 0.55) and later it has been continuously decreased with further growth of the plant. This clearly indicates that the shoot growth in *Cleome gynandra* dominates over the root growth during the later stages of growth. This behavior of *C. gynandra* seems to be similar to that observed in *C. simplicifolia*. The rate of biomass (fresh and dry weights) production in *C. gynandra* linearly increases with age of the plant but at the faster magnitude from the VIIth stage of growth of the plant. It is difficult to explain the reason or mechanism for such sudden increase in dry matter production by the plant. After XIIth stage of growth plant has acquired the highest dry biomass (25.43g per plant) among the *Cleome* species studied. It is estimated that 4.4g per week per plant appears to be the average rate of dry matter production in the species. It is also found that *C. gynandra* has produced the highest amount of dry matter among all the *Cleome* species studied. The highest average leaf area (4792.78cm2 per plant) produced up to the XIth stage of growth of this plant is also supportive for maximum biomass produced in the plant.The Relative Growth Rate, Net Assimilation Rate and Leaf Area Ratio calculated during first to XIth developmental stages have been recorded in table 8 and represented graphically in the figure 7and 8. It is evident that the Relative Growth Rate of *C. gynandra* is slightly lowered up to the Vth development stage as compared to that during Ist stage. Later it has dramatically increased during VIth stage and then remaining almost unchanged throughout. For comparison the changes in NAR and RGR, their curves have been depicted in the figure 7. It is very clear that the pattern and the magnitude of both NAR and RGR well agree with each other. Contrary to this however, there is very low correlation between LAR and RGR of *C. gynandra* measured at different stages of development (fig 8). For this, it can be concluded that

there is good level of agreement between NAR and RGR which is indicative of Net Assimilating Rate as the deciding component of Relative Growth Rate of *C. gynandra.* The higher biomass produced by *C. gynandra* may be because of major contribution of leaf area. However, it is NAR and not the LAR which is showing greater correlation with RGR. It appears that higher NAR, that is higher rate of photosynthetic assimilation of CO_2 due to larger photosynthetic area (average leaf area per plant) may be the major contributing component for RGR. The average dry weight of pods (1.97g per plant) which is the highest in *C. gynandra* also confirms the vigorous growth observed in the species.The growth and development of *Cleome speciosa* with respect to some basic growth parameters such as linear growth, biomass, leaf area and reproductive growth at different developmental stages (I^{st} to XII^{th}) have been recorded in table 9. It is observed that the root length, shoot length and total linear growth have been continuously increased almost with similar proportion till the XII^{th} stage of growth. However, it is interesting to find that there is almost no change in the root to shoot ratio throughout the growth of the plants. This behavior of *C. speciosa* appears to be different from those observed in other four species. The trend of increasing rate of biomass production in the species seems to be similar to that observed in earlier four *Cleome* species. It can be seen that in *C. speciosa* also there is continuous increase in amount of dry biomass with increase in the age of plants. The average dry biomass produced by the species per week, has been calculated which appears to be 2.64 g per plant. The high values of average leaf area per plant throughout the growth and development seems to be an important parameter contributing the large amount of biomass produced. The Relative Growth Rate in *C. speciosa* has been remarkably increased up to the second stage and then continuously decreased with an increase in the age of the plant (table 10 and fig 9-10). The behavior of Leaf Area Ratio is also the same as that of NAR and RGR. It can be seen that the pattern of LAR and RGR, particularly after second stage of development, appears to be identical. It seems that Net Assimilation Rate and also Leaf Area Ratio well agree with Relative Growth Rate suggesting that both NAR and LAR equally contribute to RGR in *Cleome speciosa*. Similar kind of results has been obtained in woody plants by Jarvis and Jarvis (1964) and in open sun and shade plants by Corre (1983).The RGR is the product of NAR and LAR where NAR is largely the net result of carbon gain (photosynthesis) and carbon loss (respire-ation, exudation and volatilization) expre-ssed per unit leaf area. The LAR is the ratio of leaf area and total weight of plant. From the discussions above, it appears that in most of the *Cleome* species studied Net Assimilation Rate and therefore, photos-ynthesis appears to be an important component for the Relative Growth Rate observed. Similar kinds of results about Net Assimilation Rate have been obtained in the experiments on different climatic races of *Dactylis glomerata* by Eagles (1967) and in *Geum urbanum* and *Cirsium palustre* by Pons (1977). The growth difference between the species could be ascribed totally to a

difference in NAR. However, Higgs and James (1969) in upland grasses, Smeets and Garretsen (1986) in tomato geno-types and Dijkstra and Lambers (1986) in two inbred lines of *Plantago major* L. found inters-ecific variation in RGR to be due to differences in LAR.

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Table 1: *Growth and development of Cleome viscosa*

S.no	Growth Parameter	Stage											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Average Root Length (Cm Plant $^{-1}$)	2.78	3.4	3.8	4.9	5.2	6.36	7.9	9.74	11.4	11.2	14.52	15.6
2	Average Shoot Length (Cm Plant $^{-1}$)	0.68	1.34	2.6	3.7	7.78	13.5	14.08	32.82	39.4	39.66	55.74	62.2
3	Average Total Length (Cm Plant $^{-1}$)	3.46	4.74	6. 4	8.60	12.98	19.86	21.98	42.56	50.80	50.86	70.26	77.80
4	Root : Shoot Ratio	4.088	2.537	1.462	1.324	0.668	0.471	0.561	0.297	0.289	0.282	0.260	0.251
5	Average Leaf Number	4	4	6	8	13	15	18	20	24	36	91	116
6	Average Leaflet Number	12	12	18	24	39	45	54	60	72	108	273	348
7	Average Fresh Weight (g Plant $^{-1}$)	0.0202	0.102	0.341	0.521	1.130	2.43	2.89	3.85	7.002	16.954	38.77	44.11
8	Average Dry Weight (g Plant $^{-1}$)	0.002	0.011	0.040	0.061	0.142	0.320	0.424	0.608	1.146	2.874	6.846	8.593
9	Average Fresh Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	6.89	7.024
10	Average Dry Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	1.181	1.54
11	Average Pod Number	-	-	-	-	-	-	-	-	-	-	11	13
12	Moistur % (Plant $^{-1}$)	90.59	89.58	88.34	88.20	87.442	86.82	85.32	84.212	83.629	83.025	82.342	80.52
13	Average Leaf Area (Cm^2 Plant $^{-1}$)	14.63	20.79	31.18	40.74	52.76	71.59	112.76	144.86	178.74	411.40	895.72	1788.22

Table 2: *Growth and development of Cleome viscosa*

Growth Stages	RGR ($g\ g^{-1}day^{-1}$)	NAR ($gcm^{-2}\ day^{-1}$) x 10^{-4}	LAR (cm^2g^{-1}) x 10^2
I	0.2436± 0.034	0.7335± 0.194	33.204±0.505
II	0.1845± 0.022	1.6164±0.221	11.411±0.161
III	0.0603±0.039	0.8394±0.0589	7.183±0.459
IV	0.1207±0.022	2.4894±0.233	4.849±0.561
V	0.1161±0.009	4.1223±0.244	2.816±0.118
VI	0.0402±0.003	1.6398±0.14	2.452±0.270
VII	0.0515±0.002	2.0517±0.745	2.510±0.368
VIII	0.0906±0.003	4.7685±0.156	1.899±0.099
IX	0.1314±0.024	8.8466±0.237	1.4849±0.198
X	0.1240±0.025	9.1174±0.164	1.3602±0.115
XI	0.0325±0.014	1.9335±0.089	1.6795±0.088

Table 3: *Growth and development of Cleome simplicifolia*

S.no	Growth Parameter	Stage											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Average Root Length (Cm Plant $^{-1}$)	2.38	3.72	3.76	4.2	6.3	7.94	9.2	9.3	10.8	15.0	15.2	14.54
2	Average Shoot Length (Cm Plant $^{-1}$)	0.78	0.8	0.9	0.9	1.3	1.36	1.9	10.18	11.6	13.32	28.2	25.8
3	Average Total Length (Cm Plant $^{-1}$)	3.16	4.52	4.66	5.1	7.6	9.3	11.1	19.48	22.4	28.32	43.4	40.34
4	Root : Shoot Ratio	3.05	4.65	4.18	4.67	4.85	5.84	4.84	0.91	0.93	1.13	0.54	0.56
5	Average Leaf Number	4	5	8	10	15	24	31	36	41	53	60	76
6	Average Fresh Weight (g Plant $^{-1}$)	0.0502	0.145	0.436	0.798	1.476	1.954	2.379	3.144	3.152	5.910	17.40	17.96
7	Average Dry Weight (g Plant $^{-1}$)	0.003	0.010	0.031	0.070	0.137	0.183	0.224	0.354	0.387	0.781	2.466	2.507
8	Average Fresh Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	0.65	0.84
9	Average Dry Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	0.14	0.18
10	Average Pod Number	-	-	-	-	-	-	-	-	-	-	9	10
11	Moistur % (Plant $^{-1}$)	93.124	92.90	92.87	91.24	90.69	90.63	90.57	88.74	87.72	86.78	85.83	85.04
12	Average Leaf Area (Cm^2 Plant $^{-1}$)	2.71	6.19	17.26	27.20	52.57	101.84	135.59	142.23	192.09	390.04	464.71	610.44

Table 4: *Growth and development of Cleome simplicifolia*

Growth Stages	RGR ($g\ g^{-1}day^{-1+}$)	NAR ($gcm^{-2}\ day^{-1}$) x 10^{-4}	LAR (cm^2g^{-1}) x 10^2
I	0.1720±0.056	2.3739±0.111	7.2464±1.226
II	0.1617±0.038	2.7795±0.10	5.8160±1.404
III	0.1164±0.056	2.5498±0.159	4.5642±0.632
IV	0.0959±0.044	2.4864±0.122	3.8587±0.381
V	0.0414±0.059	0.8821±0.116	4.6893±0.733
VI	0.0289±0.056	0.4968±0.079	5.8138±0.811
VII	0.0654±0.045	1.3374±0.129	4.8892±0.141
VIII	0.0127±0.0081	0.2842±0.019	4.4810±0.887
IX	0.1003±0.093	2.0143±0.212	4.9805±0.885
X	0.1643±0.054	5.6478±0.754	2.9088±0.657
XI	0.0024±0.0003	0.1096±0.126	2.1487±0.165

Table 5: *Growth and development of Cleome chelidonii*

S.no	Growth Parameter	Stage											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Average Root Length (Cm Plant $^{-1}$)	0.84	1.84	3.58	7.84	8.14	11.34	16.02	19.82	20.12	22.5	22.7	24.8
2	Average Shoot Length (Cm Plant $^{-1}$)	1.46	4.5	8.96	15.7	25.16	32.58	44.3	61.72	66.24	70.86	76.2	85.6
3	Average Total Length (Cm Plant $^{-1}$)	2.30	6.34	12.54	23.54	33.30	43.92	60.32	81.54	86.36	93.56	98.70	110.40
4	Root : Shoot Ratio	0.575	0.409	0.400	0.499	0.324	0.348	0.362	0.321	0.304	0.318	0.265	0.290
5	Average Leaf Number	5	7	15	19	35	50	54	69	75	81	85	98
6	Average Leaflet Number	32	42	65	93	145	168	210	276	302	308	315	354
7	Average Fresh Weight (g Plant $^{-1}$)	0.157	0.291	1.95	4.479	8.83	15.54	31.21	41.56	48.822	52.843	56.445	61.253
8	Average Dry Weight (g Plant $^{-1}$)	0.009	0.021	0.149	0.398	0.926	1.687	3.856	5.448	6.655	7.709	8.392	9.658
9	Average Fresh Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	-	-
10	Average Dry Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	-	-
11	Average Pod Number	-	-	-	-	-	-	-	-	-	4	9	15
12	Moistur % (Plant $^{-1}$)	94.258	92.884	92.354	91.117	89.517	89.143	87.646	86.891	86.368	85.412	85.132	84.232
13	Average Leaf Area (Cm^2 Plant $^{-1}$)	11.54	24.81	48.81	91.98	159.55	168.43	296.59	336.98	403.28	420.69	509.75	632.13

Table 6: *Growth and development of Cleome chelidonii*

Growth Stages	RGR ($g\ g^{-1}day^{-1+}$)	NAR ($gcm^{-2}\ day^{-1}$) x 10^{-4}	LAR (cm^2g^{-1}) x 10^2
I	0.1211±0.055	0.9889±0.121	12.2411±0.878
II	0.2800±0.056	5.1566±0.913	5.4292±0.358
III	0.1404±0.036	5.2220±0.350	2.6883±0.866
IV	0.1207±0.033	6.1495±0.334	1.9619±0.633
V	0.0857±0.031	6.6321±0.312	1.2923±0.018
VI	0.1181±0.027	13.6827±0.710	0.8633±0.167
VII	0.0494±0.015	7.1903±0.105	0.6868±0.067
VIII	0.0286±0.012	4.6719±0.864	0.6120±0.055
IX	0.0210±0.018	3.6559±1.32	0.5746±0.062
X	0.0121±0.014	2.1041±0.120	0.5765±0.029
XI	0.0201±0.006	3.1804±0.465	0.6312±0.075

Table 7: *Growth and development of Cleome gynandra*

S.no	Growth Parameter	Stage											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Average Root Length (Cm Plant $^{-1}$)	0.54	1.58	2.52	3.96	4.62	7.32	9.86	12.84	13.63	16.06	21.9	24.52
2	Average Shoot Length (Cm Plant $^{-1}$)	1.02	2.96	3.72	6.1	7.74	13.52	18.82	25.22	37.86	47.9	70.26	80.6
3	Average Total Length (Cm Plant $^{-1}$)	1.56	4.54	6.24	10.06	12.36	20.84	28.68	38.06	51.49	63.96	92.16	105.12
4	Root : Shoot Ratio	0.53	0.53	0.68	0.65	0.60	0.54	0.52	0.51	0.36	0.34	0.31	0.30
5	Average Leaf Number	4	6	7	12	18	23	25	38	49	61	86	128
6	Average Leaflet Number	12	18	21	36	54	75	85	132	205	265	396	540
7	Average Fresh Weight (g Plant $^{-1}$)	0.0662	0.155	0.242	0.350	0.7085	0.905	14.80	18.614	31.119	55.162	73.55	128.13
8	Average Dry Weight (g Plant $^{-1}$)	0.0021	0.0075	0.0137	0.0264	0.0557	0.0845	1.4184	1.9701	3.6048	8.1871	12.1181	25.4338
9	Average Fresh Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	2.94	8.86	10.25
10	Average Dry Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	0.45	1.47	1.97
11	Average Pod Number	-	-	-	-	-	-	-	-	-	4	11	13
12	Moistur % (Plant $^{-1}$)	96.845	95.146	94.352	92.463	92.137	90.668	90.416	89.416	88.416	85.158	83.524	80.150
13	Average Leaf Area (Cm^2 Plant $^{-1}$)	30.47	56.54	92.92	176.12	262.52	386.11	489.60	916.10	1204.94	1783.17	3487.33	4792.78

Table 8: *Growth and development of Cleome gynandra*

Growth Stages	RGR ($g\ g^{-1}day^{-1+}$)	NAR ($gcm^{-2}\ day^{-1}$) x 10^{-5}	LAR (cm^2g^{-1}) x 10^3
I	0.1819±0.048	1.8296±0.260	9.9410±0.149
II	0.0861±0.025	1.2097±0.475	7.1162±0.499
III	0.0937±0.013	1.3946±0.068	6.7207±0.764
IV	0.1067±0.045	1.9341±0.177	5.5156±0.271
V	0.0595±0.0463	1.2845±0.012	4.6359±0.092
VI	0.4030±0.048	4.3733±0.170	0.9215±0.137
VII	0.0469±0.0049	1.1580±0.096	0.4054±0.098
VIII	0.0863±0.0033	2.2162±0.089	0.3895±0.257
IX	0.1172±0.012	4.4382±0.041	0.2641±0.222
X	0.0560±0.018	2.2107±0.076	0.2535±0.123
XI	0.1059±0.017	4.6342±0.091	0.2286±0.215

Table 9: *Growth and development of Cleome speciosa*

S.no	Growth Parameter	Stage											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Average Root Length (Cm Plant $^{-1}$)	1.04	3.54	4.92	7.0	8.86	13.08	15.74	16.96	18.82	19.48	21.3	24.32
2	Average Shoot Length (Cm Plant $^{-1}$)	4.67	9.04	12.7	15.48	23.42	32.30	39.7	48.92	59.86	66.72	73.24	76.46
3	Average Total Length (Cm Plant $^{-1}$)	5.71	12.58	17.62	22.48	32.28	45.38	55.44	65.88	78.68	86.20	94.54	100.78
4	Root : Shoot Ratio	0.223	0.392	0.387	0.452	0.378	0.405	0.396	0.347	0.314	0.295	0.291	0.318
5	Average Leaf Number	2	2	4	6	8	11	12	16	19	22	24	28
6	Average Leaflet Number	6	6	12	18	24	33	36	48	57	66	72	84
7	Average Fresh Weight (g Plant $^{-1}$)	0.127	0.250	1.56	4.602	7.97	12.65	15.83	24.84	34.51	45.88	55.246	63.84
8	Average Dry Weight (g Plant $^{-1}$)	0.007	0.0142	0.1180	0.3556	0.7104	1.1562	1.2901	2.4691	4.1308	5.7075	7.2262	8.4524
9	Average Fresh Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	2.80	3.15
10	Average Dry Weight Of Pod (g Plant $^{-1}$)	-	-	-	-	-	-	-	-	-	-	0.34	0.42
11	Average Pod Number	-	-	-	-	-	-	-	-	-	-	4	4
12	Moistur % (Plant $^{-1}$)	95.24	94.32	93.438	93.272	93.087	92.86	91.85	90.06	88.93	88.56	87.92	86.76
13	Average Leaf Area (Cm^2 Plant $^{-1}$)	3.65	7.14	18.67	44.53	80.33	157.75	217.53	381.04	545.51	630.38	788.65	1079.34

Table 10: *Growth and development of Cleome speciosa*

Growth Stages	RGR ($g\ g^{-1}day^{-1}$)	NAR ($gcm^{-2}\ day^{-1}$) x 10^{-4}	LAR (cm^2g^{-1}) x 10^2
I	0.1011± 0.055	1.977±0. 121	5.1097±0.88
II	0.3025±0.056	12.364±0.913	2.4469±0.036
III	0.1576±0.036	11.411±0.356	1.3812±0.087
IV	0.0989±0.0033	8.354±0.330	1.1835±0.063
V	0.0696±0.0031	5.552±0.312	1.2533±0.175
VI	0.0157±0.0027	1.028±0.711	1.5225±0.017
VII	0.0928±0.0015	5.775±0.105	1.6059±0.068
VIII	0.0735±0.0012	5.179±0.860	1.4195±0.055
IX	0.0462±0.0018	3.838±0.132	1.2035±0.062
X	0.0337±0.0014	3.071±0.120	1.0976±0.029
XI	0.0224±0.0070	1.891±0.465	1.1841±0.075

Fig 1:

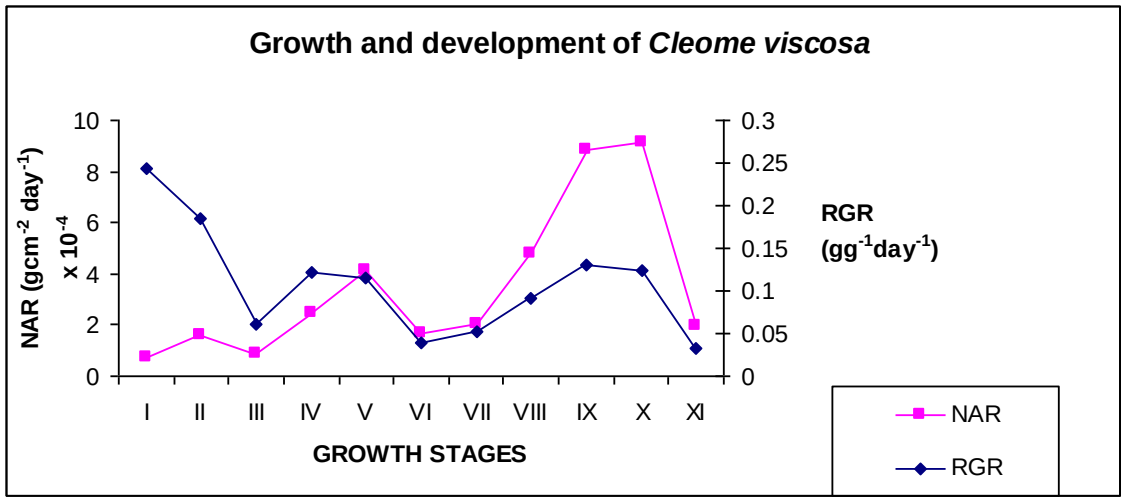

Growth and development of Cleome viscosa
NAR (gcm-2 day-1) x 10-4
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
NAR
RGR

Fig 2:

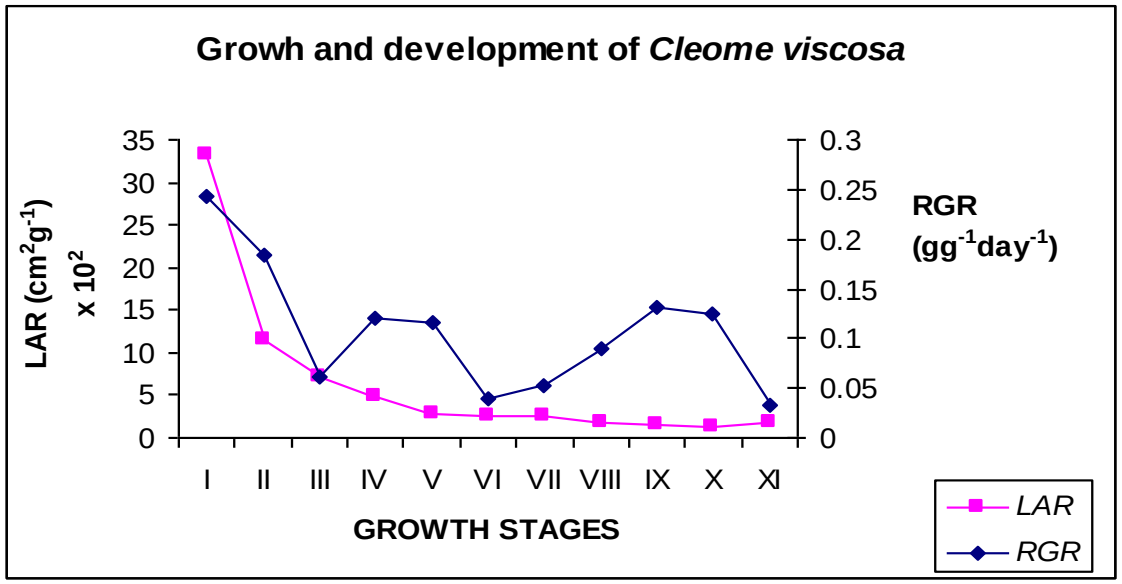

Growh and development of Cleome viscosa
LAR (cm2g-1) x 10-2
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
LAR
RGR

Fig 3:

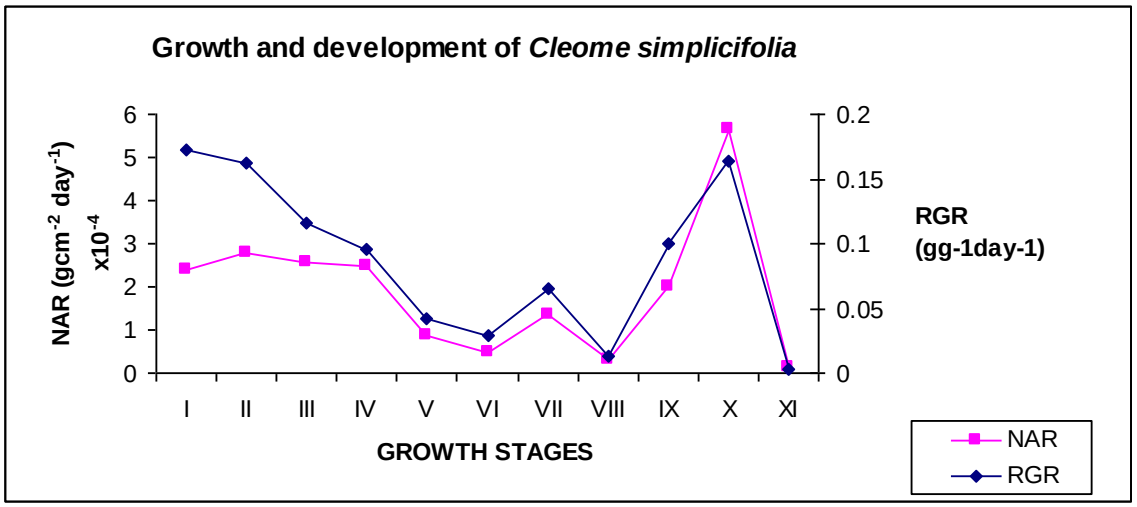

Growth and development of Cleome simplicifolia
NAR (gcm-2 day-1) x10-4
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
NAR
RGR

Fig 4:

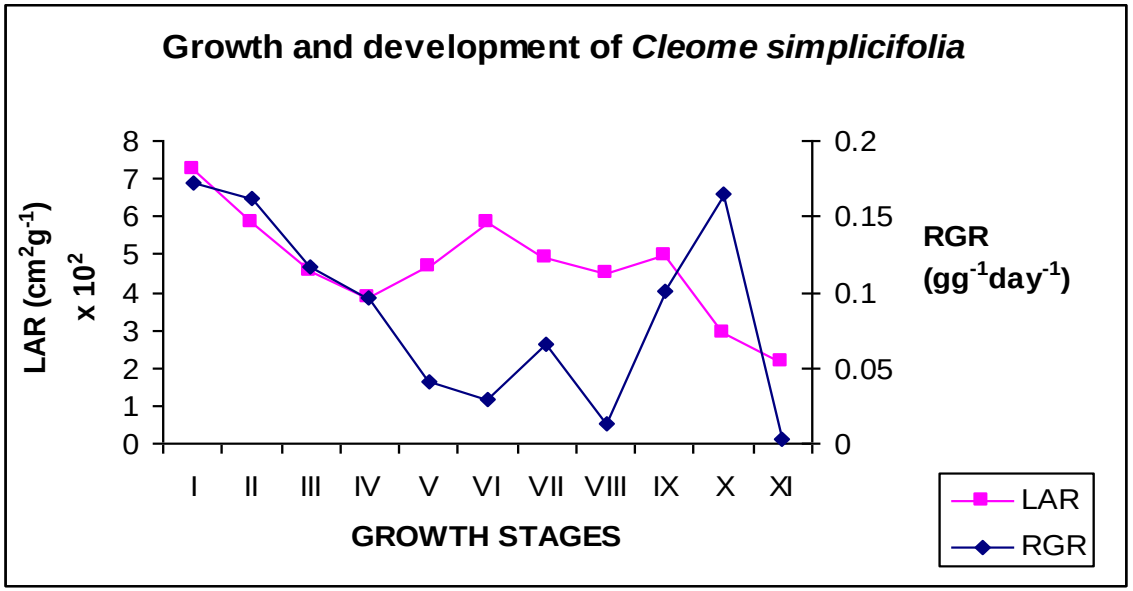

Growth and development of Cleome simplicifolia
LAR (cm2g-1) x 10-2
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
LAR
RGR

Fig 5:

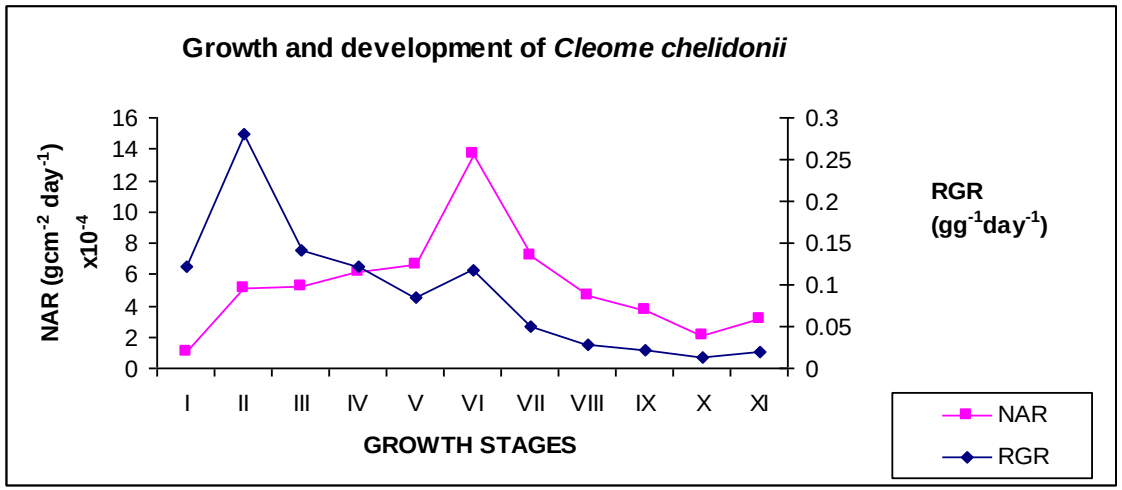

Growth and development of Cleome chelidonii
NAR (gcm-2 day-1) x10-4
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
NAR
RGR

Fig 6:

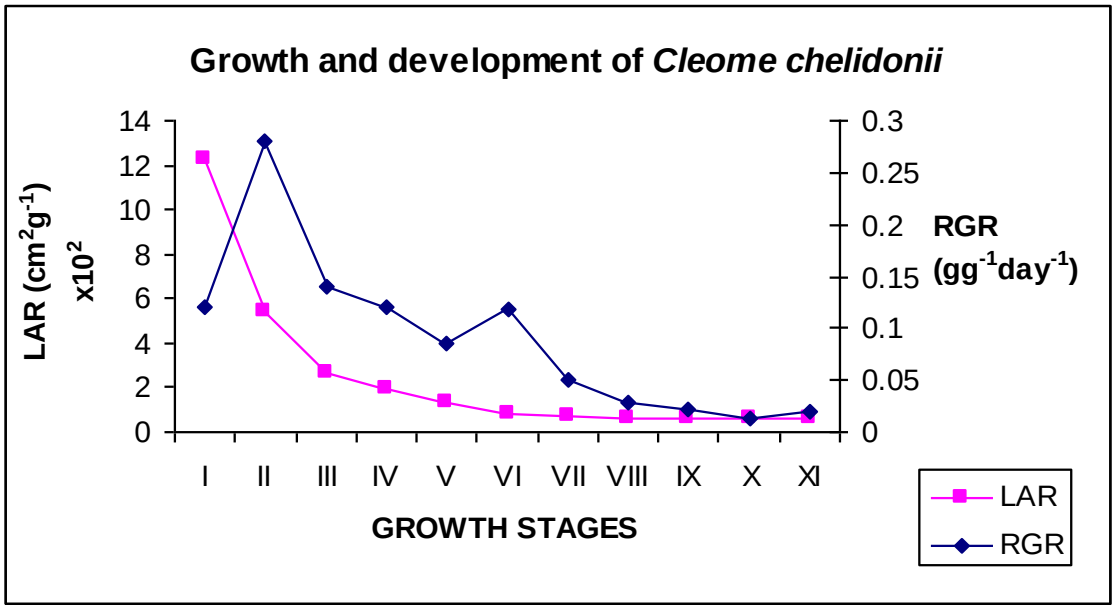

Growth and development of Cleome chelidonii
LAR (cm2g-1) x10-2
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
LAR
RGR

Fig 7:

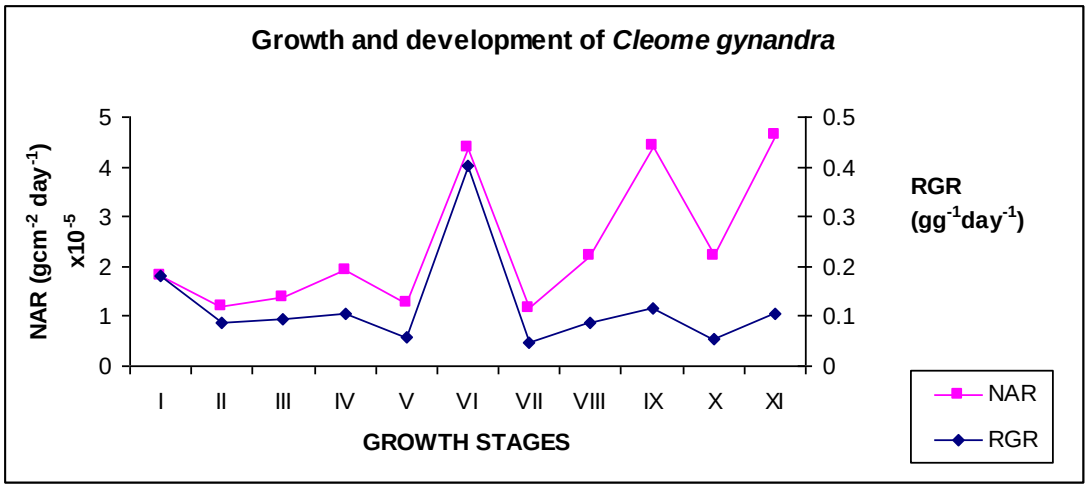

Growth and development of *Cleome gynandra*
NAR (gcm-2 day-1) x10-5
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
NAR
RGR

Fig 8:

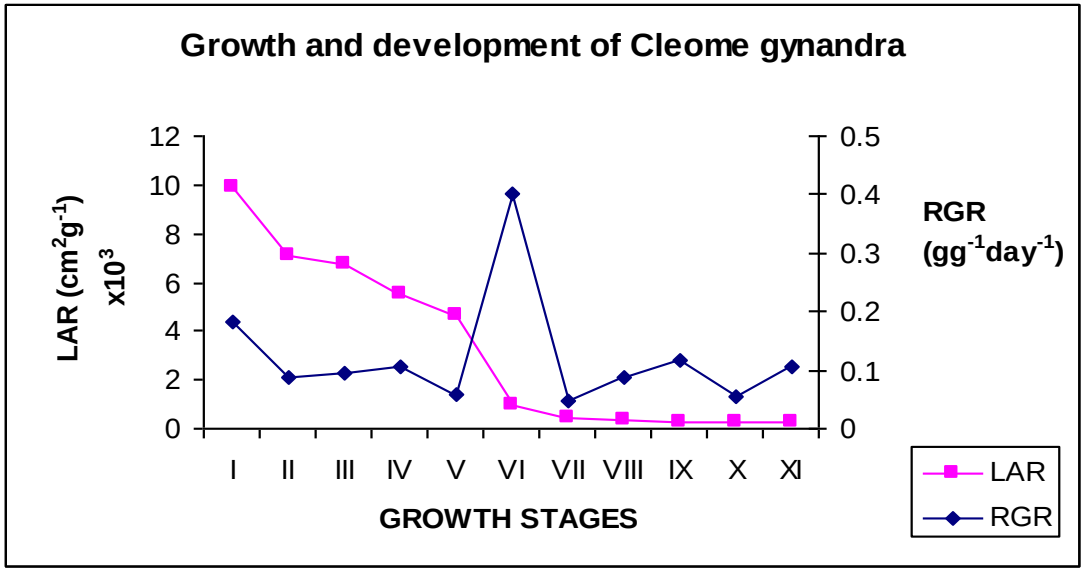

Growth and development of Cleome gynandra
LAR (cm2g-1) x10³
RGR (gg-1day-1)
GROWTH STAGES
I II III IV V VI VII VIII IX X XI
LAR
RGR

Fig 9:

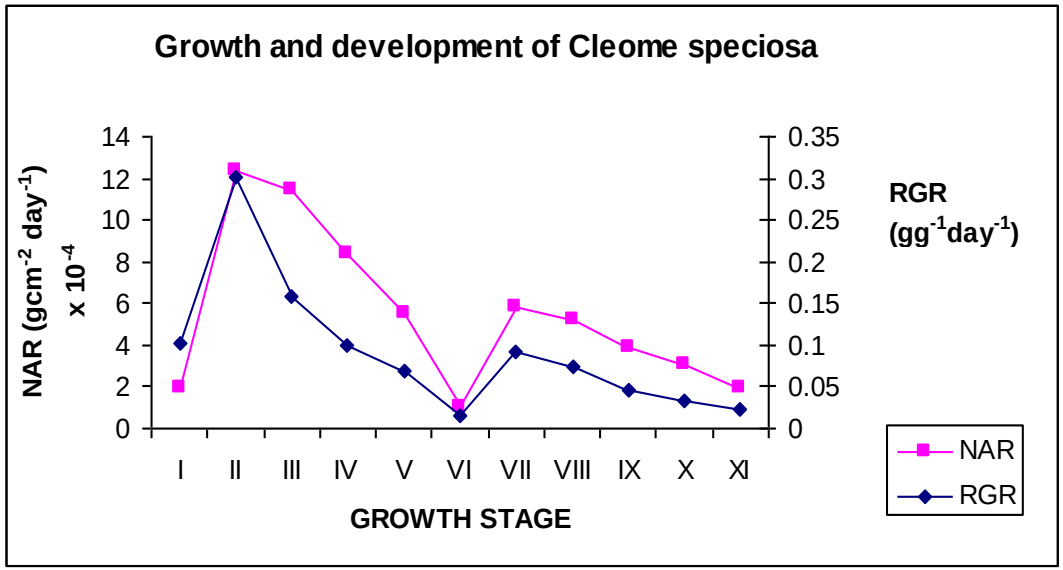
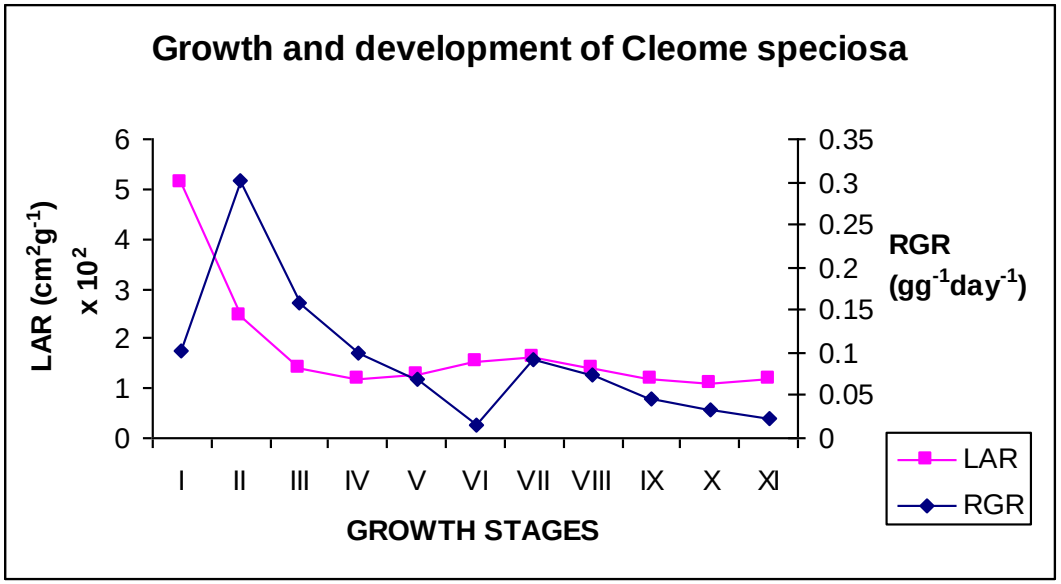

Growth and development of Cleome speciosa
NAR (gcm-2 day-1) x 10-4
RGR (gg-1day-1)
0
2
4
6
8
10
12
14
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
GROWTH STAGE
NAR
RGR

Fig 10:


Growth and development of Cleome speciosa
LAR (cm2g-1) x 10-2
RGR (gg-1day-1)
0
1
2
3
4
5
6
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
GROWTH STAGES
LAR
RGR