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EFFECT OF SOIL MOISTURE ON GROWTH OF *CORTALARIA RETUSA* L. AND *C. STRIATA* DC.

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The paper reports the effect of varying soil moisture on growth of *Crotalaria retusa* and *C. striata*. The maximum biomass and leaf areas were observed under a soil moisture around the field capacity. Waterlogging and drier soil caused poor growth in both the species in which waterlogging appeared more detrimental. In *C. retusa* the number of leaves was higher in the waterlogged soil. The RGR and NAR were lower in the drier soil. The latter was more in *C. retusa* in the waterlogged condition. The stressed plants had lesser S/R ratio. The chlorophyll content was maximum in alternate day watered plants. Delayed flowering and poor seed setting were witnessed in plants under waterlogging as well as under drier soil.

Key words : Soil moisture, Grwoth, Adaptibility, Harvest, Treatment, Watering.

The two species of *Crotalaria* namely *C. retusa* and *C. striata* face the differential soil moisture from waterlogging during the rainy season to near xeric condition during the summer months. As such, it was considered useful to compare their growth performance in a renge of soil moistures by resorting to varying irrigational regimes in the pots. The performance has been assessed with respect to the established growth parameters including dry matter accumulation. RGR, NAR, LAR etc. with a view to finding out the comparative adaptabilities of the two species under the stress of waterlogging and drought conditions.

MATERIALS AND METHODS

For culture experiments, earthen pots of 20 cm height and of 15 and 8 cm diameter at the inside top and bottom respectively, were used. Pots were filled with a mixture of powdered field soil, sandy soil and farmyard manure (in the ratio 5:2:3 v/v). Seeds of the two species of *Crotalaria* were sown in these pots on 13th June. After a week of sowing, seedlings were thinned to one in each pot. Four irrigational cycles were maintained in the following way :

- WL - Waterlogged condition was created by plugging the bottom hole of the pot with the help of wax. Care was taken that about 1/2 cm water remained on the surface of soil.
- WAD - Pot watted to field capacity every alternate day.
- W_4D - Pots wetted to field capacity every 4th day.
- W_6D - Pots wetted to field capacity every 6th day

Four harvests were taken fortnightly as per detalis in table I. At each harvest, 5 plants were rendomly selected for each treatment. The monoliths of the pots were washed with fine jet of water to remove adhering soil particles. Roots, shoots and leaves were separated. Cotyledonary leaves were collected with normal ones. Outlines of leaves were drawn on graph paper and their areas were calculated. Plant parts were oven dried separately in butter paper bags at $80^0 \pm 2^0$ for 48 hours and stored in a desiccator before weighing. The 5th harvest was taken under each treatment at their full maturity for the estimation of fruits and seeds per plant.

With the help of dry weights of roots, stems and leaves, the growth parameters including dry matter (DM), leaf area, RGR, NAR, SLA, LWR and S/R ratio were worked out as per Evans (1972) and the data were analysed statistically for test of significance.

Chlorophyll was extracted from fresh leaves (discarding midrib) with 80% acetone and optical densities were measured at 645 and 663 nm and chlorophyll a, b and total chlorophyll per gm tissue were calculated according to Witham *et al.* (1971).

RESULTS

The mean percentage of soil moisture and the relative water content of the two species under different watering regimes have been given in Table 4.

Table 1: Primary growth attributes of the two species of *Crotalaria* (CR and CS) at different harvest under varying watering regimes.

Attributes Treatment	Age in days Harvest No.	Dry weight/Plant in mg WL	WAD	W_4D	W_6D	Leaf area (in cm^2) WL	WAD	W_4D	W_6D	Number of Leaves WL	WAD	W_4D	W_6D
CR	28 1st	412.65 ±16.02	755.78 ±26.62	281.78 ±15.52	294.92 ±16.68	63.83 ±9.99	135.83 ±5.02	65.21 ±3.29	54.15	12.0	22.0	13.0	11.0
CS		169.95 ±8.13	405.63 ±19.22	70.62 ±81.25	72.36 ±9.28	40.20 ±3.69	60.97 ±4.14	24.25 ±3.14	25.65 ±3.22	10.0	18.0	15.0	13.0
CR	42 2nd	1184.10 ±27.67	1273.10 ±37.14	596.25 ±26.39	656.06 ±36.44	167.46 ±3.72	272.03 ±15.48	145.38 ±9.48	124.18 ±4.27	21.0	27.0	22.0	16.0
CS		234.15 ±15.45	850.23 ±26.74	347.69 ±15.85	280.62 ±14.63	41.58 ±3.72	242.29 ±15.48	98.33 ±9.48	72.20 ±4.27	12.0	28.0	18.0	18.0
CR	56 3rd	4235.79 ±68.30	3173.15 ±58.06	1708.42 ±17.38	1184.03 ±27.07	524.90 ±16.26	427.28 ±19.05	275.77 ±11.61	174.97 ±9.16	66.0	40.0	27.0	21.0
CS		797.35 ±26.68	1972.40 ±47.58	889.82 ±26.79	737.70 ±25.66	116.14 ±8.75	380.36 ±15.84	158.93 ± 9.06	168.10 ±10.12	22.0	37.0	25.0	23.0
CR	70 4th	6448.03 ±88.77	3495.00 ±68.15	1755.15 ±37.47	1207.46 ±47.09	635.57 ±19.45	451.93 ±16.01	164.07 ±15.09	162.93 ± 9.09	58.0	27.0	22.0	23.0
CS		828.29 ±16.71	2003.06 ±37.60	1011.18 ±36.91	972.85 ±28.88	117.23 ±14.76	361.61 ± 8.89	216.44 ±15.37	252.60 ±12.53	19.0	38.0	24.0	25.0

CR = *Crotalaria retusa;* CS = *Crotalaria striata.*

Table 1a: Derived growth parameters of the two species of *Crotalaria* (CR and CS) at harvest under varying watering regimes.

Attributes Treatment Spaces	Age in days	LAR WL	WAD	W_4D	W_6D	SLR WL	WAD	W_4D	W_6D	LWR WL	WAD	W_4D	W_6D	S/R Ratio WL	WAD	W_4D	W_6D
CR	1	0.15	0.17	0.22	0.18	0.31	0.36	0.41	0.33	0.48	0.48	0.54	0.54	1.96	2.86	2.39	2.98
CS		0.23	0.15	0.34	0.35	0.53	0.18	1.23	0.73	0.44	0.82	0.27	0.47	0.60	10.68	0.74	2.57
CR	2	0.14	0.21	0.24	0.18	0.31	0.27	0.54	0.44	0.44	0.76	0.44	0.42	2.13	3.22	2.13	2.14
CS		0.15	0.28	0.28	0.25	0.35	0.54	1.16	0.51	0.50	0.52	0.24	0.49	2.55	2.89	0.98	2.90
CR	3	0.12	0.12	0.16	0.14	0.29	0.28	0.36	0.31	0.41	0.47	0.43	0.46	2.39	2.79	2.46	2.55
CS		0.14	0.19	0.17	0.22	0.30	0.40	0.51	0.48	0.47	0.47	0.34	0.47	1.90	3.10	1.60	2.67
CR	4	0.07	0.16	0.15	0.16	0.27	0.28	0.32	0.34	0.35	0.59	0.47	0.47	1.76	2.40	3.08	2.53
CS		0.18	0.18	0.21	0.25	0.41	0.44	0.88	0.55	0.45	0.40	0.24	0.46	1.49	1.90	1.13	2.64

Waterlogging caused initiation of branches of *C. retusa* as observed with 3 and 4 branches respectively at 3rd and 4th harvest. In WAD, W_4D and W_6D plants of both the species remained unbranched. Plants of *C. retusa* were with more leaves and with maximum number in WL condition whereas in *C. striata* the maximum number was in W_4D condition at the last harvest (Table 1).

The dry weight accumulation (Table 1) was more in WAD regimes for *C. retusa*. In the drier condition (W_4D and W_6D) the reduction of dry weight was more in W_6D regimes for both the species. Senescence was noted in *C. retusa* at the 3rd and 4th harvest. The leaf area increase (Table 1a) was maximum under WL and WAD condition. The leaf number reduced at the fourth harvest particularly in *C. striata*.

Relative growth rate was higher over the first and second harvest intervals in WL for *C. retusa*. While fluctuating values were obtained in the other species. An uniform RGR pattern was noticed in WAD regime over the three harvest intervals. In

Table 2: Derived growth parameters of the two species of *Crotalaria* (CR and CS).

Attributes Treat-species	Age (in Harvest No.	RGR WL	RGR WAD	RGR W_4D	RGR W_6D	NAR WL	NAR WAD	NAR W_4D	NAR W_6D
CR	1-2	0.22	0.11	0.18	0.08	1.55	0.57	0.81	0.92
CS		0.06	0.16	0.34	0.29	0.13	0.72	1.13	0.29
CR	2-3	0.27	0.19	0.22	0.12	2.11	1.20	1.16	0.77
CS		0.26	0.18	0.20	0.20	1.77	0.79	0.93	0.23
CR	3-4	0.09	0.16	0.10	0.04	2.82	1.09	0.65	0.26
CS		0.05	0.00	0.02	0.06	0.31	0.01	0.14	0.40

the drier regime (W_6D) the values were comparatively lower.

Table 3: Analysis of variance for the data of dry matter accumulation, leaf area, LAR, RGR and NAR.

Source	Dry matter accumulation F	Leaf Area F	LAR F	RGR F	NAR F
Sp	8.7*	7.4*	3.8	(142.9)	8.8*
Tr	2.7	4.9*	1.3	(1.4	
Har	6.4*	11.3**	1.02	10.9*	1.6
Sp x Tr	2.0	3.3	(4.2)	2.05	2.0
Tr x Har	(1.8)	(1.7)	(4.4)*	(1.1)	(1.12)
Har x Sp	(9.1)	(1.9)	(11.4)	1.9	1.0
Residual					

* Significant at 5% level; ** Significant at 1% level.

The net assimilation rate of *C. retusa* was higher (Table 2), under the WL regime. In WAD, the values were higher in *C. striata* at the first harvest interval. But between 2nd and 3rd and 3rd and 4th the rates were higher in the former species. The similar trend was noticeable in drier soils (W_4D and W_6D). Over the last harvest interval in W_6D the rate (0.40 mg/cm^2/week) of *C. striata* was higher over that of *C. retusa* with 0.26 mg/cm^2/week.

The plants of *C. retusa* displayed lower leaf area ratios over *C. striata* (Table 1a) in all the four watering regimes. The ratio increased gradually till W_4D in the former while up to W_6D in the latter. The specific leaf area was lower in the case of *C. retusa*, while in *C. striata* it was more in the W_4D and W_6D conditions. The leaf weight ratio did not show any specific relationship from harvest to harvest.

The shoot/root ratio was higher in WAD regimes for both the species. Chlorophyll a and total chlorophyll in mg/gm of tissue was more (Table 5), in WAD and W_4D regimes for both the species. However, for chlorophyll b, no consistency was noticed.

Table 4: Percentage of soil moisture (SM) and relative water content (RWC) of the two species of *Crotalaria* (CR & CS) under different watering regimes.

Species	WL SM	WL RWC	WAD SM	WAD RWC	W_4D SM	W_4D RWC	W_6D SM	W_6D RWC
CR	50	79	33	76	20	70	15	49
CS	49	79	31	76	17	70	16	50

The initiation of flowering started on 60th and 48th day in *C. retusa* and *C. striata* respectively in alternate day watered plants (Table 6). It was delayed both under WL and W_6D regimes by five to ten days. The mean number of fruits was 12.0 and 14.0 per plant respectively in the two under WAD condition with no fruit setting in other regions.

DISCUSSION

From the results it is evident that waterlogging favoured initiation of branching in *C. retusa*. Excessive soil moisture has been reported to enhance branching and foliage number (Ethrington, 1975) with which the present finding is in agreement with.

Both the species displayed maximum biomass in the alternate day watered plants. It was indicative of their better performance under a moisture around the field capacity as has also been reported by other workers (Walter, 1955; Ethrington, 1984). From the higher dry weight acquisition of *C. retusa* in the waterlogged condition, its adaptation to waterlogging was marked. From a lower dry matter under drier regimes, it might be inferred that both are poor performers in the dry conditions of the soil. The hastened senescence of leaves of *C. retusa*, indicated its adaptability under drier condition as has also been observed by Montieth, (1977). It is worth noting that DM accumulation and the leaf area increase were maximum under alternate day watered plants. The results are in conformity with the observations of Walter (1955), Coutts (1982) who have asserted that the sensitivity of plants to waterlogging varied with species, the stage of

Table 5: Effect of varying watering regimes on chlorophyll content of the two species of *Crotalaria* (CR & CS) at 3rd Harvest.

Speciesmg	Chlorophyll a/gm tissue				mg Chlorophyll b/mg tissue				mg Total Chlorophyll/mg tissue			
	WL	WAD	W_4D	W_6D	WL	WAD	W_4D	W_6D	WL	WAD	W_4D	W_6D
CR	0.68	0.76	0.76	0.61	1.02	1.14	1.30	0.98	1.70	1.91	2.06	1.60
CS	0.82	0.80	0.81	0.75	0.28	1.26	1.37	1.26	1.12	2.06	2.18	2.0

Table 6: Reproductive growth attributes of two species of *Crotalaria* (CR & CS) under varying watering regimes (at 5th Harvest).

Species	Days of Flowering Primoria after seed sowing				Number of Fruits/Plants				Number of Seeds/fruit			
	WL	WAD	W_4D	W_6D	WL	WAD	W_4D	W_6D	WL	WAD	W_4D	W_6D
CR	61	60	66	69	Nil	12	Nil	Nil	Nil	16	Nil	Nil
CS	87	48	52	55	Nil	14	Nil	Nil	Nil	32	Nil	Nil

growth and the environmental condition prevailing thereon. From the data of RGR also the adaptability of *C. retusa* under waterlogged condition was indicated. The uniform RGR in the alternate day watered plants of both the species reflected their identical response. Further, fluctuating values of *C. retusa* at different harvest intervals, indicated its disturbed morphogenetic set up (Mutsaers, 1983).

It is worth noting that under stressed condition both the species displayed lower RGR at the later harvest intervals - a phenomenon also noted by Evans (1972). The rates were more, over the other harvest interval in the former species indicating better performance under adverse soil moisture. Over the last harvest interval *C. striata* had maximum NAR in the W_6D regime with lowest soil moisture and being almost near to permanent wilting percentage. Such a situation could be explained on the basis of specific inherent adaptability. In both the species the RGR appeared to be governed by the level of NAR and the reduction of the latter under adverse condition could be because of the loss of photo synthetic surface (Pope & Magdwick, 1974).

No significant effect could be marked for S/R ratio in the two species.

As regards chlorophyll content, both the species behaved indentically in having higher chlorophyll content in WAD and W_4D regimes and that the plants under the extremes of soil moisture, displayed lower values. However, no definite trend could be established for this attribute. These results corroborate the findings of Tabbada & Flores (1983) with increased as well as decreased content respectively in the conditions of stress.

It is evident that the drier soils as well as waterlogging delayed the initiation of flowering in both the species.

This observation is in consonance with those of Tabbada & Flores (1983). Also the extreme conditions did not allow seed setting in either species. Such an observation lay in contradiction of Mank *et al.* (1984) that number of pods was directly proportional to high irrigation. Thus, we can say that the reproductive attributes did not indicate any significant difference between the two species.

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