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The Effect of Water Stress on Siratro *(Macroptilium atropurpureum)* Seed Production

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ABSTRACT

The early and extended soil moisture stress can cause a severe reduction in plant weight, branch development, leaf number and LAI leading to significant reduction in seed yield. However, soil moisture stress imposed at peak flowering resulted in a significant increase in seed yield compared with adequate moisture to final harvest. This beneficial was due to the increase in number of inflorescences and pods formed on the primary and particularly the secondary branches. Other yield components which are number of seed per pod and seed weight were unaffected by water stress.

Water stress has no effect on seed quality characteristics of Siratro, as quality appeared to be more dependent on stage of maturity.

INTRODUCTION

Siratro *(Macroptilium atropurpureum)* has been widely used as a pasture legume in the tropic and sub-tropic since its release in 1960 (Hutton and Beall, 1977). Siratro has a large seed which when accompanied by rapid germination and strong seedling vigour make its establishment faster and more certain than many other tropical legumes.

Climate conditions particularly water stress may influence the wide range of morphological and physiological responses in plant and also reflected to the final product-seed yield. From the literature (Salter and Goode, 1967) it appears that water stress before flowering can reduce vegetative growth of the plant but has little effect on pod and seed yields provided the soil does not reach permanent wilting point. However, water stress during the reproductive period can cause a marked reduction in seed yield through a reduction in pod number (Biddiscombe, 1975) and size (Sionit and Kramer, 1977) and number of seeds per pod (Momen *et al.*, 1979).

Fewer studies have been conducted on the effects of water stress on the vegetative and reproductive with reference to Siratro. This paper reports an investigation of the effect of water stress when imposed at three different stages of growth on vegetative and reproductive growth of Siratro.

MATERIALS AND METHODS

The experiment was conducted in the climate control rooms at the Plant Physiology Division, DSIR, Palmerston North, New Zealand. The condition in the controlled environment room were: temperature 30/20 ± 0.5 °C (day/night), humidity 70/90 ± 5% R.H. (day/night) and 12 hours photoperiod. CO_2 level was monitored during the experiment and ranged from 290 – 350 ppm during day conditions and from 320 – 390 ppm during night conditions.

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Siratro seeds were scarified in order to overcome hard seededness, and sown in one gallon containers filled with a sterilised North Carolina soil mixture. Each pot was connected to a watering tube and watered automatically with N.C.S.U. nutrient solution throughout the experiment. Water stress was imposed at different growth stages by removing the automatic watering tubes and subsequently watering by hand to maintain soil moisture content and leaf relative water content (RWC) in the pF range of 2.8 – 3.0 and 75 – 80% respectively.

The three water treatments were: water stress commenced half-way through the vegetative stage and continued until final harvest (W1). Water stress commenced at peak flowering and continued until final harvest (W2). Well water supplied throughout the experiment from sowing until final seed harvest as a control (W3). A randomized complete block design with three replications was employed. Harvesting involving three plants at each of seven harvest times were dissected into leaf and non-leaf component with subsequent measurement of leaf area, branch and pod numbers. Dry weight was determined by using vacuum oven. Seed yield and components were obtained from each harvest after peak flowering. Seed moisture content and germination were carried out following the ISTA Rules (1976).

RESULTS AND DISCUSSION

I. Effect on vegetative growth

The effects of water stress on vegetative growth of Siratro plant throughout the experimental period under a controlled environment are presented in terms of plant dry weight, leaf area and branch number.

The importance of an adequate supply of soil moisture for maximum plant growth was clearly highlighted in this experiment. Plants in the well-watered control treatment (W3) continued to increase in dry weight (Table

Table 1 Effect of water treatments on total plant dry weight (gm/plant)

Treatment	HARVESTING						
	$\frac{1}{2}$V	F.A.	P.F.	10D	15D	20D	25D
W1	(0.33)	1.86	6.75	7.07	6.72	7.28	7.98
W2	(0.33)	(3.59)	(22.71)	38.01	43.79	40.20	44.72
W3	0.33	3.59	22.71	43.27	53.27	65.56	74.21
Mean	0.33	3.01	17.39	29.45	34.59	37.68	42.30
Significance	N.S.	**	**	**	**	**	**
L.S.D. .05		0.87	9.57	11.84	9.05	10.38	9.45
.01		1.32	14.49	17.94	13.72	15.72	14.31

(Figures in brackets in this and subsequent tables reflect the data from the W3 treatment which was identical to W1 and W2 at those harvests, i.e. W1 treatment commenced at half vegetative stage, W2 commenced at peak flowering).

$\frac{1}{2}$V = at half vegetative stage
F.A. = Floral appearence
P.F. = Peak flowering
10D – 25D = 10 days – 25 days after peak flowering

Table 2 Effect of water treatments on leaf area (cm^2) per plant

Treatment	HARVESTING						
	$\frac{1}{2}$V	F.A.	P.F.	10D	15D	20D	25D
W1	(90)	302	505	495	494	528	488
W2	(90)	(735)	(5249)	5318	5355	4124	4259
W3	90	735	5249	7661	9990	12293	11888
Mean	90	591	3668	4479	5280	5648	5545
Significance	N.S.	**	**	**	**	**	**
L.S.D. .05		144	2113	1599	2897	1822	1497
.01		219	3201	2422	4389	2760	2268

Table 3 Effect of water treatments on total branch number per plant

Treatment	HARVESTING						
	$\frac{1}{2}$V	F.A.	P.F.	10D	15D	20D	25D
W1	(6)	5	8	8	9	8	8
W2	(6)	(7)	(9)	39	37	32	33
W3	6	7	9	39	38	49	47
Mean	6	6	9	29	28	30	29
Significance	N.S.	N.S.	N.S.	**	**	**	**
L.S.D. .05				5	6	6	8
.01				9	11	11	13

1) at a relatively high rate right up to final harvest, although there was the suggestion that growth rate was beginning to decline in the last week. The same response was reflected in leaf area per plant and branch numbers as shown in Table 2 and 3 although these components declined increasingly in their rate of development during the late reproductive stages approaching the final harvest. In contrast, the early restriction of soil moisture (W1) led to a severe reduction in plant growth indicating that Siratro is highly sensitive to water stress applied early in its life, as reported by Ludlow (1980), Ahmed and Quilt (1980) and Ludlow *et al.* (1983). Such plants struggled throughout the entire experimental period with little chance to develop and support any real number of green leaves, a worthwhile area of leaf or adequate numbers of branches, as also reported by Gates (1955 b); Salter and Goode (1967); Boyer and McPherson (1975) and others.

Plants receiving adequate water up to peak flowering (W2) continued to increase in dry weight for some 10 – 15 days after the water restriction was imposed before showing any marked reduction in growth rate. However, leaf area was much more sensitive to water restriction and was affected almost immediately. Such response were also reported in the same species by Peake *et al.* (1975). Branching, on the other hand, was much less sensitive to late water stress and developed dramatically in number over the 10 days following peak flowering before presumably suffering the effects of stress. The reduction in branch numbers recorded over the last two weeks was due to the 'death' of a significant number of very small tertiary branches.

II. Effect on reproductive growth.

Seed yield and components.

Seed components are presented in terms of inflorescence number, pod number, number of seed per pod and seed weight respectively.

The importance of adequate soil moisture in determining seed yield was again clearly evident. As shown in Table 4 when plants were subjected to water stress early in their life (W1) seed yields were severely depressed, by some 23%, compared with plants well watered throughout their life span (W3) or, by some 72% when compared with plant well watered through to peak flowering (W2). By comparison, well watered plants (W3) with a continuous supply of water failed to achieve as high a level of seed production and, along with those plants stressed early (W1), produced significantly less and similar seed yield. The effects of water stress on seed yield were expressed mainly through the number of inflorescences and the number of pods produced per plant (Table 5 and 6). However, it is interesting that surprisingly good yields of seed were obtained from such small and highly stressed plants (W1) which must have been highly efficient in their productive processes. Such efficiency probably resulted from the plant's capacity to survive by shedding old leaves which effectively reduced the total demand for water, enabling some available water to be conserved

Table 4 Effect of water treatments on seed yield (gm/plant)

Treatment	HARVESTING Days after peak flowering			
	10	15	20	25
W1	0.79	2.17	3.12	3.44
W2	1.15	3.12	7.31	11.94
W3	1.01	2.46	3.14	4.49
Mean	0.99	2.58	4.52	6.62
Significance	N.S.	N.S.	**	**
L.S.D. .05			2.44	2.99
.01			3.70	4.54

Table 5 Effect of water treatments on total inflorescence number per plant

Treatment	HARVESTING Days after peak flowering			
	10	15	20	25
W1	9	12	13	15
W2	30	37	37	43
W3	14	22	25	36
Mean	18	24	25	31
Significance	*	*	**	**
L.S.D. .05	12	16	8	7
.01	–	–	12	11

Table 6 Effect of water treatments on numbers of pod which contributed to seed yield per plant

Treatment	HARVESTING Days after peak flowering			
	10	15	20	25
W1	7	18	23	28
W2	13	30	57	77
W3	9	23	28	42
Mean	10	24	36	49
Significance	N.S.	N.S.	**	**
L.S.D. .05			17	25
.01			26	38

for limited growth and seed development as reported by Wither (1979). The reproductive tissue seemed to compete effectively for available assimlates and then showed less sensitivity to water stress during seed filling than during the vegetative phase as suggested by Hsiao and Acevedo (1974).

Of even greater interest and significance was the very high seed yield obtained from plants subjected to late water stress (W2). At the final harvest these plants produced 3 folds more than well water control plants (W3). Such and effect was largely due to an increase in the number of inflorescences and number of pods formed particularly on the secondary and to a lesser extent on primary branches in the late stressed plant as shown in Table 5 and 6. As expected, plant well watered throughout their life span (W3) produced a vigorous vegetative frame, but did not produce a higher seed yield when compared with plants in the W2 treatment and only 23% higher than plants in the W1 treatment at the final harvest. This effect was probably due to the competition for assimilates between the vegetative and reproductive components as also reported by Herbert and Hill (1978 b), Kattan and Fleming (1956) and Salter, 1962, 1963). The average seed numbers per pod remained relatively constant around 10 – 12 (Table 7) and was relatively unaffected by water treatments, reflecting their insensitivity to water stress, while seed weight (Table 8) appeared to be slightly advantaged by moisture stress.

The results of this experiment clearly show the importance of correct sowing date in relation to local rainfall pattern in determining both the vegetative and seed yield of Siratro. Certainly they suggested that a sowing date which provides adequate rainfall or irrigation to allow the production of a well grown plant with high leaf area and branch number is important. Subsequently however, a period of water stress is advantageous in stimulating a large number of inflorescences and hence a large number of pods and thereby achieving a high seed yield.

Table 7 Effect of water treatments an number of seed per pod

Treatment	HARVESTING Days after peak flowering			
	10	15	20	25
W1	10	12	12	11
W2	12	9	11	13
W3	12	10	11	11
Mean	11	10	11	12
Significance	N.S.	N.S.	N.S.	N.S.

Table 8 Effect of water Treatments on the 100 seed weight (gm)

Treatment	HARVESTING Days after peak flowering			
	10	15	20	25
W1	1.020	1.003	1.097	1.090
W2	0.710	1.087	1.137	1.223
W3	0.900	1.057	1.047	0.960
Mean	0.877	1.049	1.093	1.091
Significance	**	N.S.	N.S.	**
L.S.D. .05	0.150			0.132
.01	0.226			0.199

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