EFFECTS OF ADVENTITIOUS ROOT REMOVAL ON THE GROWTH OF FLOODED TROPICAL PASTURE LEGUMES *Macroptilium lathyroides* and *Vigna luteola*

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ABSTRACT

***Macroptilium lathyroides* and *Vigna luteola* with either intact or removed adventitious roots from the immersed stem, were flooded continuously for 15 and 30 days from the start of flowering.**

The removal of adventitious roots from the immersed stem of the flooded plants hastened leaf chlorosis and abscission. Dry matter yield (shoots and roots) and nodule dry weight were reduced to a considerable extent in *V. luteola* but only to a minor extent in *M. lathyroides*.

All flooded plants survived with increase in flooding duration. The rapid formation of adventitious roots noted in these species soon after immersion provided the adaptive mechanism for plant survival and growth under flooding.

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KEY WORDS: Pasture legumes. Flooding. Adventitious root removal. Leaf chlorosis. Abscission. Dry matter yield. Leaf diffusive resistance.

INTRODUCTION

The presence of special adaptations in plants to withstand waterlogging injury has not been given much attention. Nevertheless, plants have to adjust physiologically and morphologically by showing changes not only in the root system but also in the stems if they have to persist under anaerobic conditions.

The formation of adventitious roots is an important excess-water-tolerance strategy (Kramer, 1951). Gill (1970) stated that flood tolerant species adapt to waterlogging by production of functional adventitious roots. Because root aeration is critical in flooded soil, any plant species or cultivar with high proportion of adventitious roots would be at an advantage. In clover, the Yarloop cultivar has higher proportion of near-surface roots than the Mt. Barker cultivar which makes the former more flood tolerant than the latter (Francis and Devitt, 1969).

Since adventitious root formation on the stem tends to be characteristic of woody species native to periodically flooded habitats, it is therefore often seen as an adaptation conferring flooding tolerance. However, experimental evidence for this is lacking. This study was thus conducted to determine whether the adventitious root system formed during flooding can sustain and extend the growth of the plant at times of flooding.

MATERIALS AND METHODS

Macroptilium lathyroides and *Vigna luteola* are both short-lived perennials (Sherman, 1977) and are normally mesophytic pasture legumes that have the ability to persist and produce well on seasonally wet soil (Whiteman, 1977). They could show rapid initiation and growth of adventitious roots from the immersed stem a few milimeters below the water level, and further growth beyond the flowering period (Whiteman et al., 1981; Chudasama, 1981) hence, they were the species chosen for this study.

The experiment was conducted in a glasshouse using a split-split plot arranged in a randomized complete block design with four replications per treatment. The two pasture legume species *(M. lathyroides* and *V. luteola)* served as the main plots, three flooding durations (0, 15 and 30 days) as the subplots, and three adventitious root removal treatments (C = control or unflooded, F_1 = flooded plants with adventitious roots intact, and F_2 = flooded plants with adventitious roots removed from the immersed stems as soon as they were visible) as the sub-subplots.

Before flooding, the 36 pots planted to each species were divided into groups according to plant height and allocated such that plant size in each treatment was uniform. Flooding treatments were imposed at the onset of flowering so that comparison could be made at the same physiological stage. Each of the pots was placed in 20-liter drums filled with water. A water depth of 5 cm above the soil surface was maintained.

The plants subjected to 0 flooding duration were harvested on the day when flooding was begun while those in the other two durations were harvested after 15 and 30 days. At each harvest, plants in unflooded pots for each flooding duration were simultaneously harvested for comparison.

Visual symptoms during flooding periods were observed. At each harvest, the oven dry weight of shoots, roots and nodules were also recorded. Every 4 days, the diffusive resistance on the abaxial surface of young fully expanded leaves of each plant was measured between 11:00 a.m. and 12:00 noon using a leaf porometer.

Figure 1. *Macroptilium lathyroides:* a) Control (unflooded), b) Plants flooded for 15 days with adventitious roots intact, and c) Plants flooded for 15 days with adventitious roots removed.

Figure 2. *Vigna luteola:* a) Plants flooded for 30 days with adventitious roots removed, b) Plants flooded for 30 days with adventitious roots intact, and c) Control (unflooded).

flooding, respectively. In contrast, the root dry weights of F_2 plants were significantly reduced by 33 and 57% compared with the control at 15 and 30 days flooding, respectively. This could be attributed to the decay of some of the original roots.

The two species differed in their pattern of nodulation with increasing flooding duration. In *M. lathyroides,* nodulation in the flooded treatment (F_1 and F_2) was higher than in the control with increasing flooding duration. After 30 days of flooding, it became significantly higher in F_1 plants than in the control by 26% due to further nodulation in the adventitious roots. In F_2 plants, the increase over that of the control was only 18% (Table 1). Nodulation was markedly reduced in *V. luteola* with increasing duration of flooding. At 15 days flooding, nodulation in the flooded treatments (F_1 and F_2) was lowered by 15% relative to that of the control. Extending the flooding duration to 30 days significantly lowered the nodule dry weight by as much as 28% in F_1 and 61% in F_2 As flooding duration increased, nodulation was reduced due to the decay of the nodules that appeared at the time of flooding.

Leaf Diffusive Resistance (s/cm)

The leaf diffusive resistance values at each sampling period over 30 days flooding treatment are presented in Table 2. Over the entire period, the leaf diffusive resistance values ranged from 1.4 to 3.6 s/cm in *M. lathyroides* and from 2.4 to 3.7 s/cm in *V. luteola.*

The leaf diffusive resistance of flooded *M. lathyroides* plants was lower than that of the control and this was maintained particularly in those whose adventitious roots were still intact. The leaf diffusive resistance of the flooded *V. luteola* plants (F_1 and F_2) was statistically similar to that of the control.

DISCUSSION

Physiological response to the flooding treatments varied between the two species and may be related to their flooding tolerance. Generally, there was a good relationship between the ability of the plant to produce adventitious roots and its survival under flooded condition. The rapid production of adventitious roots noted in both *M. lathyroides* and *V. luteola* plants soon after immersion provided an adaptive mechanism for their continued growth under flooded conditions.

Removal of all adventitious roots as they emerged from the immersed stems delayed the growth of the two species. However, growth reduction was more severe in *V. luteola* than in *M. lathyroides* as the flooding duration was extended. The dry weights of shoots and roots were significantly reduced by flooding.This confirms the results obtained by Jackson (1955) that the primary role of adventitious roots in both flooded tomato and sunflower plants is to act as absorbing organs.

Root growth was reduced to a greater extent in flooded *V. luteola*

Table 1. Dry weights of flooded *Macroptilium lathyroides* and *Vigna luteola* plants as affected by adventitious root removal.

Species	Treatment: Flooding Duration (days)	Treatment: Adventitious Root Removal[1]	Dry Weight (g/plant): Total	Shoot	Root[2]	Nodule
M. lathyroides	0	C	5.36	3.65	1.49	0.22
		F_1	5.68	4.10	1.37	0.21
		F_2	5.73	4.03	1.48	0.22
	15	C	12.08	10.02	1.73	0.33
		F_1	13.56	10.64	2.50	0.42
		F_2	11.45	8.98	2.08	0.39
	30	C	20.76	17.62	2.77	0.37
		F_1	23.54	19.27	3.77	0.50
		F_2	19.77	16.25	3.07	0.45
V. luteola	0	C	7.46	5.46	1.59	0.41
		F_1	8.38	6.03	1.83	0.52
		F_2	8.36	5.93	1.98	0.45
	15	C	14.61	10.82	3.20	0.59
		F_1	17.53	13.35	3.68	0.50
		F_2	13.50	10.87	2.13	0.50
	30	C	26.84	20.50	5.57	0.77
		F_1	26.63	19.45	6.63	0.55
		F_2	19.74	17.05	2.39	0.30
Species x Flooding x Adv. Root-Rem. treatment	LSD	.05	2.82	ns	0.72	0.13
		.01	3.79	ns	0.96	0.18

[1] C = control (unflooded), F_1 = flooded plants with adventitious roots, F_2 = flooded plants without adventitious roots.

[2] Adventitious roots in F_1 were excluded to justify comparison.

Table 2. Diffusive resistance of flooded *Macroptilium lathyroides* and *Vigna luteola* plants as influenced by adventitious root removal.

Species/ Treatment	Leaf Diffusive Resistance (s/cm) Days After Imposition of Flooding										
	-1	3	5	8	11	14	17	20	23	27	30
M. lathyroides											
C	3.5	3.6	2.2	2.4	2.6	2.9	2.5	2.6	2.3	2.9	2.5
F_1	3.5	2.9	2.2	1.4	2.2	2.1	2.4	2.4	1.8	2.9	1.8
F_2	3.6	2.6	2.9	3.0	2.3	2.9	3.1	3.2	2.3	3.0	2.7
LSD .05	ns	0.6	0.7	0.8	ns	0.8	ns	0.8	ns	ns	0.6
V. luteola											
C	2.7	2.9	2.8	2.8	3.3	3.3	3.5	3.0	2.7	2.7	3.2
F_1	2.7	3.3	2.4	3.4	3.1	2.8	2.9	2.9	2.4	2.6	3.1
F_2	2.8	3.3	3.3	3.7	3.1	3.4	3.3	3.1	2.8	2.9	3.1
LSD .05	ns	ns	ns	0.8	ns	ns	ns	ns	ns	ns	ns

C = control (unflooded).
F_1 = flooded plants with adventitious roots.
F_2 = flooded plants without adventitious roots.

and to a lesser extent in flooded *M. lathyroides*. Root weight in *V. luteola* F_2 plants was 64% less than that in F_1 plants after 30 days flooding. This is probably due to oxygen deficiency in the root environment (Conway, 1940) due to removal of adventitious roots. Harris and van Bavel (1957) reported that of all plant activities, root respiration is the most sensitive to soil aeration. With impaired root respiration, nutrient and water uptake as well as energy for root growth are limited.

M. lathyroides maintained an almost similar growth rate in the flooded as well as in the control treatments. Flooded plants with excised adventitious roots were almost similar in appearance to those of the other treatments (Fig. 2). This suggests that *M. lathyroides* has other mechanisms aside from prolific production of adventitious roots which enable the species to survive under submerged condition and tolerate waterlogging. Probably, the unaerated soil condition brought about by flooding triggered the production of highly differentiated stems and roots which are anatomically and physiologically different from those in well-aerated soil (Kramer, 1951). Bryant (1934) found that barley roots produced in unaerated cultures had more and larger air spaces in the cortex, thinner cell walls and a greater tendency to be differentiated along the sides and tip than those in aerated cultures.

The yellowing and abscission of the leaves of flooded *V. luteola* plants (Fig. 1) may have been due to desiccation or to poisoning by toxic substances moving up from the dying roots (Kramer, 1951). These toxic substances may have escaped from the dying cells in the roots or they may have been produced by microorganisms in the roots or in the soil. Rowe and Beardsell (1973) reported that under anaerobic condition, there is much greater production of compounds such as sulfides and nitrites which are toxic to the roots and which when carried upwards in sufficient amounts might poison the leaves. It is likely that these factors responsible for the changes in flooded *V. luteola* plants became operative even before the appearance of the adventitious roots and remained operative for some time after the adventitious roots have developed (Jackson, 1955).

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