https://doi.org/10.29321/MAJ.10.A01746

Madras Agric. J. 79, (3) : 146 - 153 March, 1992

EFFECT OF WATER LOGGING ON BIOMASS PRODUCTION, NODULATION AND NITROGEN FIXATION BY *Sesbania rostrata* AND ROOT NODULATING SPECIES OF *Sesbania*

M. KALIDURAI and S. KANNAIYAN

ABSTRACT

Sesbania rostrata is a stem and root nodulating tropical green manure legume. The bacterium *Rhizobium Azorhizobium caulinodans* is involved in stem and root nodule formation. A pot culture study was conducted with *S. rostrata, S. aculeata* (Willd.) poir and *S. speciosa* during January - April, 1988 to investigate the effect of water logging on plant growth, biomass production, nitrogenase activity was higher than root nodules on 45th, 65th and 85th day after sowing. *S. aculeata* recorded higher biomass on 45th day after sowing. Chlorophyll content, nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese were accumulated more in *S. rostrata* while, *S. aculeata* and *S. speciosa* recorded higher organic carbon and phosphorus content with wider C:N ratio.

Biological nitrogen fixation is an important process in flooded rice field ecosystem and contribute nitrogen to the rice crop. Despite the use of fertilizer nitrogen in modern rice production, soil nitrogen and biological nitrogen fixation remain primary source for a vast area under rice production. Root nodulating *Sesbania aculeata* and *Crotalaria juncea* are widely used as potential nitrogen fixing leguminous green manure crops and known to contribute an average of 2.6 kg N ha^{-1} day^{-1} (Pandey and Morris, 1983). Recently, a tropical legume *S. rostrata* that grow as wild plant under water logged soils in Senegal (West Africa) which bears nodules on both stem and root was identified (Dreyfus and Dommergues, 1981). it is known to tolerate waterlogging and produce around 25 t ha^{-1} biomass in 45 days in rice soil (Kalidurai and Kannaiyan, 1988). Green manuring with *Sesbania* spp for rice crop considerably increased organic carbon N, P and K status of the soil and also enhanced the uptake of N, P, Ca, Mg, S, Fe, Mn and Zn (Swarup, 1988). The effect of water logging on biomass production, nitrogen fixation and accumulation of major and micronutrient in three *Sesbania* spp. were investigated and presented.

MATERIALS AND METHODS

A pot culture study with cement pots of size 30 x 30 x 45 cms (LBH) cms was conducted adapting randomized block design with three replications during January - April, 1988. The rice field soil samples with EC (0.70 M mhos/cm), pH (8.5), organic carbon (0.80%), available N (329 kg N ha^{-1}), p (26.88 kg ha^{-1}), K (470.00 kg N ha^{-1})

and CEC (44.62) was filled in cement pots. Three leguminous green manure rops were raised under waterlogged and 100% moisture saturation level. The seeds of *S. rostrata* were treated with peat based inocula of *S. rostrata* stemand root nodulating isolates (SRS-1 and SRR-1) and *S. aculeata* and *S. speciosa* seeds were treated with their specific root nodulating rhizobia isolates (SAR-1 and SSR-1) which were selected based on *in vitro* growth, infection and nodulation. These isolates were grown in Tryptone glucose yeast extract broth (10g tryptone, 5g glucose, 5g yeast extract, 0.9g $CaCl_2$ $2H_2O$ and 1 litre distilled water) at 28±1°C in a Psychrotherm incubator cum shaker for 72 hours and inoculated in peat soil. Fifteen seeds/pot were sown and after ten days excess seedlings were thinned out and nine seedlings/pot were allowed to establish in each pot. Plants were maintained in waterlogged and 100% moisture saturation throughout the period of experiment.

Fresh biomass, plant dry weight, shoot and root length, nodule number, nodule dry weight were assessed on 45th, 65th and 85th days after sowing. Nitrogenase activity by acetylene reduction assay (Hardy *et al.* 1968) and chlorophyll content (Arnon, 1949) were estimated on 45th, 65th and 85th day after sowing. Plant samples collected on 60th day were dried and analysed for organic carbon (Walkley and Black, 1954), available nitrogen by using kjeletc auto 1030 analyser (Humpries, 1956), available phosphorus by Vanadomolybdo phosphoric yellow method and potassium by using EEL Photometer (Jackson, 1973). Micronutrient such as zinc, copper, iron and manganese were estimated by feeding triple acid extract in the atomic absorption spectrophotometer (Jackson, 1973). Available calcium and magnesium were estimated by Versanate titration method (Jackson, 1973).

RESULTS AND DISCUSSION

Flooding increased the biomass production, nodulation and nitrogen fixation in three species of *Sesbania*. Initially on 45th day *S. aculeata* recorded higher root and shoot length and biomass (Fresh and dry) on 45th day after sowing while, *S. rostrata* recorded higher root and shoot length and biomass on 45th and 85th day after sowing (Table 1, 2 and 3).

Water logged condition favoured the growth of all the three *Sesbania* spp. and *S. rostrata* produced higher biomass on 65th and 85th day than *S. aculeata* and *S. speciosa*. *S. rostrata* under waterlogged condition produce more stem nodule than 100% moisture saturation (Table 4 and Fig.1). Similarly, all the three *Sesbania* spp. have recorded higher root nodule numbers under waterlogged condition. The senescence of root nodules and reduction in ARA in *S. rostrata* and the absence of senescence and increase in ARA in *S. aculeata* was observed as the plant ages. In general stem nodules have shown higher nitrogenase activity than root nodules. Dreyfus *et al.* (1985) have shown that the nitrogenase activity in stem nodules was 600 μ mol/h per plant in lowland rice field condition.

TABLE 1. Effect of Waterlogging on the plant height of three *Sesbanis* spp.

Treatments	Plant height (cm)								
	45 DAS			65 DAS			85 DAS		
	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
S.rostrata									
Waterlogging	15.5	79.2	94.7	24.2	145.1	169.3	26.7	187.7	214.4
100% MS	11.2	61.7	72.9	20.8	109.8	130.6	31.4	138.3	169.7
S. aculeata									
Waterlogging	16.2	85.2	101.4	22.9	143.6	166.5	29.6	164.6	194.2
100% MS	13.7	77.5	91.2	25.6	102.1	127.7	35.9	140.2	176.1
S. speciosa									
Waterlogging	16.7	68.3	85.0	21.9	139.4	161.3	27.6	159.3	186.9
100% MS	11.5	62.8	74.3	24.3	99.5	123.8	33.4	135.9	168.6
CD:	1.16	4.21	5.05	1.24	75.8	91.9	2.35	38.2	107.02

DAS : Days after sowing MS : Moisture saturation

TABLE 2. Effect of Waterlogging on the biomass production of three *Sesbanis* spp.

Treatments	Plant height (cm) X (Biomass t/ha)								
	45 DAS			65 DAS			85 DAS		
	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
S.rostrata									
Waterlogging	4.56	34.65	39.18	11.14	46.16	57.30	10.80	59.58	70.38
100% MS	4.43	31.38	35.81	9.61	38.79	48.40	12.14	47.60	59.74
S. aculeata									
Waterlogging	5.53	35.30	40.83	10.23	43.50	53.73	13.12	55.36	68.48
100% MS	5.52	30.95	36.47	7.73	32.97	40.70	12.19	44.90	57.09
S. speciosa									
Waterlogging	4.36	19.34	23.70	10.07	40.91	50.98	12.07	52.16	64.23
100% MS	4.36	18.11	22.47	8.01	31.39	39.40	10.04	44.83	54.87
CD:	0.23	1.04	1.27	0.52	4.50	3.80	3.65	3.12	2.95

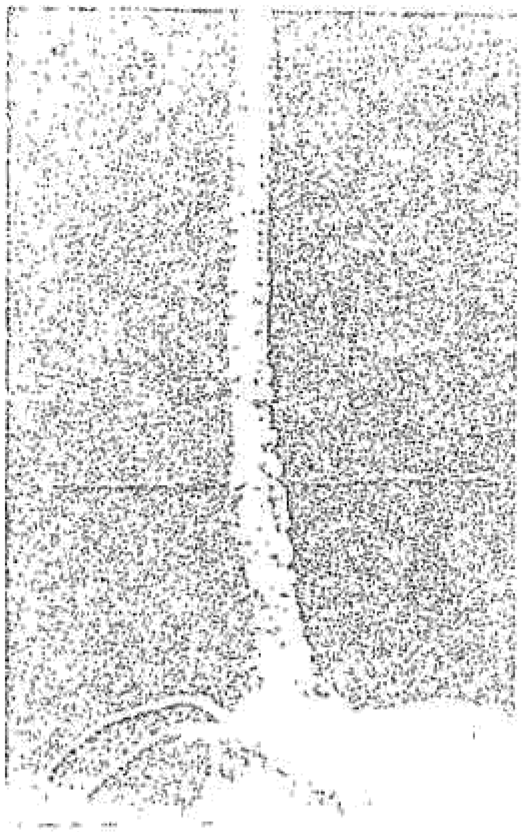

FIG. 1. STEM NODULE FORMATION IN *S. rostrata*.

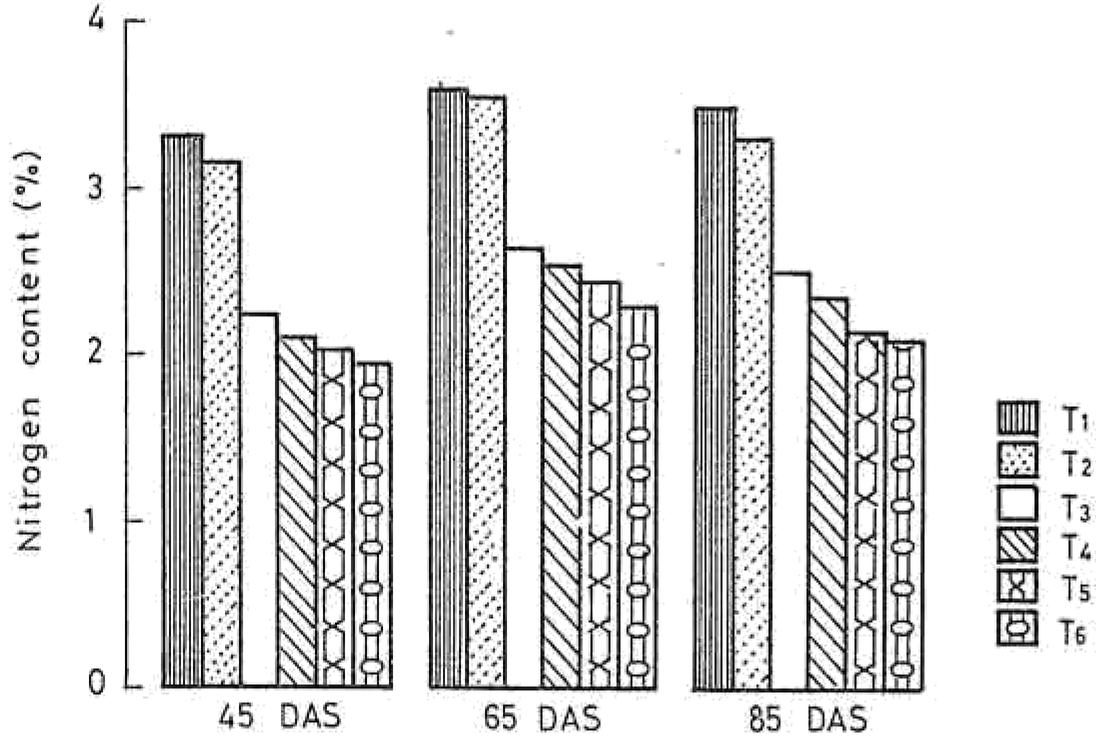

FIG. 2. EFFECT OF WATER LOGGING ON NITROGEN ACCUMULATION IN *Sesbania* spp.

TABLE 3. Effect of Waterlogging on dry weight of three *Sesbanis* spp.

Treatments	Plant height (cm)								
	45 DAS			65 DAS			85 DAS		
	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
S.rostrata									
Waterlogging	1.38	5.46	6.84	2.14	7.60	9.74	3.24	8.02	11.2
100% MS	1.66	4.68	6.34	2.27	5.69	7.96	2.94	7.20	10.14
S. aculeata									
Waterlogging	1.32	6.06	7.38	2.24	7.13	9.37	2.43	7.89	10.32
100% MS	1.12	5.49	6.61	2.07	5.09	7.16	3.81	6.33	10.14
S. speclosa									
Waterlogging	0.93	4.08	5.01	1.83	6.51	8.34	2.76	7.47	10.23
100% MS	0.79	4.18	4.97	1.84	5.43	7.27	1.94	7.30	9.24
CD:	0.02	0.34	0.44	0.25	0.35	0.54	0.52	0.89	0.87

DAS : Days after sowing MS : Moisture saturation

TABLE 4. Effect of Waterlogging on nodule number, dry weight and nitrogenase activity of three *Sesbanis* spp.

Treatments	45 DAS			65 DAS			85 DAS		
	Nodule (Number/ plant)	Nodule dry weight (g/plant)	Nitro-* (Number/ Plant)	Nodule (Number/ plant)	Nodule dry weight (g/plant)	Nitro-* (Number/ Plant)	Nodule (Number/ plant)	Nodule dry weight (g/plant)	Nitro-* (Number/ Plant)
S.rostrata stem									
Waterlogging	81.96	0.19	120.68	149.78	0.21	229.73	258.92	0.36	397.12
100% MS	79.04	0.15	114.38	128.23	0.19	194.63	225.19	0.37	339.40
S. rostrata root									
Waterlogging	19.30	0.08	91.98	40.85	0.12	143.16	12.90	0.06	61.67
100% MS	14.80	0.05	70.49	38.63	0.09	139.07	10.61	0.05	57.07
S. aculeata root									
Waterlogging	21.68	0.11	90.33	35.26	0.14	129.84	47.33	0.16	172.64
100% MS	11.97	0.06	49.86	30.33	0.11	122.12	60.72	0.19	179.62
S. speciosa root									
Waterlogging	15.34	0.05	63.45	23.66	0.10	99.29	71.03	0.24	207.54
100% MS	8.44	0.03	34.44	16.05	0.08	67.12	72.90	0.26	197.50
CD:	3.27	0.06	32.21	4.94	3.73	13.16	23.54	0.04	34.24

DAS : Days after sowing * n moles ethylene produced/g dry nodule nodule nodule/h.
MS : Moisture saturation

TABLE 5. Effect of Waterlogging on the Chlorophyll content of three *Sesbania* spp.

Treatments	Chlorophyll content (mg/g)								
	45 DAS			65 DAS			85 DAS		
	Chl-a	Chl-b	Total	Chl-a	Chl-b	Total	Chl-a	Chl-b	Total
S.rostrata									
Waterlogging	1.01	1.21	2.22	1.09	1.18	2.27	1.04	0.99	2.03
100% MS	1.05	0.86	1.91	1.08	1.17	2.25	1.03	0.94	1.97
S. aculeata									
Waterlogging	1.05	1.21	2.26	1.06	1.16	2.22	1.03	0.96	1.99
100% MS	1.01	1.21	2.22	1.17	0.97	2.14	1.08	0.88	1.96
S. speciosa									
Waterlogging	1.03	1.04	2.07	1.05	1.12	2.17	0.93	1.05	1.98
100% MS	0.93	0.86	1.79	1.13	1.01	2.14	1.02	0.84	1.86
CD:	0.14	0.05	0.84	0.17	0.45	0.89	0.97	0.06	0.99

DAS : Days after sowing MS : Moisture saturation

TABLE 6. Effect of waterlogging or Organic Carbon, Phosphorus and Potassium content of *Sesbani* spp.

Treatments	65 DAS					
	Organic carbon (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	C:N ratio
S. rostrata						
Waterlogging	21.24	0.50	1.42	1.14	0.91	5.97
100% MS	21.26	0.50	1.51	1.26	0.89	5.92
S. aculeata						
Waterlogging	23.83	0.53	1.18	1.39	0.89	8.99
100% MS	23.63	0.50	1.28	1.16	0.96	9.88
S. speciosa						
Waterlogging	23.84	0.52	1.61	1.01	0.76	9.88
100% MS	22.93	0.53	1.25	1.16	0.91	9.85
CD :	1.46	0.02	0.49	0.26	0.04	1.33

DAS : Days after sowing.

The total chlorophyll content was higher in all three species of *Sesbania* raised under water logged condition. *S. rostrata* recorded comparatively higher chlorophyll content on 45th, 65th and 85th day after sowing (Table 5). *S. aculeata* and *S. speciosa* recorded higher organic carbon and phosphorus content with wider C : N ratio.l While, *S. rostrata* accumulated higher potassium, calcium and magnesium with narrow C:N ratio (Table 6). Nitrogen accumulation was also significantly higher in *S. rostrata* (Fig.2). Furoc et al. (1985) reported fifty days old *S. rostrata*accumulated 3.14 per cent nitrogen under rice field condition. Organic matter with wide C : N ratio depresses the availability of nitrogen during decomposition while green manures like *Sesbania* with narrow C : N ratio could release major part of nitrogen within 40 days of incorporation (Ponnamperuma, 1972). Iron content in S. aculeata was found to be more while, S. rostrata accumulated high amount to manganese, zinc and copper (Fig.3). Zinc, copper and manganese content was higher at early stage of plant and decreased later.

Species of Sesbania have shown common ability to tolerate water logged condition. The results of biomass and dry weight suggests that for incorporation at 45 DA S. *S. aculeata* observed to be better than *S. rostrata* or *S. speciosa*. Only on longer duration the latter two species perform well. It is clearly shown that flooded condition increased biomass production, nodulation and nitrogen fixation in three species of *Sesbania* under waterlogged condition. The accumulation of major and micronutrient in all the three nitrogen fixing leguminous green manure crop was also enhanced.

ACKNOWLEDGEMENT

The senior author is thankful to the Indian Council of Agricultural Research, New Delhi for the financial assistance.

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Madras Agric. J. 79, (3) : 153 - 157 March, 1992

IMPACT OF MINIKIT DEMONSTRATION - AN ANALYTICAL STUDY

R. ANNAMALAI[1] and V. SEKAR[2]

ABSTRACT

Minikit demonstrations acted as medium of enriching knowledge and enhance adoption of practices though differential level of knowledge and adoption among small and marginal

1. Professor and Head, Dept. of Agrl. Extn. & Ru. Soc., TNAU, Coimbatore - 3.

2. Asst. Professor, KVK, Virudhachalam.