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RESPONSE OF THE PIGEONPEA (*CAJANUS CAJAN* (L.) MILLSPAUGH) TO NITROGEN APPLICATION AND TEMPORARY WATERLOGGING

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SUMMARY: Short-duration pigeonpea (*Cajanus cajan* (L.) Millspaugh, cv. ICPL 87)) responded to applied N by increasing its shoot and root growth in a Vertisol field at ICRISAT Center in India. However, growth of shoot and roots was impaired and N concentration in leaf was decreased by short-term (three days) waterlogging. During the recovery phase pigeonpea developed new adventitious roots around the base of tap root with new nodules. Therefore waterlogged pigeonpea had higher total nodule activity than control plants and there were no differences in N concentration in leaf at 40 days after the termination of waterlogging.

1 INTRODUCTION: Short-duration pigeonpea (*Cajanus cajan* (L.) Millspaugh), which has been recently released to farmers' fields in India, can complete its life cycle within the rainy season due to its early maturity. However, this type of pigeonpea has a high probability of suffering damage due to waterlogging in heavy soils such as Vertisols in the rainy season, and there is normally insufficient time for recovery to produce maximum seed yield.

The objectives of this study were to clarify the physiological and morphological responses of short-duration pigeonpea, especially of its root system, to temporary waterlogging. Besides waterlogging treatment, the effects of N application on short-duration pigeonpea were studied in this experiment, because available N content in the soil might interact with waterlogging.

2 MATERIALS AND METHODS: Short-duration pigeonpea (cv.ICPL 87) was planted on 13 June, 1990 in a Vertisol field at ICRISAT Center in peninsular India. The experimental field was divided into two main plots, control and waterlogged with three replications. Each main plot was divided into three subplots with basal N application rates of 0, 25 and 100 N kg ha-1 (hereafter referred as N0, N1 and N4, respectively).

Waterlogged subplots were bunded at the edges to retain standing water before the initiation of the waterlogging treatment, which was imposed at 54 days after sowing (DAS) and kept for three days. The water was allowed to drain away thereafter.

3 RESULTS: Shoot dry weight and N concentrations in leaf were increased by N application at the early growth and flowering stages (36 and 65 DAS, respectively). However, around the pod filling stage (96 DAS) total N content did not differ among N treatments and shoot dry weight was increased significantly only by the N4 treatment (Table 1).

Cumulative root length was not increased by N treatments at the early growth stage (36 DAS), while it was increased at 71 and 96 DAS, though the difference was not significant at 71 DAS (Table 1).

Temporary waterlogging decreased N concentrations in leaf and shoot dry weight in short-duration pigeonpea (Table 2). However, N concentration in leaf of waterlogged plants recovered at 40 days after treatment termination and there was no significant difference between control and waterlogging treatments. There were little significant interactive effects

Table 1. Effects of N application on the pigeonpea plants (Cv. ICPL 87) in Vertisol field.

Character	N treat.	Days after sowing		
		36	65	+96
Total shoot dry wt. (g/m^2)	N0	1.05	118	269
	N1	2.04	229	313
	N4	3.99	281	493
	SE	±0.03**	±26**	±29**
Total N concentration in leaf (g/kg)	N0	27.9	22.9	41.3
	N1	39.3	27.6	42.8
	N4	53.8	27.8	39.9
	SE	±3.9*	±1.4*	±1.8NS
Cumulative root length under a plant ($m/10^3 mm^2$)++	N0	0.30	0.59	1.66
	N1	0.28	0.54	2.21
	N4	0.29	0.90	3.08
	SE	±0.06NS	±0.03NS	±0.11*

Note: Values are means of three replicated control and waterlogged plots except for root length at the second and third samplings which were means of non-replicated control and waterlogged plots.

\+ Root samples were collected at 71 days after sowing.

++ Root samples were collected up to 40, 80 and 100 cm depth in the soil at 36, 71 and 96 days, respectively, after sowing.

Table 2. Effects of waterlogging on the pigeonpea plants (Cv. ICPL 87) in Vertisol field.

	Days after the termination of waterlogging			
	29+		40	
	Control	Water	Control	Water
Total shoot dry wt (g/m^2)	361	201	427	289
SE	±21*		±12**	
Total N concentration in leaf (g/kg)	36.6	28.1	42.1	40.1
SE	±1.3*		±1.5NS	
Cumulative root length under a plant ($m/10^3 mm^2$)++	0.86	0.50	2.34	2.29
SE	±0.1NS		±0.09NS	

Note: Values are means of N treatments with three replication except for root lengths which are without

\+ Root samples were collected at 15 days after the termination of waterlogging treatment.

++ Root samples were collected up to 80 and 100 cm depth in the soil at 15 and 40 days, respectively, after treatment termination.

between N and waterlogging treatments on N concentrations in leaf and total shoot dry weight, though both treatments were very influential in the growth of pigeonpea.

Effects of waterlogging on the root system of pigeonpea was observed about 2 weeks after the withdrawal of standing water. Cumulative root length under a plant was decreased by the temporary waterlogging at this stage (Table 2). However, at 40 days after termination considerable development of new adventitious roots was found near the base of tap roots in the shallow soil profile in the waterlogged treatment (Fig. 1). The cumulative root length of waterlogged plants did not surpass that of control plants at this stage (Table 2), due to the lower root length density in the deeper soil profile (data not shown).

Nodule activity was measured by acetylene reduction assay for samples of soil-root monoliths up to 30 cm depth at 43 days after the termination of waterlogging, since several new nodules were observed on the new adventitious roots. Total nodule activity per soil-root monolith was around five times higher for waterlogged plants at 0-10 cm depth under a plant (Table 3). Obviously the highest nodule activity was observed in the same position as the new adventitious roots.

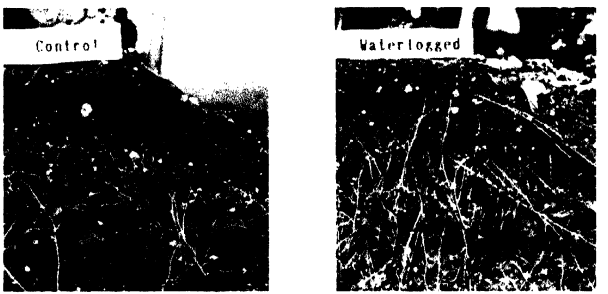

Fig. 1. Effects of waterlogging on the development of new adventitious roots at 40 days after the termination of treatments (96 DAS).

Table 3. Effects of waterlogging on the total nodule activity (C_2H_4 nmole/ monolith*/sec.) measured by acetylene reduction assay at 99 days after sowing.

Soil depth (cm)	Distance from a plant (cm)					
	Control			Waterlogging		
	0-10	10-20	20-30	0-10	10-20	20-30
0-10	139	24	29	666	75	1
	(52)	(5)	(13)	(298)	(12)	(0.4)
10-20	16	20	41	41	15	49
	(16)	(9)	(20)	(39)	(14)	(35)
20-30	46	29	13	2	38	3
	(11)	(4)	(2)	(0.4)	(6)	(0.1)

Values are means of three N treatments and those in parenthesis are standard errors of the means.
Size of a soil-root monolith is 15 x 10 x 10 cm in three dimensions.

4 **DISCUSSION**: The fertility of the Vertisol field used was estimated to be very low because of the low availability of N in the soil, generally less than 10 mg kg-1 throughout the growing season at N0 treatment (data not shown). Therefore, the positive response of short-duration pigeonpea to applied N was clear. Similar response to N application has been described earlier for medium-duration pigeonpea grown in Vertisol (Kumar Rao and Dart 1981).

The symptoms on pigeonpea caused by waterlogging were similar to those described for soybean, namely reduction of shoot and root mass and yellowing of leaves which is apparently attributed to decline in total available soil N levels (Nathanson et al., 1984) and decrease of nodule function (Sugimoto et al., 1989) in saturated soil. However, at 40 days after the termination of the waterlogging, new adventitious roots developed with new nodules, which resulted in the higher nodule activity and no difference in N concentrations in leaf between control and waterlogging treatments. This morphological change of pigeonpea root system is obviously one of the adaptations to the excess moisture in the soil.

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