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INFLUENCE OF MOISTURE STRESS AND NITROGEN ON GROWTH AND YIELD OF PEA AND SORGHUM

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C_4 plants are generally better adapted to high temperature and light intensity conditions. On the other hand C_3 plants perform better under low temperature and moderate light intensity conditions. There are reports on performance of these plants under stress conditions e.g. for pea (C_3) by Rao and Reddy (1973) and for sorghum (C_4) by Decock and Kirkby (1969). Influence of stress and form of nitrogen on CO_2 compensation point in pea and sorghum was reported by Chandra and Sirohi (1983). This report covers the influence of stress and form of nitrogen on dry matter production and yield of pea and sorghum in relation to their CO_2 compensation point at different stages of growth and development.

Sorghum (*Sorghum vulgare* Pers. cv CSV-5) and Pea (*Pisum sativum* L. cv EC 33886) plants were raised during summer and rabi, respectively, in pots; each pot contained 15 kg of air dry sandy loam soil. Main treatment consisted of normal watered non-stress series and stress series. Stressed plants were watered only when relative water content (RWC) (Barrs, 1968) of its leaves declined by 15-20% over control, beginning 15-20 days after sowing. The sub-treatments comprised nitrogen in two forms (as nitrate from potassium nitrate or ammoniacal from ammonium sulphate), applied at the rate of 20 kg/ha (200 ppm) and 40 kg/ha (400ppm). Nitrogen application was done at 4 different stages of growth. For plants under moisture stress, the nitrogen treatment was preceded by a period of moisture stress.

CO_2 compensation point was measured by the modified method of Sirohi and Srivastava (1978), which consisted of titrimetric analysis of CO_2 of an ambient air sample from a closed gas exchange system, after expiry of time when a steady state of equilibrium was attained. The apparatus consisted of an assimilation chamber (11.55 l) for an attainment of equilibrium of CO_2 concentration and an assembly for titrimetric analysis of CO_2 in air sample collected in a sample collector (a round bottom, air tight 500 ml flask) connected to assimilation chamber. Since there was not much difference in CO_2 compensation points due to concentration of nitrogen, the data were pooled.

In pea water stress, in general, reduced dry matter production at all stages in control as well as in nitrogen treated plants. Maximum reduction occurred at pod maturity stage (Table 1). However, per cent reduction due to stress was maximum with

Table 1 : Dry weight (g/plant) of above-ground parts of pea at various stages of growth and development. Figures in parentheses indicate per cent increase in dry matter over control by the nitrogen treatment
(a — non-stress; b — stress; c — per cent reduction due to stress)

Treatment	Seedling			Flowering			Pod formation			Pod maturity		
	a	b	c	a	b	c	a	b	c	a	b	c
Control	0.75	0.50	33.33	1.38	0.56	59.42	2.40	1.00	58.33	5.10	1.54	69.8
KNO_3	1.25	0.63	49.60	1.48	1.38	6.76	3.20	1.70	46.87	6.45	1.60	75.19
	(66.66)	(16)		(7.24)	(146.42)		(33.33)	(70.00)		(26.47)	(3.89)	
$(NH_4)_2SO_4$	1.37	1.00	27.00	2.37	2.00	15.16	3.60	1.30	63.88	7.05	2.70	61.70
	(82.66)	(100.00)		(71.74)	(257.14)		(50.00)	(30.00)		(38.23)	(75.32)	
CD at 5% level for sub-treatment	0.55			ns			0.285			ns		

Table 2 : Dry weight (g/plant) of above ground parts of sorghum at various stages of growth and development. Other details are same as in table 1. Figures in parentheses indicate per cent increase or decrease (—) in dry matter over control by the nitrogen treatment
(a — non stress; b — stress; c — per cent reduction due to stress)

Treatment	Seedling			Anthesis			Grain formation			Grain maturity		
	a	b	c	a	b	c	a	b	c	a	b	b
Control	7	3	57.14	21	11	47.62	22	12	45.45	35	13	62.85
KNO_3	15	4	73.33	26.5	13	50.94	26.5	14	47.17	42.5	17.5	58.82
	(114.29)	(33.33)		(26.19)	(18.18)		(20.45)	(16.66)		(21.43)	(34.61)	
$(NH_4)_2SO_4$	23.5	2.5	89.36	31.0	7.62	75.42	33.5	13.5	59.70	43	15	65.12
	(235.71)	(−16.66)		(47.62)	(−30.72)		(52.27)	(12.5)		(22.86)	(15.38)	
CD at 5% level for sub-treatment	ns			ns			1.83			1.57		

ammoniacal nitrogen treatment and minimum was seen at flowering stage. Under both stress as well as non-stress conditions, nitrogen treatment increased the dry matter at all stages. The increase in dry matter was more by the ammoniacal nitrogen treatment than by the nitrate nitrogen at all stages (except at pod formation under stress condition).

In sorghum, under non-stress conditions, increase in dry matter followed the some pattern as that of pea (Table 2). But under stress conditions the dry matter recorded with ammoniacal nitrogen treatment was lower than that with nitrate nitrogen treatment. Similar findings were reported by Rao and Reddy (1973) for pea and by Decock and Kirkby (1969) for sorghum.

Nitrogen application, in both nitrate and ammoniacal form, increased CO_2 compensation point over control (Table 3). At all stages ammoniacal nitrogen recorded higher CO_2 compensation point than nitrate nitrogen. Grossman and Cresswell (1973) attributed the increase in CO_2 compensation point in maize and sorghum to the increased growth, which in turn accelerated the demand for carbon compounds. The generation of the carbon compounds, they suggested, could be through glycolate metabolic pathway and the consequent release of CO_2 increasing the compensation point.

Sorghum maintained much lower CO_2 compensation point in comparison to pea (Table 3). The pattern of changes in CO_2 campensation point at different stages of growth and development was more or less similar for both crop plants. Stress invariably increased the CO_2 compensation point.

Under non-stress conditions, in pea nitrogen treated and control plants showed increased CO_2 compensation point (Table 3). Nitrogen in general increased dry matter (Table 1). Pod number and seed yield was maximum in ammoniacal nitrogen treated plants (Table 4). It was also noted that pod number was positively related to dry matter. In wheat, similar increase in yield with ammoniacal nitrogen was reported by Morris and Giddens (1963). However, increased per cent CO_2 compensation point, recorded in pea plant treated with ammoniacal nitrogen, did not reflect on per cent reduction in dry matter.

In pea, water stress in control plants reduced dry matter (Table 1) and increased CO_2 compensation point (Table 3), thus suggesting a negative influence of the latter on the former. Under stress conditions, ammoniacal nitrogen treated plants recorded maximum per cent reduction in pod number, though per cent reduction in dry matter was minimum. Thus increased dry matter did not increase pod number (Tables 1 and 4). Under stress conditions, it could be seen that the per cent reduction in dry matter was minimum over control though per cent increase in CO_2 compensation point was maximum (Tables 1 and 3). Thus, even under stress conditions increased CO_2 compensation

Table 3 : CO_2 compensation points (ppm CO_2) in pea and sorghum at different stages of plant growth. Figures in parentheses indicate per cent increase or decrease (—) over control by nitrogen treatment
(a — non-stress: b — stress)

Treatment	Seedling		Flowering		Pod formation		Pod maturity	
	a	b	a	b	a	b	a	b
			Pea					
Control	81	106	93	106	106	131	156	186
KNO_3	103	131	78	157	124	152	162	171
	(27.16)	(23.58)	(−16.13)	(48.11)	(16.98)	(16.03)	(3.85)	(−8.77)
$(NH_4)_2SO_4$	134	137	102	249	137	193	193	214
	(65.43)	(29.24)	(9.68)	(134.90)	(29.24)	(47.33)	(23.72)	(15.05)
CD at 5% level for for sub-treatment		11 55		15.18		8.8		16.18
			Sorghum					
Control	12	43	03	50	24	56	43	81
KNO_3	13	31	06	27	21	59	36	81
	(8.33)	(−27.90)	(100)	(46)	(−12.5)	(5.36)	(−16.28)	
$(NH_4)_2SO_4$	24	41	21	49	50	65	62	109
	(100)	(−4.65)	(600)	(−2.0)	(108.33)	(16.07)	(44.18)	(34.57)
CD at 5% level for sub-treatment		1.36		3.99		4.58		12.97

Table 4. Yield (g/plant) and yield component per plant of pea and sorghum in different treatments. Figures in parentheses indicate per cent increase or decrease (—) in yield or its components over control by nitrogen treatment (a — non stress; b — stress; c — per cent reduction due to stress)

Treatment	Pod number			**Seed weight (g)			**Seed (no./plant)			Grain yield		
	a	b	c	a	b	c	a	b	c	a	b	c
Pea												
Control	4.5	3.3	26.66	17.9	13.96	22.011	20.25	9.9	51.11	3.62	1.38	61.88
KNO_3	5.6	3.4	39.29	20.4	14.00	31.37	30.80	11.9	61.36	6.28	1.66	73.56
	(24.44)	(3.03)		(13.97)	(0.28)		(52.09)	(20.20)		(73.48)	(-20.28)	
$(NH_4)_2SO_4$	8.95	3.15	64.80	18.9	16.8	11.11	44.75	15.75	64.80	8.28	2.65	67.99
	(98.9)	(-4.5)		(5.58)	(20.34)		(120.98)	(59.09)		(128.72)	(92.08)	

Sorghum	*No. of seeds			**Seed weight (g)			Grain yield		
	a	b	c	a	b	c	a	b	c
Control	558	436	21.86	31	20	35.48	17.29	8.72	49.57
KNO_3	598	410	31.44	39	30	23.08	23.22	12.30	47.03
	(0.19)	(–5.96)		(25.80)	(50.0)		(34.29)	(–28.87)	
$(NH_4)_2SO_4$	617	310	49.75	36	26	27.78	22.21	11.92	46.33
	(10.57)	(–28.89)		(16.13)	(30.0)		(28.45)	(–31.06)	

*Per plant for pea, per ear for sorghum

**Per 100 for pea, per 1000 for sorghum

point did not reduce dry matter. Evidently, CO_2 compensation points did not directly influence the dry matter, pod number or seed yield in pea.

Interestingly, CO_2 compensation point decreased at the flowering stage (Table 3). This implied a very efficient CO_2 fixation when demand for carbon compounds is know to be high. Similar results were also obtained in gram and mung bean by Sirohi and Srivastava (1978).

In sorghum under non-stress conditions dry matter and CO_2 compensation point showed same trend as that in pea (Tables 2 and 3). Both dry matter and grain number were maximum in ammonia treated plants (Tables 2 and 4). Though maximum grain yield was noted in nitrate treatment, there was no statistically significant difference in grain yield between the two nitrogen treatments (Table 4).

Under stress conditions ammoniacal nitrogen treatment recorded maximum reduction in dry matter (Table 2). But there was no corresponding increase in CO_2 compensation point (Table 3). Thus reduction in CO_2 compensation point did not help in increasing dry matter (Tables 2 and 3). Reduction of dry matter with stress in sorghum was reported by Decock and Kirkby (1969).

Thus, both nitrate and ammoniacal nitrogen treatments increased dry matter and CO_2 compensation point. Their effects on CO_2 compensation point, however, differed depending on crop and stage of growth and development. It was also shown that increased CO_2 compensation point need not necessarily reduce dry matter production, seed/grain weight and yield. The reduction in dry matter and yield components was primarily due to stress effect and increased CO_2 compensation point might have only secondary effect.

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