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CP093

EFFECT OF NITROGEN AND WATER STRESS ON LEAF AREA DEVELOPMENT IN SORGHUM

M. SEETHARAMA, L.J. WADE[1/], J.M. PEACOCK, P.K. VERMA, T.J. REGO, AND SARDAR SINGH

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru P.O., A.P., 502 324, India.

1/ Permanent address: Department of Primary Industries, P.O. Box 81, Emerald, Queensland 4720, Australia.

ABSTRACT

The effects of nitrogen, water, and temperature on components of leaf area in sorghum [Sorghum bicolor (L.) Moench] grown on a Vertisol during the postrainy season at Patancheru, India are described. The combined effect of nitrogen and water stress reduced leaf area development, resulting in lesser radiation interception and lower crop yields. Nitrogen stress reduced yields more than water stress.

INTRODUCTION

The importance of leaf area in determining canopy photosynthesis and water used by a crop is well recognized. Although the effects of water supply and nitrogen fertilizer on the yield of sorghum [Sorghum bicolor (L.) Moench] are well documented, the effect of these factors and their interactions on leaf area development and duration has not been systematically investigated.

In this paper we report the effect of nitrogen and water supply on leaf emergence, expansion, and senescence in sorghum. Effects of environmental factors on leaf extension rates are also discussed.

MATERIALS AND METHODS

The experiment was conducted on a Vertisol (2-m deep) at ICRISAT Center during the postrainy season following an unfertilized maize crop grown in the rainy season. Approximately 13 kgs of NO_3 N was present in the top 120 cm of the soil before planting. Sorghum hybrid CSH-8R was sown on 23 Oct 1981, with plants 8 cm apart in 75 cm rows. The top 188 cm of soil contained 23 cm of available water. All the plots were fertilized with single superphosphate (26 kg P/ha). Nitrogen (main plots) and irrigation (subplots) treatments were applied in a split-plot design. Each treatment was replicated twice. The nitrogen treatments were:

i) N_0 : No urea applied

ii) N_{80} : 174 kg urea/ha incorporated before sowing.

The irrigation treatments were:

i) WET : 2 cm water at sowing and irrigations to recharge the profile at 30 and 50 days after sowing (DAS).

ii) DRY : No irrigation except 2 cm water at sowing.

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The time of emergence, time to full expansion (time of appearance of the ligule), and senescence of each leaf were monitored on alternate days in randomly selected eight plants from each plot. Leaf extension rates (LER) on 16 plants/plot were measured as described by Wade (1980). The interception of radiation by the crop (using the solarimeters), leaf area, and soil water content (by neutron probe) were measured at approximately 10-day intervals.

EXAMINATION OF THE EXPERIMENTAL DATA

Crop growth was affected more by nitrogen than by water supply (Fig.1). There was 23 cm of available water at sowing, and the evaporative demand during the season was low (about 4 mm/day), therefore the DRY treatment suffered only mild water stress during the later part of the season.

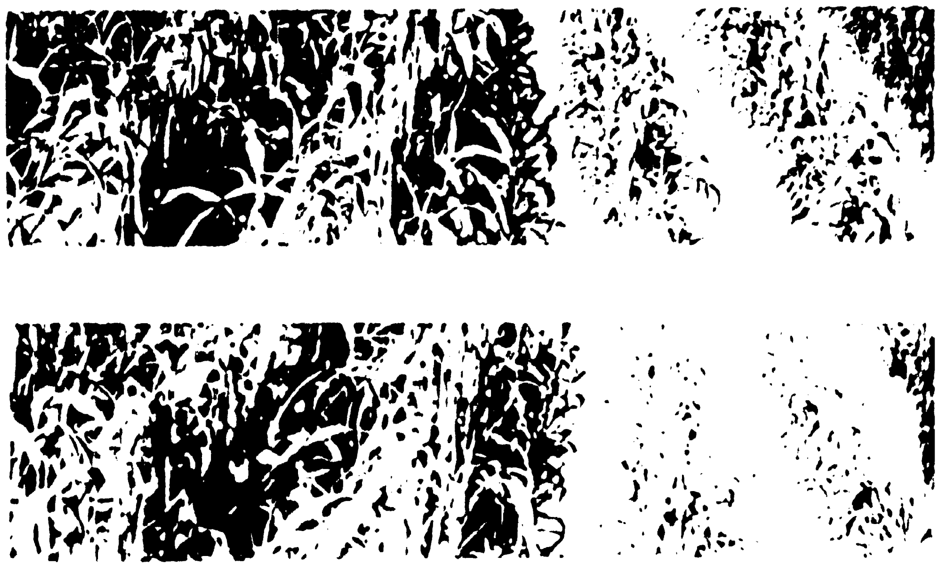

Fig.1. The effect of nitrogen and water on sorghum development 60 days after sowing under the following treatments:
A. 80 kg N/ha; Irrigation (N_{80} WET) B. No nitrogen, Irrigation (N_0 WET)
C. 80 kg N/ha; No irrigation (N_{80} DRY) D. No nitrogen, No irrigation (N_0 DRY)

Leaf number and emergence (Fig.2)

In the N_{80} WET treatment, 15 leaves were produced in 57 DAS; the N_{80} DRY required 2 days longer, but produced the same number of leaves. Only 14 leaves were produced under N_0 in 72 and 74 DAS, with and without irrigation (N_0 WET and N_0 DRY), respectively. Individual leaves of N_0 plants took 13 (leaf 4) to 20 (leaf 14) more days to emerge than those under N_{80}.

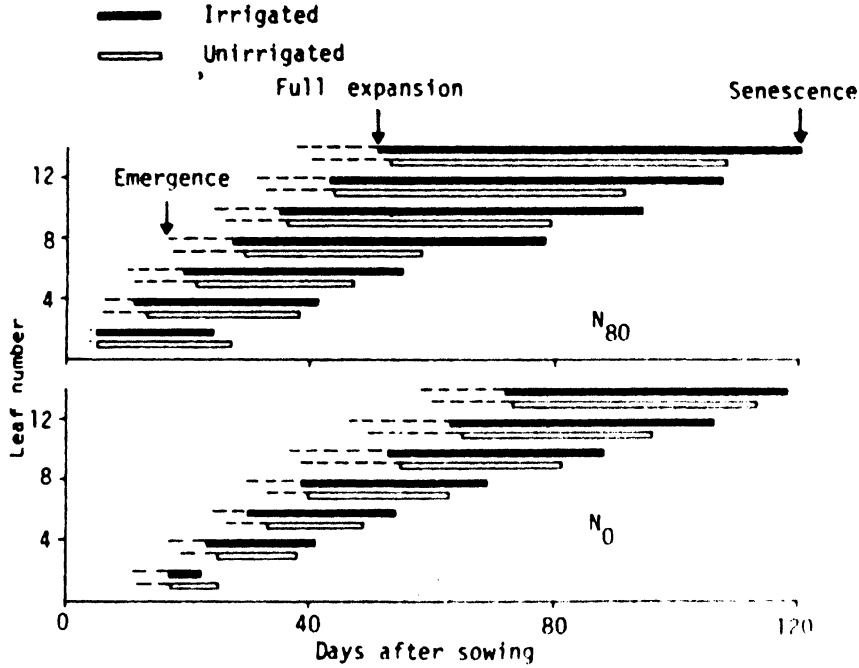

Fig.2. Time of emergence, full expansion, and longevity of leaves under different irrigation treatments. [Only alternate (even) leaves are shown; there were 15 leaves under N_{80} and 14 under N_0].

Duration of expansion, senescence, and longevity of leaves (Fig.2)

Under nitrogen stress, the duration of leaf expansion was also 1 and 4 days longer for leaf 4 and 12, respectively, than under N_{80} WET. The longevity of leaves under N_0 was drastically reduced to 2-25 days less than under N_{80}. Thus N_0 plants always had 1-2 less green leaves than N_{80} throughout the season. The duration of extension was unchanged under water stress, which, however, reduced the longevity of leaves more under N_{80} than under N_0.

Leaf extension rates (LER; Fig.3)

In the grasses, when nitrogen and water stress are absent, leaf area development is largely determined by the temperature (Peacock 1975). Diurnal LER closely followed the temperature in all treatments. N_{80} WET showed highest LER. Nitrogen stress had a greater effect in reducing LER than water stress since the latter stress was quite mild. Regression of LER on temperature was highly significant for all treatments ($P < 0.01$). Regression estimate of LER at 25°C in N_0 WET was 49% lower than in N_{80} WET; it was only 40% lower in N_{80} DRY. Nitrogen and water stress together reduced LER by 56%.

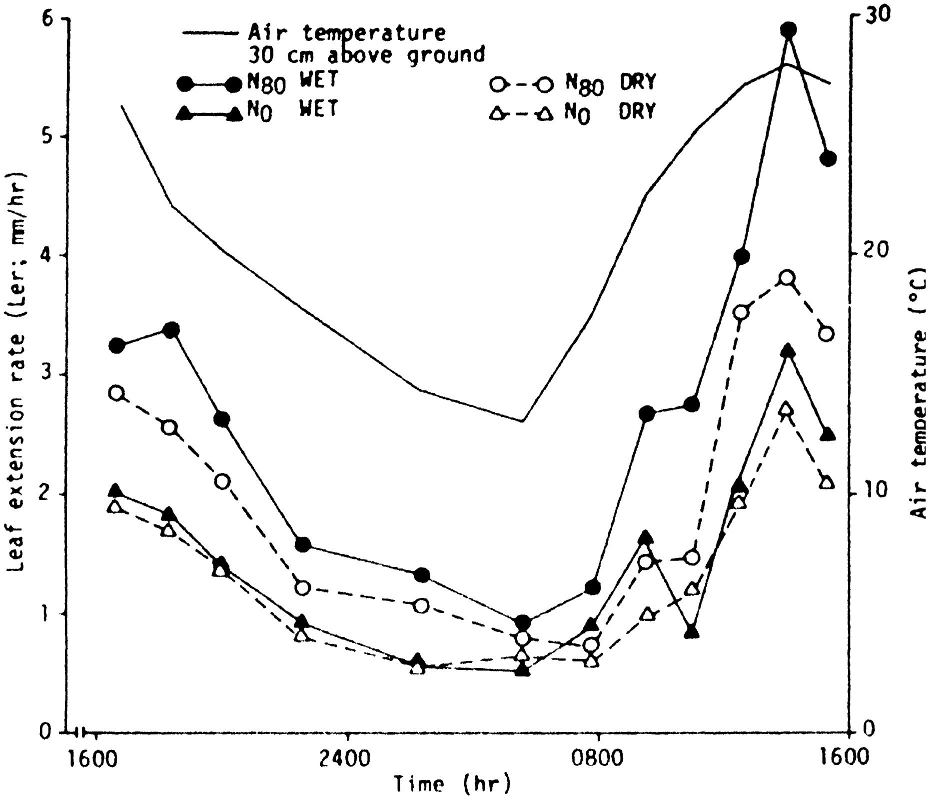

Fig.3. Diurnal variation in leaf extension rates and air temperature 40 days after sowing.

Leaf area profile (Fig.4)

The maximum area of each leaf is a product of duration of leaf expansion, LER, and leaf width (Wade 1980). Individual leaf area was affected more by nitrogen than by water, which was apparent frou the fifth leaf onwards.

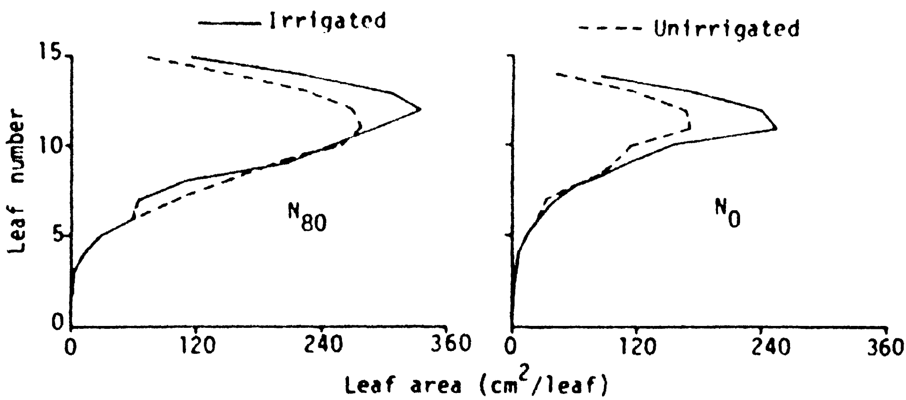

Fig.4. Area of individual leaves under different irrigation treatments

Leaf area index (LAI) and radiation interception (Fig.5)

The combined effect of area per leaf and number of green leaves determines the LAI. This was drastically reduced under nitrogen stress, and less so under water stress, from 40 DAS. Consequently, the intercepted radiation (IR) was also low under N_0 (Fig. 5B). N_0 DRY showed highest reduction in LAI and IR.

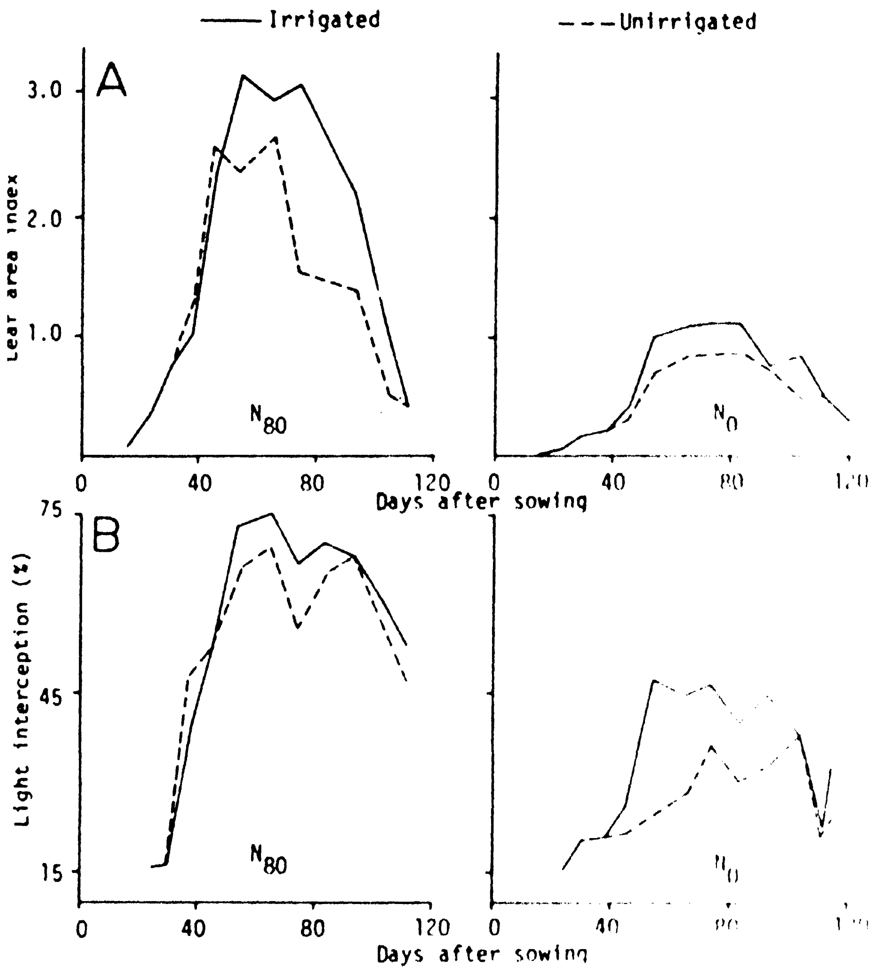

Fig.5. Seasonal changes in (A) leaf area index, and (B) light interception under different irrigation treatments.

Dry matter and grain yields (Table 1)

Crop maturity was significantly delayed by both the stress factors, but nitrogen stress delayed it longer than water stress. The effects of water stress on grain and dry matter yields, and leaf area duration were significant ($P < 0.05$) only under N_{80}; effects of water stress on these variables were less clearly seen under nitrogen stress. However, the total radiation intercepted by the canopy for the whole season was significantly reduced only under N_0.

The extension of crop growth duration in N_0 by 12 days did not compensate for the reduction in total dry matter and grain yield at harvest due to stress. Dry matter yields were highly correlated with leaf area duration and seasonal total intercepted radiation ($r = 0.94$ and 0.88, respectively; $P < 0.01$). The efficiency of conversion of radiation into dry matter was highest under N_{80} WET; conversely, nitrogen and water stress decreased this efficiency. Grain yields were reduced in a higher proportion than biomass under both kinds of stress, although nitrogen stress effect was more severe than water stress.

TABLE 1

Effect of nitrogen and irrigation treatments on maturity, yields, leaf area duration (LAI days) and radiation interception.

Nitrogen treatment	N_{80}		N_0		LSD (0.05)	
Irrigation treatment	WET	DRY	WET	DRY	Fertility	Irrigation
Days to maturity	107	101	119	115	6.4	1.5
Total dry matter (t/ha)	9.1	5.6	3.8	2.8	3.3	1.1
Total grain yield (t/ha)	5.0	2.5	1.5	1.1	0.8	0.8
Leaf area duration (LAI days)	182	138	69	55	11	15
Seasonal radiation interception (mJ/m^2)	949	903	632	489	130	75
Dry matter/radiation interception (g/mJ)	0.96	0.62	0.61	0.56	0.17	0.14

CONCLUSIONS

1. Nitrogen, and not water, was the major limiting factor in the postrainy season at Patancheru when sorghum was grown on a Vertisol with 23 cm of available water in the profile following unfertilized maize in the rainy season.
2. The yield reductions under the experimental conditions were clearly connected with reduction in leaf area mainly due to nitrogen stress.

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ZINC DEFICIENCY INDUCED CHANGES IN CABBAGE

C.P. SHARMA, P.N. SHARMA, S.S. BISHT, B.D. NAUTIYAL

Botany Department, Lucknow University, Lucknow, India

ABSTRACT

Cabbage (*Brassica oleracea* L. var. Capitata L. cv. Pride of India) grown at 0.001 μM zinc supply in sand culture developed zinc deficiency effects that were manifest both externally and internally. Compared to normal plants grown at 1 μM zinc supply, leaves of zinc deficient plants were small, thick and leathery, had thick epicuticular wax deposition, appeared dark bluish green and a large proportion of their stomata remained closed; mesophyll cells contained larger and more numerous chloroplasts and starch grains. Zinc deficiency resulted in decrease in the tissue concentration of zinc and activities of carbonic anhydrase and adenosine triphosphatase and marked increase in the concentration of sugars, starch, and soluble nitrogenous compounds including proline. Zinc deficiency caused marked increase in water saturation deficit, and decrease in water potential and rate of water loss by leaves. On supplying zinc to zinc deficient plants, changes in metabolism and water balance resulting from zinc deficiency underwent reversal.

INTRODUCTION

Zinc is essential for plants and has been attributed a greater diversity of roles than any other micronutrient. It is an essential requirement for over 70 enzymes belonging to all the six categories, and performs an important regulatory role in stabilisation of structure at the subcellular level (Vallee 1977). It has recently been attributed a role in reproductive physiology (Sharma et al 1979). In this paper we examine the effect of zinc stress on water balance of plants and some other aspects of metabolism having a bearing on water stress (Spencer & Possingham 1960, Cockburn et al 1968, Singh et al 1973).

MATERIALS AND METHODS

Cabbage (*Brassica oleracea* L. var. Capitata L. cv. Pride of India) was grown in sand culture (Agarwala & Sharma 1976) at 1 μM (normal) and 0.001 μM (deficient) zinc supply. Plants were maintained under glass-house conditions during October–February on nitrate type solutions, supplied daily around 8 a.m. At three months growth, microscopic examinations were made of transverse sections and microrelief impressions of lower epidermis of leaves of zinc deficient plants showing visible symptoms and corresponding leaves of normal plants. The microrelief impressions of lower surface of leaves were made with Quickfix adhesive made by Wembley Laboratories, New Delhi. The replica were mounted in dilute glycerine and