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EFFECTS OF WATER TABLE DEPTH AND CALCIUM PERIOXIDE APPLICATION ON COWPEA (*VIGNA UNGUICULATA*) AND SOYBEAN (*GLYCINE MAX*)

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Key words

Calcium peroxide Cowpea Soybean Water table depth

Summary

The effects of three water table (WT) depths (0, 15 and 40 cm) and calcium peroxide (Calper) on the growth and yield of cowpea (*Vigna unguiculata*, L.) and soybean (*Glycine max*) were investigated in field lysimeters for a sandy loam soil. Cowpea growth was the best at 40 cm WT depth. Leaf area, plant height, dry matter production, number of leaves and pods, grain yield and consumptive water use of cowpea increases with deeper (lower) WT depth. Application of calcium peroxide improved per cent emergence, leaf area, dry matter, number of leaves and pods, weight of 100 seeds, grain yield and water use in cowpea. The optimum WT depth for vegetative growth of soybean was 15 cm, although the highest grain yield was obtained at 40 cm WT depth. Number of pods, grain yield and water use efficiency of soybean increased with deeper water table depth. Application of calcium peroxide to soybean increased number of leaves and pods per plant, and grain yield for the 15 cm WT depth treatment.

Introduction

Leguminous plants subjected to poor drainage conditions exhibit symptoms of reduced nodulation and cortication, early senescence, decline in seed protein content and reduced N uptake, root decay and disintegration, hypertrophic main stem above the water line, and delayed branching[6]. These symptoms attributed to waterlogging may be due to hormonal and nutrient imbalance caused by anaerobiosis[2,3,4]. Structural instability of soils in the tropics, caused by low soil organic matter content and impacting raindrops, impedes surface drainage during periods of frequent rains and even the upland crops suffer from poor aeration conditions for variable lengths of time. The objective of this study was to investigate the effects of different water table depths on cowpea and soybean, and whether the adverse effects of waterlogging can be alleviated by soil application of some oxygenating compounds.

Materials and methods

These experiments were conducted at the International Institute of Tropical Agriculture (7°26′ N, 3°54′ E) during the dry season from December 1979 to March 1980. Field lysimeters were constructed

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by using 220-liter drums (58 cm in diameter and 83 cm deep). These drums were buried in trenches flush with the ground surface. Lysimeters were filled with the surface soil from 0–20 cm layer of the Apomu soil series (Psammentic Ustorthent). The soil is of sandy loam texture with weak fine crumb structure, pH 6.3 (1 : 1 in water), and has organic carbon content of about 2.0 per cent[5]. A 5-cm layer of washed quartz gravel was placed at the bottom of the drum, and a 3-cm diameter perforated rigid plastic pipe was installed in the middle to regulate the water table depth. Soil was packed in the drum at a bulk density of 1.4 $g cm^{-3}$. Twelve seeds of soybean (TGN-294-4) and cowpea (Vita 5) were seeded concentrically 15 cm from the central tube. Soybean and cowpea seeds were inoculated with rhizobium culture.

Water table (WT) at 0 (W_0), 15 (W_{15}), and 40 (W_{40}) cm depth was maintained with an inverted bottle technique (Wien et al., 1979). A 5-liter bottle filled with water was inverted on the central perforated tube. A rubber tubing connected to a glass tubing through a hole drilled in the bottle stopper was inserted in the central perforated tube in the lysimeter. The length of the rubber tube determined the depth of the free water surface maintained in the lysimeter. The bottle was refilled twice daily. The oxygenating compound, calcium peroxide (Calper) was applied at 0 (C_0) and 4 kg/ha (C_1) at seeding. Necessary precautions were taken to avoid direct seed contact with calper. The oxygenating compound was mixed in the surface 5-cm layer. Both cowpea and soybean received an equivalent of 100 kg/ha of 15 : 15 : 15 compound fertilizer. Seedlings were thinned to 4 per lysimeter 2-weeks after emergence. All treatments were replicated thrice, and allocated according to the completely randomized design.

Periodic measurements were made for plant height and leaf area. Consumptive water use was monitored daily from the amount of water used from each mariotte bottle. Yield and yield components were monitored at maturity.

Results and discussion

Seedling emergence, plant growth, and vigour

The seedling emergence of cowpea and soybean was maximum at 15-cm WT depth. Application of calcium peroxide significantly improved cowpea emergence at 0 and 40 cm WT depths, and only slightly at 15 cm WT depth. Soybean emergence was significantly low at 0 cm compared with other WT depths. Application of calcium peroxide improved soybean emergence at 0 cm WT and decreased for 15 and 40 cm WT depths (Table 1).

Plant height measured 8 weeks after seeding indicated significant differences due to treatments (Table 1). Soybean seedlings died within 2 weeks after emergence for the 0 cm WT treatment without calcium peroxide application. The plant height in soybean was maximum for the 15 cm WT treatment, and the application of calcium peroxide resulted in an increase in plant height. Plant height of cowpea was also significantly affected by the WT depth and was highest for the 15 cm WT depth. Cowpea height increased significantly with the application of calcium peroxide for the 0 cm WT depth treatment only (Table 1).

Leaves of plants grown at 0 cm WT depth showed chlorotic symptoms. Leaf area and leaf number measured 6 weeks after seeding followed a general pattern similar to that of plant height, although the maximum leaf area and number in cowpea was observed at 40 cm WT depth. Application of calcium peroxide increased leaf number and area for all WT depths both in soybean and cowpea (Table 1).

Dry matter production measured 11 weeks after seeding was also different among treatments. Application of calcium peroxide significantly increased dry matter production in cowpea for 15 and 40 cm WT depths. The beneficial effect of calcium peroxide in dry matter production of soybean was rather slight (Table 1).

Table 1. Effects of water table depth and calcium peroxide on growth and vigour of cowpea and soybean

Treatment	Emergence (%)		Plant height (cm)		Leaf area/plant (dm^2)		Leaf number/ plant		Dry matter (g/plant)	
	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean
W_0C_0	44.4	8.3	9.8	0	2.5	0	21	0	1.3	0
W_0C_1	72.2	19.4	12.6	25.2	4.2	3.0	27	24	3.1	2.7
$W_{15}C_0$	83.3	44.4	86.4	40.4	33.2	17.7	93	50	21.1	7.7
$W_{15}C_1$	91.7	36.1	78.9	42.9	53.3	19.7	109	58	36.2	8.4
$W_{40}C_0$	47.8	25.0	80.9	30.7	47.3	11.9	123	50	39.7	7.8
$W_{40}C_1$	80.6	19.4	70.3	38.0	54.7	13.4	137	71	49.9	8.6
LSD (.05)										
(i) C	12.2	15.5	9.8	5.3	5.8	4.5	–	–	6.9	2.3
(ii) WT	15.2	19.0	12.0	5.3	7.1	5.6	–	–	8.5	2.8
(iii) Treatment	21.3	26.9	17.0	7.4	9.9	7.9	–	–	12.0	3.4

W_0 = 0-cm water table depth; W_{15} = 15-cm water table depth; W_{40} = 40-cm water table depth; C_0 = Control; C_1 = 4 kg/ha calcium peroxide.

Grain yield and yield components

Grain yield components of cowpea and soybean were significantly affected by water table depth. The highest and the lowest grain yields were obtained at the 40 and 0 cm WT depth treatments, respectively. The application of calcium peroxide also increased grain yield. The increase in grain yield in treatments with deep WT depth was reflected in an increase in number of pods/plant and to some extent in the unit grain weight. Number of pods/plant was maximum at the 40 cm WT depth and generally increased with calcium peroxide application (Table 2).

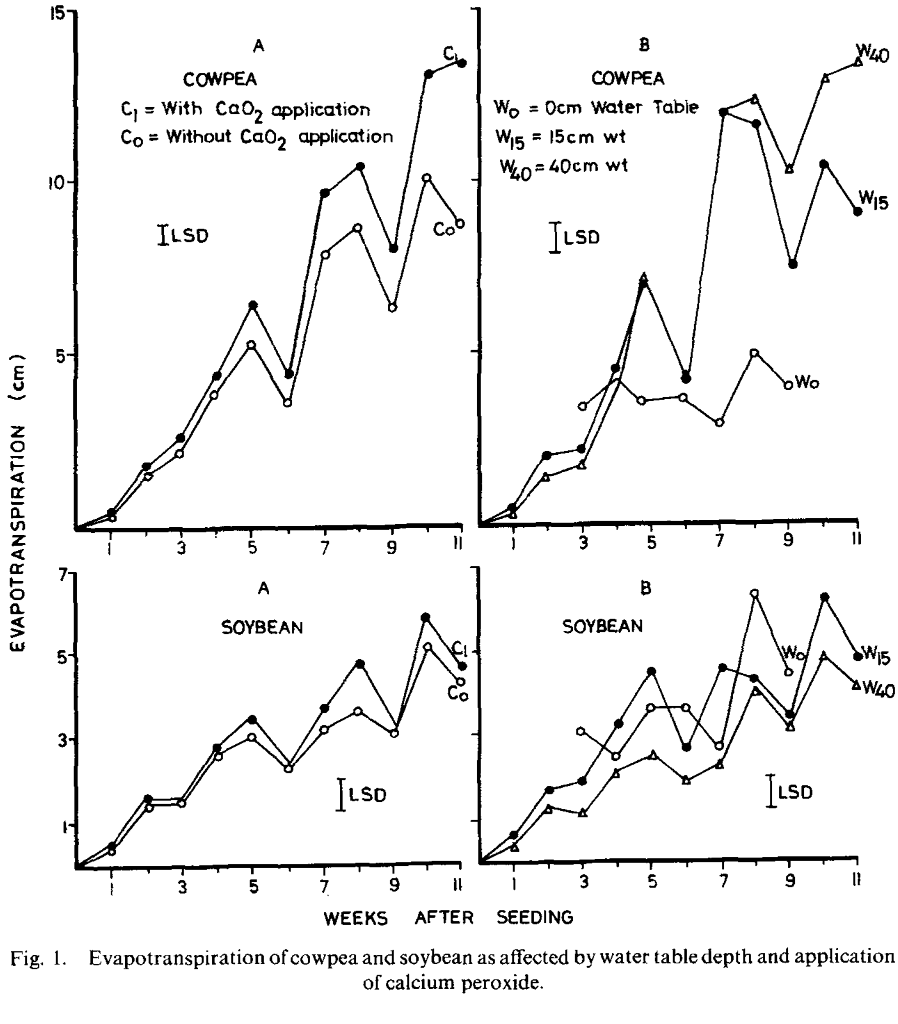

Fig. 1. Evapotranspiration of cowpea and soybean as affected by water table depth and application of calcium peroxide.

Table 2. Grain yield and yield components of cowpea and soybean as affected by water table depth and calcium peroxide application

Treatment	Grain yield (g/plant)		Pods/plant		Weight of 100 grains (g)		Water use efficiency (g/cm)	
	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean
W_0C_0	0.1	0	0.3	0	8.4	0	0.01	0
W_0C_1	1.4	0.7	1.8	9.0	11.2	6.6	0.12	0.07
$W_{15}C_0$	18.9	2.9	16.2	17.3	13.0	9.0	1.31	0.32
$W_{15}C_1$	24.3	5.4	19.2	25.1	13.1	10.5	1.19	0.56
$W_{40}C_0$	26.5	4.5	22.5	23.2	12.3	10.1	1.45	0.72
$W_{40}C_1$	27.8	5.6	26.0	29.8	12.9	9.9	1.32	0.74
LSD (.05)								
(i) C	3.4	1.9	3.1	5.7	0.6	2.3	0.31	0.20
(ii) WT	4.2	2.3	3.4	7.0	0.7	2.8	0.38	0.30
(iii) Treatment	5.9	3.3	5.4	9.8	1.0	4.0	0.53	0.40

W_0 = 0-cm water table depth; W_{15} = 15-cm water table depth; W_{40} = 40-cm water table depth; C_0 = Control; C_1 = 4 kg/ha calcium peroxide.

Water use efficiency (WUE) and evapotranspiration

Evapotranspiration was proportional to vegetative growth and therefore increased with calcium peroxide application (Fig. 1). In cowpea, the evapotranspiration was in the order of 40 cm WT > 15 cm WT > 0 cm WT depth, although there were no significant differences due to water table depth in soybean (Fig. 1). Water use efficiency, measured as grain yield/cm of water/plant was significantly affected by the WT depth treatments (Table 2). In soybean, the maximum WUE was observed for the 40 cm WT depth, and was more with CaO_2 than without it (Table 2). In cowpea the water use efficiency was improved by the CaO_2 application for the 0-cm WT depth treatment only.

Conclusions

Shallow WT depth has an adverse effect on growth and development of cowpea and soybean even in coarse textured sandy soils. Some of the adverse effects are attributable to low oxygen availability in the root zone since the application of oxygen generating compound improved growth and yield for the shallow WT depth treatments. The results of the effects of oxygen deficiency in root zone on soybean and cowpea would have been more conclusive if measurements were also made of the oxygen content in soil air. The effects of calcium itself as a nutrient supplied in calper cannot be isolated in this study since its effect may be confounded with the increased supply of oxygen.

These results can have significant agronomic implications. For improving germination and seedling establishment in poorly drained soils, a small amount of oxygen generating compound can be coated on the seed. Alternatively, the compound can also be mixed with fertilizer and applied as top dressing or harrowed in the surface layer prior to seeding. Band application of fertilizer mixed with oxygen generating compound may give better results than broadcast application. A considerable agronomic research needs to be conducted to develop a suitable package.

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References

1 Burford, J. R. and Greenland, D. J. 1970 Denitrification under an annual pasture. Proc. Eleventh Int. Grassl. Conf. Univ. Queensland Press, St. Lucia, Queensland.: 59–61.
2 Cannel, R. Q. 1979 Effects of soil drainage on root growth and crop production. *In* Soil Physical Properties and Crop Production in the Tropics. Eds. R. Lal and D. J. Greenland. J. Wiley and Sons, Chichester, U.K.
3 Hong, T. D. *et al.* 1977 Recovery of nodulated cowpea plants (*Vigna unguiculata* L. Walp) from waterlogging during vegetative growth. Plant and Soil **48**, 661–672.
4 Lal, R. and Taylor, G. S. 1969 Drainage and nutrient effects in a field lysimeter study, II. Mineral uptake by Corn. Soil Sci. Soc. Am. Proc. **34**, 245–248.

5 Moormann, F. R. *et al.* 1975 Soils of IITA. IITA Tech. Bull. **3,** 48 p.
6 Wien, C. *et al.* 1979 Effects of transient flooding on growth and yield of some tropical crops. *In* Soil Physical Properties and Crop Production in the Tropics. Eds. R. Lal and D. J. Greenland. J. Wiley & Sons, Chichester, U. K.