Potassium fertilization in relation to plant water potential of wheat

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Abstract. 'The water potential of wheat plants increased during the mid-day noon, probably as an adaptation; the rise was greater with less frequent irrigation and was increased by KCl application.'

A high rate of potassium application and thus uptake, induces water uptake and depresses the osmotic potential of root cells. The uptake of water by roots and the ability of the plant to exploit soil water depend on K^+ status of the plant [12]. K^+ is an important osmoticum which drives the water flux from the surrounding cells into the xylem vessels [2]. The root pressure, which can be of importance for the upward movement or organic and inorganic solutes, is much controlled by the plant's K^+ nutritional status.

Potassium also plays an important role in stomatal opening and closure [5]. Convincing evidence for this essential K^+ effect has been provided by electron probe analysis studies [8] which showed that the increase in turgor in the guard cells associated with stomatal opening resulted from an increase in K^+ concentration in the cells. The role of K^+ in stomatal opening is very specific, and other univalent cations are generally unable to replace K^+ in this function. The subject of ion transport in stomatal guard cells from the view point of chemi-osmotic theory has been discussed by Zeigler *et al.* [16].

Potassium is also a major osmotically active component in other plant cells contributing to cell turgor and enhancing the capacity of plant cells to retain water. In this function K^+ seems to be of particular importance in young tissues. Turgor in young leaves has a direct effect on the size of cells and on the growth rate of the entire plant [1, 7]. This beneficial effect of K^+ is of particular importance in practical crop production, since K^+ reduces water loss by transpiration [4] and thus the water use efficiency is increased [3, 11].

The present experiment was designed to investigate the plant water potential of wheat var. Siete Cerros as affected by irrigation and KCl levels and the diurnal fluctuations in water potential in Kadawa (Irrigation Research

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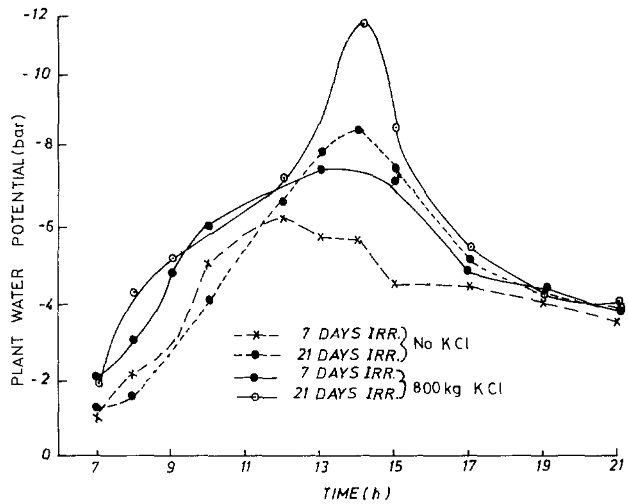

Figure 1. Diurnal fluctuations in plant water potential of wheat var. Siete Cerros at flowering as affected by irrigation and KCl-fertilization

Station, Kano State, Nigeria) soils (original soil available K^+ status = 90–100 mg kg^{-1} determined by the method described by Hanway and Heidel [9] at the flowering stage of the crop. The factors K^+ level (0, 400 and 800 kg KCl ha^{-1}) and frequent or delayed irrigation (7, 15 and 21 days intervals, 5 cm surface applied water) were introduced. Effect of the treatments on plant water potential was determined.

Materials and methods

Wheat (*Triticum aestivum* (L.) em, Thell.) var. Siete Cerros grains were sown in microplots (8 m x 6 m) at the Kadawa Irrigation Research Station, Kano State, Nigeria, located at 11°39′N and 8°27′E with an annual rainfall of 830 mm, mean maximum temperature of 29–30 °C and mean minimum temperature 13–17 °C during the wheat growing season. During this period, ground water table fluctuates between 90–120 cm and the water requirement of the wheat crop ranges between 600–800 mm. The farm soil is classified as Eutric cambisol (FAO/UNESCO) and Typic Ustropept (soil taxonomy) class. It is formed by fine sandy aeolian deposit and moderately to poorly drained to a depth of 95 cm. The surface soil and soil profile of the experimental site has been described by Ojanuga *et al.* [13] as loam to fine sand showing a weak fine crumb structure.

The crop was fertilized according to the recommended practice for this area (120 kg N, 26.2 kg P ha^{-1}) except that KCl was supplied at three rates – nil, 400 kg and 800 kg ha^{-1}. Three irrigation frequencies were maintained, viz. 7, 15 and 21 days (5 cm water per irrigation).

Plant water potential was monitored at the pre-boot stage by sampling the

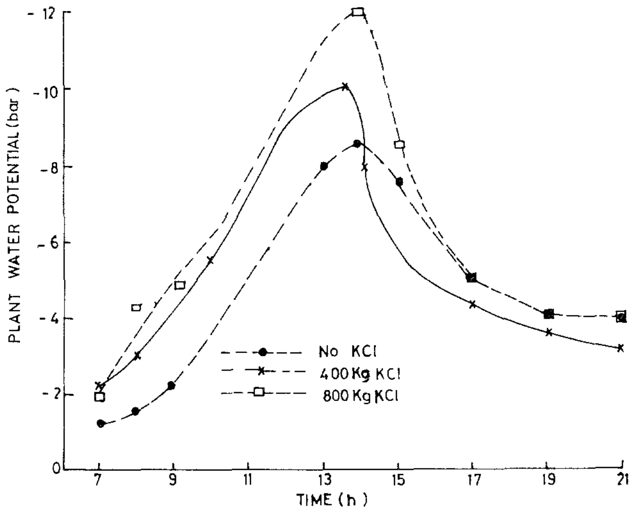

Figure 2. Diurnal fluctuations in plant water potential of wheat var. Siete Cerros grown under 21 days irrigation interval and KCl levels

mother shoot from the second internode. The modified pressure chamber technique described by Scholander *et al.* [14] and Frank and Harris [6] was followed.

Results

Plant water potential, generally, started with a lower level in the early hours (7 h) of the day, reached the peak value during the mid-day sun (13 h) and then decreased gradually, though until 21 h it was still higher than the initial value at 7 h (Figure 1). The mid-day rise in water potential increased with increased moisture stress (21 days irrigation interval as against 7 days) as an adaptation. Application of 800 kg KCl ha^{-1} maintained the plant water potential higher throughout the day as against no KCl receiving plants. The rise was more spectacular during the mid-day period especially when irrigation was delayed.

Further, when irrigation was less frequent (21 days interval), it became clear that the effect on plant water potential of wheat plant was proportional to KCl application-rate, especially from 7–13 h, as an adaptation to moisture stress (Figure 2). However, with 400 kg KCl ha^{-1}, the rise in plant water potential was not as great and the adaptation is incomplete, as during the later half of the day, i.e. after 13 h, the plant water potential values fell below the no KCl-applied control.

Discussion

The observed increase in plant potential is probably due to the involvement of K^+ in stomatal movement [5, 10]. It could also be due to the effect of associated Cl^- which is known to cause halosucculence in plants [8, 15]. Further experiments will be needed to separate the K^+ effect from Cl^-.

References

1. Arneke W (1980) PhD Thesis, F. Blg, Justus Liebig University, Giessen
2. Baker DA and Weatherley PE (1969) J exp Bot 20, 485–496
3. Blanchet R, Studer R and Chaumont C (1962) Ann agron Paris 13, 99–110
4. Brag H (1972) Physiol Plant 26, 250–257
5. Fischer RA and Hsiao TC (1968) Plant Physiol 43, 1953–1958
6. Frank, AB and Harris DG (1973) Agron J 65, 334–335
7. Green JF and Muir RM (1978) Physiol Plant 43, 213–218
8. Gupta US (1977) In: Physiological Aspects of Crop Nutrition and Resistance, pp 311–360. Atma Ram & Sons, New Delhi
9. Hanway JJ and Heichel H (1952) Iowa Agric 57, 1–31
10. Humble GD and Raschke K (1971) Plant Physiol 48, 447–453
11. Linser H and Herwig K (1968) Kali Briefe 9, Fachgeb 2(2)
12. Mengel K and Kirby EA (1980) Adv Agron 33, 59–110
13. Ojanuga AG, Valette J and Khawaja IA (1979) Seventh Annual Joint Meeting of the National Soil Correlation Committee and Soil Science Society of Nigeria, Kano, 21–27 October, 1979
14. Scholander PF, Hammel HT, Bradstreet ED and Hemmingsen EA (1965) Science 148, 339–346
15. Strogonov BP (1964) 'Physiological Basis of Salt Tolerance of Plants', Translated and edited by Pojakoff-Mayber A and Mayer AM, Monson, Jerusalem
16. Zeigler E, Bloom AJ and Hepler PK (1978) What's New in Plant Physiol 9, 29–32