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EFFECT OF VARIOUS MOISTURE TENSIONS ON YIELD AND NUTRIENT UPTAKE BY SOME CEREAL CROPS

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Effect of low, medium and high moisture tensions on yield and nutrient uptake by wheat, barley and oat plants was studied to know the economic water levels for optimum nutrient absorption from soils. Both straw and particularly the grain yields of crops were severely reduced (8 –16 % and 25 – 41 % respectively as the avialable water supply was diminished from medium or high to low. However, the severity in the reduction of crop yields became milder (9 – 11% in grain and 3 – 5% in straw) as the available water was curtailed from high to medium.

The concentration of nutrient elements in plants grown in any moisture tension generally decreased with time and increased with the rise in the moisture tension. Otherwise, the concentration of nutrient elements in each crop plant was inconsistently affected by changes in the moisture tension. Generally, the contents of nutrient elements, except that of Fe and Mn, decreased with the fall in water supply. Iron and Mn contents, however, showed opposit trends.

INTRODUCTION

Water is mostly applied in abundance than required by crops. In this way, water is not only unnecessarily wasted but also some crops are deprived of this vital life–component. This causes a tangible losses in crop production. It, therefor, strongly suggests that accurate water applications which help in optimum nutrient absorption by plants should be ascertained. Since a specific water content is very difficult to maintain in the soil due to continuous removal of water by plants and evaporation (Viets, 1967), the crop response to water changes can be studied by comparing one water content against another by careful growth measurements and chemical analysis of plants.

This study was planned to obtain information on the effect of selected soil moisture tensions on growth and nutrient uptake by wheat, barley and oats.

MATERIAL AND METHODS

The experiment was laid out on a 31 m x 9 m piece of land which was divided into three main plots, each measuring 9 mx 7.2 m, representing three moisture tensions viz. low, medium and high. It meant that the soils were irrigated when 75, 50 and 25% of the water at field capacity remained in the soils respectively. The plots were made 4.7 m apart from one another to check water movement among plots. The main plots were divided into three sub–plots each measuring 9.2 m x 2.4 m. The plots were uniformly fertilized at 67 kg / ha with 11–48–0 fertilizer. Wheat (Manitou), barley (Betzes) and oats (Rodney) were sown in sub-plots at a seed rate of 100, 90 and 95 kg/ha respectively. The experiment could not be replicated due to the shortage of level land.

A common lawn sprayer with a precalculated discharge was used for irrigation. When the required moisture tension for the respective plots was approached, the irrigation was applied. The moisture tensions, determined by tensiometer, were regularly checked. The growing season precipitation was 7.25 cm. In this way, the crops grown in high moisture tension received 30.75 cm, in medium 54.25 cm and in low 77.75 cm irrigation water over the growth period.

The soil of the experimental field was neutral in reaction and moderately fine

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in texture. It had 5.5 ppm NO_3– N, 6.6 ppm olsen's $NaHCO_3$ extractable –P, 204.2 ppm NH_4OAC extractable–K and 1.7% Walkley and Black's organic matter determined by their respective procedures as explained by Jackson (1965).

Plant samples were collected at mid–tillering, boot and ripening stagesof growth; corresponding to 30, 52 and 100 days after seeding respectively. Grain and straw yields were recorded at maturity. Plant samples were washed, dried in an oven at 70°C and ground to pass through a 20 mesh sieve. The concentrations of P, K, Ca, Mg, Zn, Mn, Fe and Cu in plants, using dry ashing technique, were determined by emission spectrography at the Ohio Plant Analysis Laboratory, Ohio, U.S.A . Zinc, Mn, Fe and Cu concentdration in plants were cross–checked by digesting in HNO_3–$HC10_4$ acid misxture (Jackson,1965) and measuring their concentrations in the digests on an atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield: The results (Table 1) showed that grain yield of crops was reduced by about 35 and 41% in wheat, 25 and 34% in barley and 30 and 37% in oats as the available water dropped from high and medium to low supply and loss drastically reduced (wheat 9%, barley 11% and oats 9%) when it decreased from medium to low level. Adequate available water in soil facilitates growth, in cereals (Bourget and Carsom 1962, Fulton and Findlay 1966, Mack 1965) and forage crops (Bourget and Carson 1962).

The reduction in straw yield (Table 1) was 16, 13 and 12% in whát , barley and oat plants respectively as the moisture tension increased from low to high, and 5,4 and 3% as it increased from low to medium level. Similar effects of moisture fluctuations on crop production have been reported by Fulton and Findlay (1966). It has generally been noticed that crops grown in low and medium moisture tension did not so much vary in grain and particularly the straw production as that grown in low or medium and high moisture tension. Possibly the yield production factors below 50% of the available water at field capacity greatly lose their working efficiency since there is a close relation between water content and rate of photosynthesis as well as starch and sugar accumulation in plants.

Nutrients: Concentration: Irrespective of moisture tensions and plant species, concentration of all the nutrient elements in plants mostly decreased with time due possibly to the dilution effect resulting from the increased accumulation of dry matter by plants (Table 2 and 3).

Phosphorus concentration in plants generally increased, as also reported by Fawcett and Quirk (1960), with increasing moisture tension at mid–tillering stage (Table 2). It may be attributed to concentrative effect due to the reduction in yield resulting from increasing moisture tension. This

Table 1. Effect of various moisture tensions on the yield of wheat, barley and oat plants.

Moisture Tension	Yield, kg/ha					
	Grain			Straw		
	Wheat	Barley	Oats	Wheat	Barley	Oats
Low	3310	3439	*1931	4648	3186	4914
Medium	3021	3040	1745	4396	3063	4767
High	1915	2273	1223	3927	2791	4348

*Manipulated values.

trend in respect of P concentration in plants at boot and ripening growth stages was not strictly followed. The crops did not, however, much vary in P absorption as also observed by Barber (1960), particularly during the later growth stages of plants grown with various water levels. Each crop had its own trend in respect of K concentration when grown at various moisture tensions (Table 2). Though K concentration in various plants fluctuated with moisture tensions but it did not show any regular trend as reported by Barber (1960). Calcium concentration in wheat at mid–tillering and boot stages, due possibly to concentrative effect, increased with reducing water supplies (Table 2). This trend was reversed at the ripening stage. In barley, there was not much difference at any growth stage in Ca concentration of plants particulary those grown in low or medium tension although it decreased with high moisture tension. In oats Ca concentration was not affected at the mid–tillering but it increased at the boot and ripening growth stages with diminishing water supply. Similar effects of moisture tensions on Ca concentration in various plants have been reported by Cannell *et al.* (1960), Kilmer *et al.* (1960) and Moss (1964). The concentration of Mg in plants, irrespective of growth stages, generallly increased with increasing moisture tension (Table 2) possibly due to the concentrative effect as reported by Charian *et al.* (1968).

Similary, Zn concentration in wheat and barley plants, irrespesctive of the growth stages, increased with declining water levels (Table 3). Probably the reduction in crop yield, owing to the fall in water supply, exerted this effect on Zn concentration as reported by Cannell *et al.* (1960) and Moss (1964). In oat plants, Zn concentration was not affected with changing moisture tensions. Manganese concentration in wheat, barley and particulary the oat plants at the various growth stages was mostly increased with increasing moisture tensions (Table 3). However, in barley plants at mid–tillering stage Mn concentration was not affected with changing moisture supplies. The resultls are partially supported from the findings of Cannell et al. (1960). Except in barley and oats at mid–tillering stage where Fe concentration in plants was slightly depressed with rising miosture tensions, the concentration of Fe in all the plants, irrespective of growth stages, was increased with enhancing moisture tensions (Table 3). Somewhat similar findings have been reported by some other workers (Moss 1964, Veits,1967).Copper concentration was noticed to be least affected with the fluctuations in water regimes.However, it generally increased inconsistently with increasing moisture tension as also observed by Kubota *et al.* (1963).

GENERAL DISCUSSION

Water and mineral nutrients are so interdependent in their effects on growth and reproduction of plants that one cannot be considered without the other during their movement in the soil, absorption by the roots and translocation in the plants (Veits, 1967). Deficiency of one nutrient can impair the absorption of others by plants, resulting in the restriction of plant development.

Adequate availability of water, facilitating the transport of ions in the soil through diffusion and mass flow (Barber, 1960) is thus of great significance to the plants' need for the ability to absorb nutrient and soils' ability to supply them (Kee and Bloom field 1962, Veits 1972).

In a dry soil, thickness of watar around the soil particles is diminished thus increasng the shearing strength of soil. This restricts ion movement and root elongation in the soil (Barley, 1963). Some ions like, NH_4, K, PO_4, Zn and Cu are adsorbed on clay particles in the dry soil. These conditions may hamper nutrient availability and their uptake by plants (Moss 1964, Rehman *et at.* 1971), though other investigators have

Table 2. Effect of various moisture tensions on P, K, Ca and Mg concentration at differentgrowth stages of wheat, barley and oat plants

Moisture tensions	+Growth stages											
	M	B	R	M	B	R	M	B	R	M	B	R
	P			K			Ca			Mg		
	Concentration, mg/g											
Wheat												
LoW	2.6	1.9	3.0	31.2	22.0	6.8	1.7	1.0	2.4	1.6	1.2	1.4
Medium	4.6	2.4	1.7	41.0	15.6	10.8	2.9	1.5	1.4	2.3	1.5	1.6
High	4.0	2.0	1.8	33.8	20.3	7.8	2.7	1.3	1.3	2.0	1.9	1.4
Barley												
Low	4.1	2.3	2.0	39.6	20.4	8.2	5.2	3.2	2.1	2.6	1.9	1.6
Medium	4.4	2.7	2.0	33.6	23.7	11.1	5.3	3.3	2.0	3.0	2.5	1.7
High	4.5	*	2.2	34.4	*	14.4	3.6	3.1	1.6	2.5	2.2	2.3
Oats												
Low	6.4	2.3	*	40.4	27.5	*	3.3	1.7	*	2.8	1.7	*
Medium	5.0	2.7	1.9	37.8	26.4	21.9	3.2	1.7	1.5	2.7	1.7	1.5
High	6.8	2.0	2.1	45.5	31.2	18.2	2.1	2.1	2.2	2.8	2.9	2.2

+ M–mid–tillering, B–boot and R–ripening growth stages.

Table 3. Effect of various moisture tensions on Zn, Mn, Fe and Cu concentration at different growth stages of wheat, barley and oat plants

Moisture tensions	⁺Growth stages											
	M	B	R	M	B	R	M	B	R	M	B	R
	Zn			Mn			Fe			Cu		
	Concentration, µg/g											
Wheat												
Low	16	13	18	43	43	41	89	31	50	7	5	5
Medium	26	15	12	56	42	29	193	47	47	7	5	5
High	26	21	13	50	48	38	179	52	106	7	6	4
Barley												
Low	27	14	13	45	27	15	171	43	65	7	5	5
Medium	31	20	16	42	28	19	155	51	63	7	6	5
High	28	16	25	42	18	29	166	55	189	7	6	6
Oats												
Low	32	14	*	80	57	*	241	48	*	8	5	*
Medium	25	14	14	64	61	42	177	36	50	7	5	6
High	32	13	15	73	65	62	191	61	95	9	5	5

+See Table 2 for codes, * data not available.

found reverse results (Fawcett and Quirk,1960, Rehman *et al.* 1971). Water in excess either percolates, if internal drainage is good, taking along soluble ions like NO_3, Cl, SO_4, K, Ca and Mg or waterlogs the soils thus creating reduced conditions (Veits, 1967). The latter cause the concentrations of NH_4, P, Fe, Mn and perhaps Mo to increase in soil solution, NO_3 to denitrify and SO_4 to reduce to H_2S (Kee and Bloomfield, 1962). An excess soil water content should favour, due to more thickness of water around the soil particles, the nutrient uptake by plants. On the other hand, it may restrict plant growth, due to poor aeration, and nutrient uptake, as a result, may be depressed (Viets'1967, Wadleigh and Richard 1951). Consequently, the growth and nutrient uptake by plants are affected accordingly.

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