Don't Stress Your Wheat for Water!

*by A. D. Day & Suhbawatr Intalap**

Soil moisture is important in the growth and development of all agricultural plants. Normal growth may be restricted by either deficient or excessive water at any stage of growth. In tropical, humid regions there is usually sufficient moisture for cultivated crops. However, shortages of irrigation water may occur in low rainfall areas or in arid regions, where water has a dominant influence on crop production.

Economic use of water is a vital problem which confronts farmers and agricultural scientists in irrigated areas. This problem is becoming more

**Agronomist and former graduate student, Department of Agronomy.*

Table 1. Inches of water applied per acre to Maricopa wheat at the preplanting, tillering, jointing, flowering, and dough stages of growth at Tucson, Arizona in 1966 and 1967.

Irrigation treatment	*Pre-planting*	*Tillering*	*Jointing*	*Flowering*	*Dough stage*	*Total*
Optimum irrigation	6	3	4	5	4	22
Plants stressed for water at the jointing stage	6	3	2*	5	4	20
Plants stressed for water at the flowering stage	6	3	4	4*	4	21
Plants stressed for water at the dough stage	6	3	4	5	0	18

* *The amounts of water applied during these stages of growth were applied after the plants showed visible wilting for seven days.*

Table 2. Average grain yield, grain volume-weight, number of days from planting to flowering, number of days from planting to maturity, plant height at maturity, and lodging at maturity for Maricopa wheat grown under four irrigation treatments at Tucson, Arizona in 1966 and 1967.

Irrigation treatment	*Grain yield (lb/acre)*	*Grain volume-weight (lb/bu)*	*Days from planting to flowering (day)*	*Days from planting to maturity (day)*	*Plant height at maturity (in.)*	*Lodging at maturity (%)*
Optimum irrigation throughout the growing season	**5626 d†**	**61.9 c**	**116 b**	**176 b**	**40 c**	**6 a**
Plants stressed for water at the jointing stage	**2951 a**	**60.2 b**	**110 a**	**177 b**	**33 a**	**26 c**
Plants stressed for water at the flowering stage	**3237 b**	**60.0 b**	**116 b**	**169 a**	**39 b**	**11 b**
Plants stressed for water at the dough stage	**3568 c**	**56.8 a**	**117 b**	**168 a**	**39 b**	**11 b**
C. V. (%)	**8.75**	**0.89**	**0.55**	**0.54**	**0.93**	**6.05**

† *Means followed by the same letter are not different at the 5% level of significance.*

acute as the area of irrigated land throughout the world increases. A knowledge of the optimum time to apply limited amounts of water to obtain maximum yields of high quality plant products is essential. Most of the spring wheat grown under irrigation in the United States is planted in March or April and is harvested in July and August. In southern Arizona wheat is normally planted in November or December and harvested in May or June of the following year. Since spring wheat is grown under irrigation during the winter months in Arizona, its most critical period of growth may differ from that of spring wheat grown in other states.

Materials and Methods

Soil moisture stress at different periods during the growth of spring wheat planted in December were studied under field conditions for a two-year period (1966 and 1967) at Tucson, Arizona. General cultural practices for wheat in Arizona were followed throughout the experiment. The soil was Gila sandy loam with a field capacity of 14.5 percent and a permanent wilting point of 5.8 percent. A green manure crop of Guar was grown during the summer and plowed under when it was 36 in. high. The land was then disked, harrowed, bordered, and irrigated to saturate the soil to a depth of 5 ft. Seventy lb. of elemental nitrogen per acre were applied prior to planting. Seventy-five lb. per acre of seed of the wheat cultivar 'Maricopa' were planted in moist soil, with a grain drill, 1.5 in. deep, in December. Grain was harvested at maturity in June of the following year.

A randomized block design with four replications was used to compare four irrigation treatments as follows: (a) optimum irrigation water applied throughout the growing season, (b) plants stressed for water at the jointing stage for a period of seven days (plant-stress determined by visible wilting) but irrigated normally throughout the other stages of growth, (c) plants stressed for water at the flowering stage for a period of seven days but irrigated normally throughout the other stages of growth, and (d) plants stressed for water from the dough stage to maturity but irrigated normally throughout the other stages of growth. The amount of water applied in flood-type applications in each of the four irrigation treatments was measured and is shown in Table 1. Irrigation water was applied when 65 percent of available soil moisture had been used. Soil moisture was determined from samples taken with a soil probe. Average precipitation during the wheat growing season in 1966 and 1967 was 2.0 in.

The following data were obtained from 0.01-acre plots surrounded with sufficient wheat to eliminate border effects: (a) number of days from planting to flowering (flowering was when 50 percent of the heads had exposed anthers), (b) number of days from planting to maturity (maturity was when the grain had 14 percent moisture), (a) plant height at maturity (plant height was distance from ground level to tip of spike, exclud-

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ing the awns), (d) lodging percentage at maturity (percentage of plants broken or bent 45° or more), (e) grain yield (grain moisture about 14 percent), and (f) grain volume-weight. In 1967, plots 0.0001-acre in size were used to determine the three grain yield components: (a) number of heads per unit area, (b) number of seeds per head, and (c) seed weight. All data were analyzed using the standard analysis of variance and treatment means were compared using Duncan's multiple range test.

Earlier Flowering

Plants stressed for water at the jointing stage of growth flowered earlier than plants grown in any other irrigation treatment (Table 2). Similar results have been reported for winter wheat. This observation may be helpful to wheat breeders who are interested in crossing early and late varieties. If late varieties are stressed for water at the jointing stage, it may be possible to make them flower earlier.

Earlier Maturity

Plants stressed for water at the flowering and dough stages of growth matured earlier than plants grown in the other two treatments (Table 2). This may be because the consumptive use of water by wheat is highest during these stages. Plants grown with optimum irrigation and plants stressed for water at the jointing stage matured at the same time. It is evident that earlier maturity of wheat may be caused by soil moisture deficit during seed development.

Shorter Plants

Plants stressed for water at the jointing stage were shorter than plants in any other treatment (Table 2). Withholding water at the flowering and dough stages resulted in plants of the same height. Tallest plants occurred with optimum irrigation. When cereal grains are stressed for water during the vegetative and flowering stages, shorter plants are obtained as a result of lower soil moisture absorption, lower soil nutrient uptake, and reduced photosynthesis.

More Lodging

Lodging occurred during the period from flowering to maturity. Wheat stressed for water at the jointing stage lodged more than when it was grown with any other treatment (Table 2). This may be because withholding soil moisture during jointing prevented normal development of upper crown roots and resulted in weaker plants. When water was withheld at the flowering and dough stages, it resulted in more lodging than when optimum irrigation was applied.

Lower Grain Yield

Stressing wheat for water at the jointing, flowering, and dough stages of growth significantly reduced grain yields, compared with optimum irrigation (Table 2). The greatest reduction in grain yield occurred when soil moisture was withheld at the jointing stage, followed by moisture stress at the flowering and dough stages, in decreasing order. When wheat was stressed for water at the jointing stage, the reduced grain yield was produced by fewer heads per unit area and fewer seeds per head (Table 3). However, when irrigation was withheld at the flowering and dough stages, lower grain yields were caused, primarily, by lighter seeds (Table 3).

Lower Volume-Weight

Moisture stress at the dough stage resulted in the greatest reduction in grain volume-weight, followed by withholding irrigation water at the flowering and jointing stages, in decreasing order (Table 2). Wheat stressed for moisture at the flowering and dough stages had fewer days from flowering to maturity than wheat grown with optimum irrigation, and it had less time for carbohydrate accumulation in the developing seeds.

Jointing Stage Most Critical For Water

The most critical period for moisture in the growth of spring wheat planted in December was the jointing stage of growth. However, optimum irrigation must be provided throughout the entire growing season for maximum yields of high quality grain.

Table 3. Average number of heads per unit area, number of seeds per head, and seed weight for Maricopa wheat grown under four irrigation treatments at Tucson, Arizona in 1967.

Irrigation treatment	*Heads per 0.0001 acre (no.)*	*Seeds per head (no.)*	*Weight of 1,000 seeds (g)*
Optimum irrigation throughout the growing season	**99 b†**	**31 b**	**42 b**
Plants stressed for water at the jointing stage	**74 a**	**26 a**	**40 ab**
Plants stressed for water at the flowering stage	**100 b**	**28 ab**	**35 ab**
Plants stressed for water at the dough stage	**96 b**	**31 b**	**33 a**

† *Means followed by the same letter are not different at the 5% level of significance.*