Pak.J.Bot., 31(1): 109-114, 1999.

EFFECT OF DROUGHT SIMULATION ON GRAIN WEIGHT, PROTEIN AND LYSINE CONTENT OF BREAD WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

Effect of drought simulation (terminal, preanthesis, postanthesis and full irrigation) on grain weight, protein and lysine content in different strains of bread wheat viz., Chakwal, Pavon, AZS-4 and AZS-17 was studied under field conditions. Water stress especially terminal and postanthesis decreased ($P \leq 0.05$) grain weight, whereas protein and lysine content significantly ($P \leq 0.05$) increased. Correlation between grain weight and protein content was negative and highly significant ($r = -0.672$, $n=16$). Reduction in endosperm due to water deficit could be the probable cause for lower grain weight and enhanced protein content.

Introduction

In Pakistan water is one of the main limiting factors for crop production. This is specifically true in rainfed areas which constitute 17% of total wheat acreage (Anon., 1997). The areas near tail-end of canals also face problem of chronic water shortage. Water stress is therefore a major factor for low wheat yields (Bouzerzour & Oudina, 1990). Water stress not only modifies the morphology of plant but also severely affects its metabolism (Brocklehurst *et al.*, 1978; Innes & Blackwell, 1981; Nicolas *et al.*, 1985; Ober *et al.*, 1991; Khan *et al.*, 1993). The extent of modification depends on the genotype, developmental stage, duration and intensity of water stress. Grain quality is an important consideration in wheat production programmes because it affects the final consumer products. However, protein content and its quality are major factors and are useful to characterize wheat quality (Orth *et al.*, 1976). The present report describes the effect of water stress on grain weight and their protein and lysine contents in bread wheat (*Triticum aestivum*).

Materials and methods

Four genotypes of bread wheat *Triticum aestivum* L., viz., Pavon, Chakwal, AZS-4 and AZS-17 were tested under simulated drought resistance. The experimental site was divided into 12 plots each measuring 120m^2 (12m x 10m). Individual plots were separated by three meter buffer zone on each side to avoid seepage. The experiment was laid out in split plot design with water regimes in main plots and genotypes in subplots with three replicates. The desired irrigations (75mm each) were applied through water meter fitted on mobile diesel pump. The preplanting irrigation was applied on November 8th with subsequent irrigations as and when required. The following conditions were imposed to simulate the type of drought stress experienced and expected to occur in the rainfed areas as well at the tail-end of canals:

(a) Normal (four) irrigations as recommended for wheat (control).

(b) One irrigation at anthesis stage (preanthesis drought).

(c) One irrigation at tillering stage (postanthesis drought).

(d) No irrigation during the entire crop season (terminal drought). Protection from rain was provided by manually operated shelter equipped with movable sheet of white flexible plastic.

The land was well prepared and fertilizers applied @ 70:35 N:P kg ha^{-1}. The seed was hand drilled and was thinned in the seedling stage to obtain a stand of 320 seedlings/m^2. Each genotype consisted of four rows, 5 meter long, spaced 0.25 meter apart and seeded @ 100 kg ha^{-1}. One hundred grain weight was recorded in gram. Wholemeal flour was used for analytical purpose and protein contents were determined by Udy dye binding capacity (DBC) method (Udy, 1971). Lysine contents were estimated by a modified DBC method (100 mg flour, 0.45 mg/ml dye concentration) (Khan, 1978); results were expressed as % protein. The data were statistically analyzed using analysis of variance (ANOVA) and Duncan's Multiple Range Test was used to delineate mean differences (Steel & Torrie, 1980). Coefficient of correlation (r), coefficient of determination (r^2) and regression (b) between weight and protein content of wheat grains was calculated, regression equation computed and regression line drawn (Steel & Torrie, 1980).

Results and Discussion

Grain weight: Results on the effects of simulated drought conditions on the grain weight of various wheat strains are given in Table 1. Full irrigation and irrigation at anthesis had statistically similar mean 100-grain weight, but when irrigation was provided earlier at tillering stage and then it was followed by the water stress, the grain weight was significantly reduced. Complete stress (no irrigation) showed significant reduction in the grain weight.

Varieties also differed significantly in their mean 100 grain weight. AZS-17 showed maximum grain weight followed by AZS-4, Pavon and Chakwal. Among the individual treatments, AZS-17 at full irrigation (3.888g) and at irrigation at anthesis (3.851g) and AZS-4 irrigated at anthesis (3.835g) produced significantly higher grain weight than rest of the entries and treatments. The trend of reduction in grain weight among varieties was not similar. The maximum reduction of 0.759g was noted in Pavon, when irrigation was applied at tillering. Similarly, maximum reduction of 0.676g was observed in AZS-17 when there was no irrigation. At this stage it would be difficult to justify as to how the grain weight in different treatments had been relatively higher as compared to no irrigation.

Reduction in grain weight due to drought and variable response of the tested wheat genotypes to water stress, has already been reported (Khan *et al.*, 1993). Water deficit during pre-anthesis period predominantly affects grain number, whereas post-anthesis water deficit decreases grain size (Classen & Shaw, 1970; Innes & Blackwell, 1981). Decrease in grain size may occur in part due to decrease in endosperm cell number in response to water limitation (Brocklehurst *et al.*, 1978; Nicolas *et al.*, 1985). It is also

Table 1. Effect of water stress on 100 grain weight (g) of bread wheat.

Genotypes	Full irrigation	Irrigation at anthesis	Irrigation at tillering	No Irrigation	Mean
Chakwal	3.518 cd	3.508 cd	3.011 hi	3.092 gh	3.282 c
Pavon	3.689 b	3.419 de	2.930 i	3.231 fg	3.314 c
AZS-4	3.510 cd	3.835 a	3.576 bc	3.090 gh	3.503 b
AZS-17	3.888 a	3.851 a	3.361 ef	3.212 g	3.578 a
Mean	3.650 a	3.651a	3.220 b	3.156 b	

plausible that water deficit might inhibit endosperm cell division and that this in turn might diminish endosperm sink capacities (Ober *et al.*, 1991).

A reduction in potential assimilate sink capacity, as a result of water stress after anthesis in winter wheat, has been reported by Svihra (1992). Water deficit reduced the availability of sucrose which a grain may convert to starch (Brooks *et al.*, 1982). Thus drought during grain filling (postanthesis stage) decreases starch accumulation which results in shrivelled grains. Water stress accelerates physiological maturity by about two weeks in wheat grown in Pakistan (Khan *et al.*, 1994). Therefore, reduction in grain filling period in present studies may have contributed to decrease in grain weight.

Protein and lysine: Water stress has generally enhanced the protein and lysine content of bread wheat varieties (Tables 2 and 3). Significantly higher mean protein content was observed when no irrigation was applied and when irrigation was applied at tillering. There was significant difference for protein content at full irrigation and irrigation at anthesis followed by water stress; however, the lysine values were statistically similar.

The mean protein and lysine content in Chakwal 87 was the highest (14.20% and 3.259 % protein respectively). The protein content in Chakwal 87 was the lowest at full irrigation (12.95%) and the highest in irrigation at tillering (15.45%), showing the maximum variation among genotypes with reference to the water stress treatments. The

Table 2. Effect of water stress on protein content (%) of bread wheat.

Genotypes	Full irrigation	Irrigation at anthesis	Irrigation at tillering	No Irrigation	Mean
Chakwal	12.950 f	13.080 f	15.450 a	15.340 a	14.20 a
Pavon	13.475 de	13.720 cd	14.440 b	13.720 cd	13.84 bc
AZS-4	13.215 ef	13.720 cd	13.84 cd	14.080 bc	13.71 c
AZS-17	13.475 de	13.720 cd	13.96 c	14.440 b	13.90 b
Mean	13.279 c	13.560 b	14.420 a	14.395 a	

Table 3. Effect of water stress on lysine content (% protein) of bread wheat.

Genotypes	Full irrigation	Irrigation at anthesis	Irrigation at tillering	No Irrigation	Mean
Chakwal	3.227 defg	3.215 fg	3.315 a	3.278 b	3.259 a
Pavon	3.245 cdef	3.250 bcde	3.275 bc	3.250 bcde	3.255 a
AZS-4	3.217 efg	3.225 efg	3.222 def	3.260 bcd	3.234 b
AZS-17	3.195 g	3.215 fg	3.222 efg	3.235 def	3.217 c
Mean	3.221 b	3.226 b	3.261 a	3.256 a	

lysine values were examined to be less affected by the water stress treatments in variety Pavon; whereas, the most sensitive was the Chakwal 87 variety.

Drought conditions diminish endosperm sink capacity, reduce sucrose availability and shorten grain development period in wheat. These factors may result in less deposition of starch, hence grain weight is adversely affected. Correlation between weight and protein content of wheat grains produced under simulated drought condition was calculated. Regression equation was computed and regression line was drawn (Fig.1). Regression of protein (Y) on weight (X) of wheat grains can be expressed by the following equation. $Y = 19.27 - 1.57X$ ($r = -0.672$, $n = 16$).

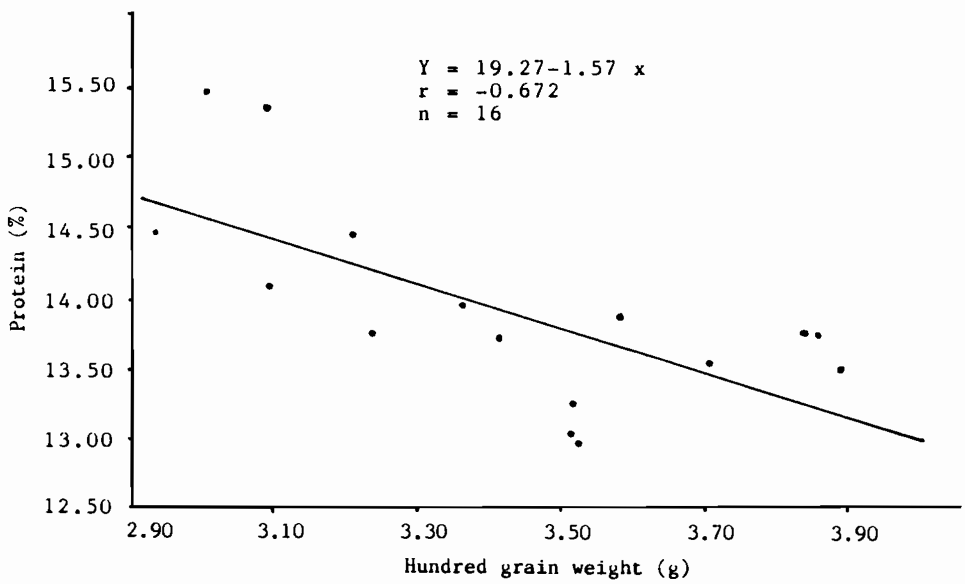

Fig.1. Linear regression between 100 grain weight and protein content of wheat genotypes grown under simulated drought conditions.

The relationship was negative and highly significant. The decrease in weight, therefore, resulted in an increase in protein content of different wheat grains. The coefficient of determination (r^2) of grain weight versus protein content was 0.45. This indicated that 45% variation in protein content could be accounted for by changes in weight of wheat grains. Dilution of protein by starch, under good growing condition (like full irrigation), could be one of the main causes for negative relationship of protein to grain weight. Campbell *et al.*, (1981) reported that the effect of moisture stress on protein content was mainly through its influence on grain yield. Hence under drought conditions, protein concentration in grain should increase, conversely, with favourable precipitation, protein content in grain is likely to be lower (Rao *et al.*, 1993).

Puchkov *ct al.*, (1983) reported that common winter wheat mutants with reduced endosperm (shrivelled grains) had significantly higher protein and lysine concentrations in grain, and lysine concentration in protein than that of its parent. According to Kapoor & Heiner (1982) and Kieffer *et al.*, (1988) the proportions of albumin and globulin decreases during wheat grains ripening, while glutenin and especially gliadin increases. Similarly, Stenram *et al.*, (1990) found that during grain development of both winter and spring wheats, the gliadin content increased and the albumin content decreased, whereas the globulin and glutinin contents remained almost constant. Therefore, structural proteins (especially albumin which is rich in lysine) decrease but storage proteins (especially gliadin which is poor in lysine) increase during grain filling in wheat. Water stress accelerates grain ripening and shortens grain filling period in wheat (Khan *et al.*, 1994). Therefore, there was probably less decrease in albumin content and less increase in gliadin content in water stressed wheat grains in the present study which resulted in the high lysine content of their proteins.

Acknowledgment

We are thankful to Dr. M.S.Sadiq for help in field studies.

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(Received for publication 3 October 1998)