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VARIETAL RESPONSE OF WHEAT TO WATER STRESS AT DIFFERENT GROWTH STAGES. EFFECT ON TILLERS PRODUCTION

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Three varieties of wheat viz: Pak 81, Punjab 85 and Kohinoor were subjected to low water stress (-10 bars on leaf water potential basis) at tillering, jointing, boot and anthesis. Crop was sown in a split plot design. Water potential of the central leaves was determined on alternate day using Pressure Bomb till the desired level of -10 bars was achieved. At this stage water stress was terminated by applying 7.5 hectare centimeter water by calibrated buckets. Stressed plots were protected from rain water by polyethylene sheets placed over iron frames when needed. Results of the 2 years data revealed that number of spike bearing tillers per unit area was significantly reduced by water stress. The effect was more pronounced in plants stressed at jointing. Kohinoor produced significantly more number of spike bearing tillers per unit area than Pak 81 and Punjab 85. However, Pak 81 and Punjab 85 were found sensitive to water stress at jointing stage and Kohinoor at tillering stage of growth.

Key words: Wheat tillers, Water stress and leaf water potential.

Introduction

In agricultural production, crop plants are usually under stress at one growth stage or another and their ability to withstand such stresses are of great economic importance. In addition many global agricultural problems arise from the fact that productive land exists in areas that have difficult or unfavourable climatic conditions causing water deficit stress. Less than 10% of land surface has been left suitable for cultivation [1]. The worldwide losses in yields from water stress probably exceed the losses from all other causes combined [2]. In wheat growing areas of Pakistan, the top soil which contains the bulk of plant nutrients in labile form dries out due to lack of irrigation or rainfall by the time when winter passes and wheat crop initiates rapid growth by stem elongation and ear emergence. When this occurs, yield and nutrient uptake by wheat are likely to be lower than if the top soil had remained wet continuously until maturity. Wheat yield depends upon 3 yield components; (a) number of heads per unit area, (b) number of grain per spike and (c) grain weight. [3]. Any setback to wheat crop during the development of these components have detrimental effect on grain yield. In this connection Robins and Domingo [4] investigated the effect of severe moisture deficit at specific stages of growth on the yield components of spring wheat and concluded that moisture stress before heading caused marked secondary growth which increased the head population but delayed the date of maturity. Moisture stress during and following heading generally resulted in fewer heads, spikelets per spike and grain per spike. They further suggested that there was no benefit from irrigating spring wheat prior to boot stage unless a considerable moisture stress, as indicated by the wilting or curling of leaves, was observed. However, Brouwer and Martin [5] reported that wheat response to early irrigation was best as it improved tillering. Slavik [6] stated that water stress during leaf development reduced the number of fertile tillers; during spikelet formation it decreased the number of spikelets per spike and during anthesis it decreased the total number of seeds. Dubetz and Bole [7] tested three cultivars of spring wheat in a metal lysimeters, in which a soil water stress of -8 bars was created at the early boot stage. They concluded that water stress reduced grain yield by severely decreasing the number of kernels per spike but tillering was not affected. Gale and Wilson [8] did not observe any significant effect of soil water deficit (151 mm) on the grain yield of wheat. Ahmad and Khalaf [9] applied water deficit stress to wheat varieties viz., Maki-Pak and Saberbeg at different growth stages and concluded that water stress significantly reduced the number of ears per plant but increased grain protein content. Davidson and Chevalier [10] studied the effects of decreasing osmotic potential in the root zone of wheat grown hydroponically. Water potential of the hydroponic medium was maintained at -0.1, -0.3 and -0.5 MPa with polyethylene glycol (PEG). They concluded that varying the osmotic concentration in the vicinity of the roots delayed tiller initiation, and reduced leaf area production and number of tertiary and quaternary tillers. The number of primary and secondary tillers was not affected by PEG treatments. After acclimation of plants to PEG treatments by accumulating solutes to lower their osmotic potential and maintain normal turgor, tillers initiation resumed but were reduced in size. They also concluded that tiller initiation and emergency were less

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sensitive to osmotic stress than the subsequent vegetative growth of the tillers. Blake [11] concluded 2 periods as most critical in the life of wheat plant when it is most succestible to water and nutrient stresses. The first is when the 5th floret of the ear is about to stop development i.e., immidiately before ear emergence. It is at this stage that number of fertile florets per plant is determined. The second period is less pronounced then the first but occurs at the jointing stage, when the supply of available water and food materials to the plant determines whether the tillers survive or not. The present project was designed to determine the effect of water deficit stress on the yield and yield components of wheat under the agro-climatic conditions prevailing in Faisalabad (Pakistan).

Materials and Methods

Wheat response to low water stress at different plant development stages was investigated at the Agronomic Research Area, Univerity of Agriculture, Faisalabad during 1988-89 and 1989-90. Soil was sandy clay-loam averaging 0.052% N, 7.4 mg/kg P_2O_5 and 96 mg/kg K_2O. Meteorological data for the growing period are presented in Table 2. Three wheat varieties viz; Pak 81 (VI), Punjab 85 (V2) and Kohinoor (V3) were given low water stress at 4 growth stages; tillering (S1), jointing (S2), boot (S3), and anthesis (S4). A control treatment (S5) was also included. Experiment was laid out in split plot design with 4 replications randomizing the stress treatments in main plots and varieties in sub-plots. Net plot size was 1.5 x 2 m. Six wheat rows at a spacing of 25 cm were sown in each plot. Prior to sowing, a composite soil sample upto 30 cm depth was collected from the experimental area and analyzed for physico-chemical properties (Table 1). Crop was planted on 23rd and 18th Nov. in 1988-1889 and 1989-90, respectively. A basal fertilizer dose of 75-75 kg NP ha^{-1} was applied at the time of sowing. Normal seed rate of 100 kg ha^{-1} was used. To avoid possible seepage from one plot to another at the time of irrigation, one meter wide drain was dug around each plot. Stress treatments were protected from rain water by polyethylene sheets placed over iron frames. Water

TABLE 1. PHYSICO-CHEMICAL ANALYSIS OF EXPERIMENTAL SOIL.

Determination	Units	Value 1988-89	Value 1989-90
Mechanical analysis			
Sand	%	65.5	65.1
Silt	%	14.6	14.9
Clay	%	20.1	20.6
Textural class	-	Sandy clay loam	
Chemical analysis			
pH	-	8.05	8.00
ECe	dsm^{-1}	2.9	2.79
Organic matter	%	0.50	0.59
Total nitrogen	%	0.046	0.058
Available phosphorous	$mg\ kg^{-1}$	7.1	7.7
Available potassium	$mg\ kg^{-1}$	90	102

TABLE 2. METEOROLOGICAL DATA FOR THE GROWING PERIOD OF CROP.

Month	1988-89 Temp(°C) Max	1988-89 Temp(°C) Min	1988-89 Rel: Hum:%	1988-89 rains (mm)	1989-90 Temp(°C) Max	1989-90 Temp(°C) Min	1989-90 Rel: Hum%	1989-90 Rains (mm)
Nov.	27.9	11.6	76	–	27.9	12.1	70.0	–
Dec.	22.4	7.4	80	21.9	21.4	8.6	79.0	25.2
Jan.	19.5	5.3	83	30.0	21.3	7.9	81.5	20.2
Feb.	22.2	6.8	72	2.8	21.7	9.2	81.0	51.7
Mar.	25.9	12.8	69	0.7	24.9	11.9	70.0	10.0
Apr.	30.0	16.1	51	1.1	34.2	17.7	51.9	16.0
				56.5				123.1

Source: Department of Meteorology, University of Agriculture, Faisalabad, Pakistan.

TABLE 3. NUMBER OF SPIKE BEARING TILLERS M^{-2} AS AFFECTED BY WATER STRESS AND VARIETIES AT DIFFERENT GROWTH STAGES OF WHEAT.

Treatment		Number of spike bearing tiller m^{-2} 1988-89	1989-90	Mean
Stress stages				
Tillering	(S1)	427.08ab	434.42c	430.75c
Jointing	(S2)	375.75c	420.50c	398.12d
Boot	(S3)	416.17b	440.7bc	428.40c
Anthesis	(S4)	432.67ab	458.17ab	445.42b
Control	(S5)	446.00a	480.42a	463.21a
LSD (0.05 P)		19.37	22.41	14.03
Varieties:				
Pak 81	(V1)	415.05b	436.85	42.95b
Punjab 855	(V2)	406.36b	44.	42.9b
Kohinoor	(V3)	437.20a	458.1	447.67a
LSD (0.05 P)		19.37	22.41	14.03
Interaction (SxV)				
S1	V1	434.25b-e	446.25a-e	440.25cd
S1	V2	447.0abc	42.2a-d	449.87bcd
S1	V3	339.0 fgh	404.75ef	402.12fg
S2	V1	377.00hi	379.00f	378.00g
S2	V2	34.50i	414.00def	379.7g
S2	V3	404.7 e-h	468.0ab	436.62cd
S3	V1	389.50gh	437.0b-e	410.00ef
S3	V2	424.2 c-f	424.75 cde	424.0def
S3	V3	441.75bcd	460.00abc	40.87bc
S4	V1	419.00c-f	436.0 b-e	427.7 c-f
S4	V2	414.00c-f	466.0abc	440.0cd
S4	V3	464.0ab	471.0ab	468.00ab
S5	V1	462.50ab	8.00a	473.0ab
S5	V2	400.00ab	470.25ab	43.12cde
S5	V3	47.00a	486.00a	480.75a
LSD (0.0 P)		32.81	41.80	26.02

Means followed by different letters in a column are significantly different at 0.05 P.
N.S. = Non-significant.

strees (-10 bars) was created at each stage of plant development by withholding irrigation and rain water while other treatments were irrigated by applying 7.5 hectare cm irrigation water. For determining leaf water potential (LWP) of -10 bars in the respective treatments, leaf samples were collected in thermos bottle at dawn and the LWP was measured by using Pressure Bomb method [12]. Leaf collections was repeated on alternate day until the LWP was obtained in the middle leaves. At this point water stress was terminated by applying measured quantity of 7.5 hectare centimeter of irrigation water. Each plot was irrigated by calibrated buckets and seepage from one plot to another was strictly checked by digging a water channel around each plot as described above. Data on spike bearing tillers in an area of one meter square at the time of harvesting were recorded and statistically analyzed at 0.05 P [8].

Results and Discussion

Final grain yield of wheat is mainly determined by the number of spike bearing tillers per unit area at harvest. Data pertaining to number of spike bearing tillers m^{-2} are presented in Table 3 which revealed that there were significant differences among stress treatments in both the years of experiment. In 1988-89, water stress given at jointing stage reduced the spike bearing tillers significantly over rest of the treatments. Numarically the highest number of spike bearing tillers was recorded in case of no stress (control) which was statistically equal to tillering and anthesis stress treatments. Differences among boot, anthesis and tillering stress treatments were also found to be non-significant. By contrast, in 1989-90, water stress at tillering, jointing and boot stage of growth were not significantly different for spike bearing tillers. The highest number of spike bearing tillers (480.42) were obtained from control plots which was statistically on a par with that following water stress at anthesis stage (458.17). On the basis of 2 years average, it was observed that all stress treatments decreased the production of spike bearing tillers significantly over unstressed plots. Lowest number of spike bearing tillers were recorded when stress was applied at jointing (398.12m^{-2}) followed by boot and tillering stage. The latter 2 treatments were statistically similar and produced 428.26 and 430.75 spike bearing tillers m^{-2}, respectively; compared with 445.42 for anthesis stress treatment. Reduced number of spike bearing tillers per unit area following stress applied at jointing stage is probably attributed to slow growth of plants some of which led to senescence in the vegetative phase before it reaches to heading and other results in partial sterility. These findings are in affirmative to those reported by Davidson and Chevalier [10] who found that tiller initiation and emergence was less sensitive to osmotic stress than was the subsequent growth of the tillers. On the other hand, Debetz and Bole [7] concluded that a soil water stress of -8 bars in early boot stage did not affect the tillering potential of spring wheat. Our results are also in agreement with those reported by Balke [11], who reported that jointing and boot stage of growth are sensitive to water stress. He concluded that at boot stage the number of fertile florets per plants is determined while at jointing stage the supply of available water and nutreints to the plant determines whether the tillers survive or not. Slavik [6] reported that wheat is very sensitive to water stress at boot stage because it is the time when number of fertile florets per plant is determined.

Varieties (Table 3) were significantly different for number of productive tillers during 1988-89. Kohinoor produced significantly more spike bearing tillers m^{-2} (437.20) than Pak 81 and Punjab 85 which produced 415.05 and 40.6.35 spike bearing tillers m^{-2}, respectively. In 1989-90, varieties did not influence the production of spike bearing tillers per unit area. According to the 2 years average data, varieties differed statistically. The highest number of spike bearing tillers (447.67) were recorded with Kohinoor as compared to Pak 81 and Punjab 85 which produced 425.95 productive tillers each. These results led to the conclusion that Kohinoor variety possessed significantly higher tillering potential than Pak 81 and Punjab 85.

Interaction of stress and varieties was significant during both the years of trial (Table 3). During 1988-89, highest number of spike bearing tillers were recorded in plots sown with Kohinoor with no water stress (S5 V3) as compared to the minimum of 345.50 m^{-2} in plots sown with Punjab 85 and given water stress at jointing stage (S2 V2). Similarly, in 1989-90, Kohinoor and Pak 81 produced highest number of productive tillers per unit area under unstressed conditions. Minimum number of tillers were recorded in plots sown with Pak 81 and applied water stress at jointing stage (S2 V1). The number of spike bearing tillers avearged over 2 years was also statistically significant and led to the conclusion that kohinoor under unstressed environment (S5 V3) produced maximum tillers (480.75 m^{-2})than Punjab 85 and Pak 81, stressed at jointing stage of growth (S2 V1) with 378 and 379.75 productive tillers, respectively.

Conclusion

From the above results it can be concluded that water deficit stress significantly reduces the production of spike bearing tiller in a unit area. Tiller initiation may not be influenced by shortage of water at the time of its initiation but it is drastically reduced when water stressed at the subsequent stages of vegetative growth i.e, jointing and boot. Therefore, shortage of water to wheat crop should be avoided from jointing to maturity to ensure nearly all the initiated tillers bear heads and mature. Secondly the potential sink at the jointing stage needs become fully explored to accommodate the photosynthates at the time of grain filling stage to produce heavier grains.

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