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Response of wheat (*Triticum aestivum*) genotypes to post-anthesis moisture stress by chemical desiccation

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ABSTRACT

A field experiment was conducted during 1997–98 and 1998–99 at Hisar, to evaluate the response of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) genotypes to post-anthesis moisture stress by chemical desiccation under different environments. The growth and yield parameters, *viz.* dry-matter production, grains/spike and 1,000-grain weight, were significantly higher in normal irrigated environment by 27.62, 26.68 and 56.39% than dry and 19.99, 47.41 and 112.11% higher than 0.1% potassium iodide (KI) spray on whole canopy of wheat. Wet environment recorded 23.19, 120.22 and 48.25% higher grain yield in wheat over dry, 0.1% KI spray on whole canopy and vegetative parts escaping ears. Among the 4 desiccant sprayed environments, significantly higher growth, yield attributes and yield were obtained in 0.075% KI spray on vegetative parts as compared to 0.1 and 0.075% KI spray on whole canopy. Among genotypes, 'UP 2338' recorded 6.33, 18.06 and 33.95% higher number of grains/spike over 'PBW 343', 'WH 533' and 'Lok 1'. Wheat cv. 'UP 2338' fetched more grain yield by 7.51, 20.23 and 44.63% than 'PBW 343', 'WH 533' and 'Lok 1' and found to be less sensitive to post-anthesis moisture stress compared with the other genotypes.

Key words : Moisture stress, Growth, Yield, Potassium Iodide (KI), Wheat genotypes

Water stress is a major constraint to wheat productivity in semi-arid region where average yield is 2 tonnes/ha. Under arid situations, the wheat crop invariably suffers due to high temperature and low soil-moisture availability, especially at reproductive stage of crop development in Indian sub-continent. Stressful environment under limited availability of water during grain-filling period leads to leaf senescence and reduced availability of current photosynthesis for proper grain growth. The importance of pre-anthesis assimilates for grain growth has been recognized in some crops including wheat (Bidinger *et al.*, 1977). In wheat post-anthesis water stress is critical for grain growth and affects the grain weight adversely as the current photosynthesis is reduced drastically. It is important to study the effect of post-anthesis water stress on plant growth and development, as it makes considerable contribution to grain yield. The genetic variability that exists among Indian wheat genotypes in their response to post-anthesis water stress has not been well studied. The genetic difference among wheat cultivars for pre-anthesis assimilates transfer from vegetative plant parts to grain due to such treatments to identify the physiological eifficient genotype will prove beneficial for improvement in grain yield under terminal moisture stress (Nicolas and Turner, 1993). In the present investigation, an attempt was made to study the growth and yield behaviour of wheat genotypes under different post-anthesis moisture stress environments by desiccant spray.

MATERIALS AND METHODS

A field experiment was conducted at Research Farm of CCS Haryana Agricultural University, Hisar (29°10'N and 75°46'E with elevation of 215.2 m above mean sea level), Haryana. The soil was sandy loam (sand 58.3%, silt 22.0% and clay 19.7%), with low in organic carbon (0.3%) and available nitrogen (160 kg/ha), medium in available phosphorus (15 kg/ha), high in available potash (300 kg/ha), alkaline in reaction pH (8.2) and ECe (0.45 dS/m). The experiment comprised 24 treatment combinations with 6 environments, viz. no post-sowing irrigation (dry), normal irrigation (wet), normal irrigation + 0.1% potassium iodide (KI) spray on whole canopy at 1/3rd filled cavity of grain (KI_1), normal irrigation + 0.075% KI spray on whole canopy at 1/3rd filled cavity of grain (KI_2), normal irrigation + 0.1% KI spray on vegetative parts (escaping ears) at 1/3rd filled cavity of grain (KI_3),

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normal irrigation + 0.075% KI spray on vegetative parts (escaping ears) at 1/3rd filled cavity of grain (KI_4) in main plots and 4 genotypes, *viz.* 'Lok 1', 'PBW 343', 'UP 2338', 'WH 533', in sub-plots in split-plot design with 3 replications. The crop was sown by hand plough on 26 November and 1 December during 1997–98 and 1998–99 with row spacing 22.5 cm, using 100 kg seed/ha respectively. The crop was sown with a pre-sowing irrigation in all plots during both the years. In irrigated environment, only one post-sowing irrigation was applied at 30 days after sowing during 1997–98 crop season due to frequent winter rainfall (88 and 31 mm during 1997–98 and 1998–99), while 3 post-sowing irrigations were applied during 1998–99 crop season in all plots. The whole amount of nitrogen (120 kg N/ha) through urea, phosphorus (60 kg P_2O_5/ha) through single superphosphate and zinc through zinc sulphate (25 kg $ZnSO_4$/ha) were applied uniformly to all plots at the time of sowing during both the crop seasons. The leaf-area index (LAI), crop-growth rate (CGR) and leaf-area duration (LAD) were calculated using standard formula at different growth stages.

RESULTS AND DISCUSSION

Effect of environment

Irrespective of treatments plant height increased from tillering to milk ripe stage and thereafter remained static till maturity (Table 1). The plant height and total biomass production were significantly higher in irrigated than dry environment by 22.34 and 63.97% at tillering, 2.88 and 27.80% at anthesis, 2.50 and 27.81% at milk ripe, 4.42 and 27.62% at harvesting stage. The LAI, LAD and CGR increased at a faster rate from tillering to anthesis and then started declining towards maturity. The moisture stress (dry environment) reduced all the growth parameters, viz. plant height, number of tillers, LAI, LAD, CGR and total biomass by 2.44, 10.39, 45.45, 24.33, 21.76% compared with the irrigated environment at milk-ripe stage. This decline in these growth parameters might be due to reduced soil water supply, which decreased turgour potential and turgour driven morpho-physiological processes and growth. The greater plant height, LAI, LAD, CGR and biomass under wet environment would have been due to the fact that higher soil moisture status maintained better plant water status which might have resulted in increase in cell elongation, cell-division, leaf expansion and more absorption of photo-synthetically active radiations (PAR) via greater plant cover.

Number of ear-bearing tillers/m row length and spikelets/spike were higher by 11.59 and 6.97% in wet than dry environment. The desiccant-sprayed plants did not differ significantly for number of ear-bearing tillers over wet environment. Significantly more grains/spike, 1,000-grain

Table 1. Effect of different environments on plant height (cm), dry-matter production (g/m²), leaf-area index and leaf-area duration (LAD) days at different growth stages in wheat genotypes (pooled data of 2 years)

Treatments	Tillering				Anthesis				Milk ripe				Harvest	
	Plant height (cm)	Dry matter (g/m²)	LAI	LAD days	Plant height (cm)	Dry matter (g/m²)	LAI	LAD days	Plant height (cm)	Dry matter (g/m²)	LAI	LAD days	Plant height (cm)	Dry matter (g/m²)
Environment														
Dry	9.4	43.3	0.38	8.5	83.1	997.0	3.20	90.5	87.8	1,228.8	0.54	48.2	88.3	1,321.5
Wet	11.5	71.0	0.47	10.5	85.5	1,274.2	3.61	105.2	90.0	1,570.6	0.99	63.7	92.2	1,686.6
KI_1	10.4	69.9	0.45	10.2	85.8	1,253.7	3.63	105.2	90.5	1,368.4			91.5	1,405.6
KI_2	10.2	71.4	0.47	10.6	85.6	1,306.6	3.62	105.3	90.0	1,480.1			91.4	1,563.7
KI_3	11.4	71.5	0.47	10.4	86.0	1,300.0	3.63	105.5	90.0	1,442.7			92.3	1,494.4
KI_4	11.4	71.5	0.47	10.5	85.4	1,266.9	3.61	104.9	90.2	1,495.7			91.3	1,567.2
CD (P=0.05)	2.0	6.4	0.04	0.5	2.6	95.3	0.38	8.9	2.3	88.9			3.1	118.3
Genotype														
'Lok 1'	10.3	54.7	0.39	8.8	82.6	1,088.6	3.18	85.9	87.3	1,250.9	0.56	45.1	88.0	1,310.9
'PBW 343'	10.6	72.1	0.48	10.7	84.1	1,299.9	3.87	111.0	88.5	1,515.1	0.84	63.7	90.3	1,579.2
'UP 2338'	10.7	74.2	0.52	11.7	84.0	1,322.9	3.92	112.1	88.4	1,559.0	0.88	66.2	89.6	1,654.0
'WH 533'	11.4	64.7	0.41	9.3	90.2	1,220.8	3.22	102.1	94.7	1,399.3	0.78	50.0	96.7	1,481.8
CD (P=0.05)	1.1	3.1	0.01	0.3	2.3	52.1	0.11	4.4	2.1	37.7			2.8	40.7

weight and grain weight/spike were recorded in wet, KI_4 and KI_3 over dry, KI_2 and KI_1 environments (Table 2). The reduction in grains/spike, 1,000-grain weight and grain weight/spike under dry environment was less in comparison to KI_1 and KI_2-treated plants. Spraying 0.1% KI on whole canopy reduced the grains/spike, 1,000-grain weight and grain weight/spike by 26.68, 56.39 and 91.93% than dry environment; 47.41, 112.11 and 204.83% than wet environment respectively. The highest grain yield was recorded under irrigated environment, which was 18.82, 54.59, 42.87, 32.54 and 22.02% higher than dry, KI_1, KI_2, KI_3 and KI_4 treatments respectively. Highest grain yield under wet environment was owing to significant improvement in yield-attributing characters, *viz.* productive tillers/m row length, grains/spike, grain yield/spike and 1,000-grain weight (Table 2). These results confirmed the findings of Ali *et al.* (1999). The better response of yield attributes and yields under wet environment might be owing to increased cell turgidity, higher stomatal conductance and photosynthesis which favoured improved growth parameters like LAI, LAD, CGR and better allocation of dry matter in different plant parts. The maximum reduction in grain yield was observed in KI_1 (120.22%) followed by KI_2 (75.06%), KI_3 (48.25%), KI_4 (28.24%) and minimum in dry environment (23.19%) compared with wet environment. The sharp decline in grain yield under 0.1 and 0.075% KI spray over whole canopy was due to reduction in grains/spike, mortality of endosperm and reduction in 1,000-grain weight as compared with wet environment (Table 2). Hossain *et al.* (1990) also reported yield injury from chemical desiccation ranged from 10.3 to 48.9%. The reduction in seed size under different chemical desiccation treatments was mainly due to poor translocation of photosynthates from vegetative plant parts to grains.

Performance of genotypes

Among the genotypes, the plants of cv. 'WH 533' were significantly taller than 'Lok 1', 'PBW 343' and 'UP 2338' at all the growth stages. Irrespective of genotypes plant height and dry-matter accumulation increased at a faster rate from tillering to anthesis and at a slow rate from milk ripe to maturity. Significantly maximum dry-matter accumulation was exhibited in 'UP 2338' which was 36.5, 18.9, 27.9, 30.3% higher than 'Lok 1' at tillering, anthesis, milk ripe and harvest stage respectively. However, the cultivars 'UP 2338' and 'PBW 343' were statistically at par for dry-matter accumulation at tillering and anthesis stage. The taller plants in cv. 'WH 533' compared to 'UP 2338', 'PBW 343' and 'Lok 1' as well as the greater LAI, LAD and CGR in 'UP 2338' and lowest in 'Lok 1', could be attributed to variation in their genetic

Table 2. Effect of different environments on crop-growth rate at different growth stages, yield-attributing characters and yield at harvest in wheat genotypes (pooled data of 2 years)

Treatments	Crop-growth rate (g/m^2-day)				Ear-bearing tillers (No./m row length)	Number of spike-lets/spike	Number of grains/ spike	1,000-grain weight (g)	Grain weight/ spike	Grain yield (q/ha)
	Emergence–tillering	Tillering–anthesis	Anthesis–milk ripe	Milk ripe–harvest						
Environment										
Dry	0.96	19.05	9.97	5.01	76.83	16.05	40.45	29.70	1.19	36.86
Wet	1.58	23.11	13.34	4.60	85.74	17.17	47.07	40.28	1.89	45.41
KI_1	1.56	23.87	3.67	1.55	85.36	16.96	31.93	18.99	0.62	20.62
KI_2	1.58	24.16	7.53	3.30	86.13	17.16	36.06	25.29	0.91	25.94
KI_3	1.59	24.23	5.68	2.48	86.13	17.11	45.65	30.92	1.41	30.63
KI_4	1.59	23.59	9.36	3.78	85.74	17.21	46.22	35.09	1.63	35.41
CD (P=0.05)	0.13	2.08	1.43	0.28	4.86	0.85	3.12	2.90	0.21	3.98
Genotype										
'Lok 1'	1.22	21.13	7.41	2.98	78.52	16.37	34.84	31.24	1.15	26.01
'PBW 343'	1.60	24.05	8.93	3.01	87.25	17.25	43.89	29.77	1.34	34.99
'UP 2338'	1.65	24.48	10.05	4.36	87.32	17.41	46.67	31.41	1.48	37.62
'WH 533'	1.44	22.36	6.64	3.46	84.19	16.74	39.53	27.76	1.14	31.29
CD (P=0.05)	0.06	0.62	0.68	0.30	3.62	1.08	3.03	1.27	0.12	2.63

constitution. The higher LAI and LAD at milk-ripe stage in cv. 'UP 2338' were simply because of its low rate of leaf senescence, probably due to its greater turgour and osmotic adjustment (Hsiao *et al.*, 1984). However, the lower LAI and LAD at milk-ripe stage in 'Lok 1' compared to 'UP 2338', 'PBW 343' and 'WH 533' were indicative of high rate of leaf senescence at later stages of growth in this genotype. Such characteristics might be due to slow down of root activity and greater sensitivity of leaves to increased temperature at later stages of growth in 'Lok 1' of wheat.

Significantly highest number of ear-bearing tillers, grains/spike, 1,000-grain weight and grain weight/spike were recorded in 'UP 2338', followed by 'PBW 343', 'WH 533' and minimum in 'Lok 1'. The grain yield was higher in 'UP 2338' by 44.63, 7.51 and 20.23% compared with 'Lok 1', 'PBW 343' and 'WH 533'. This was due to fact that 'UP 2338' produced higher LAI, LAD, CGR and better yield attributes, *viz.* grains/spike and grain weight/spike than other cultivars (Table 2). The lowest grain yield in 'Lok 1' under both dry and wet environments was due to less productive tillers and grains/spike. Similarly, 'UP 2338' had exhibited least adverse effects on grian yield under different desiccant-sprayed treatments, while 'Lok 1' was most sensitive to desiccant spray in terms of grain yield. The more reduction in grain yield in 'Lok 1' under different chemical desiccant-sprayed plants was mainly due to poor development of source components and sink capacity and as well as poor mobilization of pre-anthesis assimilates from vegetative plant parts to grain.

In general, the natural moisture and artificially created moisture stress by chemical desiccation influenced adversely different morpho-physiological processes, yield structure and yield of wheat genotypes. However, the rate of grain growth and grain yield under natural moisture stress (dry environment), 0.075 and 0.1% KI spray by escaping ears at one-third grain filling stage showed almost similar patterns. Therefore this mode of desiccant application could be utilized to screen wheat genotypes for drought tolerance in irrigated environment.

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