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Effect of shade on phenological development, thermal and radiation use efficiency of wheat genotypes

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ABSTRACT

A field experiment was conducted during *rabi* season of 2000-2001 at CCS, HAU, Hisar research farm to study effect of shade on phenological development, thermal and radiation use efficiency of wheat genotypes. Phenological stage in wheat took more days under shade stress due to low radiation and thermal regimes in the crop canopies. The difference in cumulative heat units increased with the increase in shade level in advanced phenophases during crop season. The radiation use efficiency (RUE)) increased from crown root initiation till anthesis and then decreased slightly upto dough stage. The highest RUE was recorded in highest shade levels due to more reduction in radiation consumed by the crop.

Key words: Thermal use efficiency, Radiation use efficiency, Wheat

Planting of shade trees along the canal, railways and roadsides is an age-old practice. Trees and agriculture crops compete with each other for growth resources such as light, water and nutrients. Trees may influence its neighbouring species affecting environment such as temperature, humidity, light or wind speed (Tiwari and Pandey, 2000). Crop phenology is an important aspect since biomass production and seed yield are dependent on prevailing environmental conditions during various phenophases (Prasad, 1989). Scanty information is available on the effect of shade of trees on occurrence of phenological events in wheat. So, occurrence of crop phenological events, thermal and radiation use efficiency in relation to shading of wheat cultivars by eucalyptus trees have been attempted in the present investigation.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season 2000-2001at the research farm, of C.C.S Haryana Agricultural University, Hisar, which is situated at 29°10' N lat., 75°46'E long. at 215.2 m amsl to study the impact of shade levels on phenophase development alongwith thermal and light use efficiency of wheat. Soil of the experimental site is derived from Indo-Gangetic alluvium deposits and is sandy loam in texture, low in organic matter and available nitrogen, medium in available phosphorus, rich in available potassium and slightly alkaline in reaction. Experiment consisted of twentyfour treatment combinations comprising of six wheat genotypes (IWP 72, PBW 175, WH 542, RAJ 3765, PBW 343 and UP 2338) in sub plots and four shade levels in main plot of split plot design with three replications. The shade levels were created by 12 year old north-east planted eucalyptus trees with average height of 50 feet viz. S_6 (0-6m) had shade for longest period i.e. about 4 hrs and with PAR reduction of about 47.8 per cent followed by S_{12} (6-12m) for 2.5 hrs and PAR reduction of about 21.7 per cent, S_{18} (12-18 m) for 1.5 hrs and PAR reduction of about 10.3 per cent from full sunlight S_{24} (18-24 m) away from plantation. The wheat crop was sown on December 13, 2000 at 20 cm row spacing at 5 cm depth using 100 kg seed ha^{-1}. Recommended agronomic practices were followed. The crop was inspected at frequent intervals (2 to 3 days) to observe phenological events closely from five representative tagged plants in each plot. The summation of mean temperature above base value (5°C) was used to compute heat units. Thermal use efficiency (TUE) and the radiation use efficiency (RUE) were computed following Sastry *et al.* (1985) and Nehra *et al.* (1996). The grain yields were recorded from each plot and yields are expressed in kilogram per hectare.

RESULTS AND DISCUSSION

The effect of shade differed significantly in occurrence of different phenophases (Table 1). Phenophases development was delayed with increase in shade levels from S_{24} to S_6. The delay may be due to lesser time of availability of radiation along with low thermal regimes prevailed in the crop canopies. This fact can be ascertained from the higher heat units in crop shaded for longer time than other treatments. These results corroborate the findings of Hashemi and Herbert, (1992). Nandal *et al.* (1999) also noted that under shading condition crop took more number of days to reach tillering and maturity phases.

Occurrence of different phenophases among the genotypes differed significantly. Genotype UP 2338 took maximum number of days for all stages. The number of heat units consumed increased with advancement of phenophases in wheat (Table 1) and accumulated more number of heat units with increased level of shade more so at later phenophases. Similar results were reported by Jarwal and Singh (1990) and Hashemi and Herbert (1992).

Among the genotypes the highest number of heat units were accumulated in UP 2338 whereas, the minimum in PBW 175 for heading. However for reaching physiological maturity UP 2338 consumed maximum heat unit followed by PBW 343 with a minimum in RAJ 3765. These variations are caused mainly due to variation in days taken for the development of different phenophases. Chakravarty and Sastry (1983) also found large variation in degree-days required for different varieties to progress from one stage to another.

The TUE for different phenophases go on fluctuating throughout the crop season

Table 1 : Effect of shade levels on cumulative heat units (day°C) at different phenological stages of wheat genotypes

Treatments	CRI	Tillering	Jointing	Heading	Anthesis	Milking	Dough	Physiological maturity	Grain yield kg ha^{-1}
Shades									
S_6	204 (24)	346 (47)	584 (68)	708 (86)	862 (96)	1077 (109)	1384 (123)	1645 (138)	2139
S_{12}	202 (23)	337 (45)	542 (65)	707 (86)	844 (95)	1050 (107)	1325 (121)	1642 (135)	2989
S_{18}	198 (23)	331 (44)	527 (64)	659 (84)	844 (94)	1012 (105)	1301 (120)	1563 (134)	3944
S_{24}	197 (22)	308 (42)	516 (63)	679 (81)	835 (93)	990 (104)	1276 (119)	1539 (133)	4443
CD at 5%	(1.0)	(1.0)	(2.0)	(1.0)	(1.0)	(1.0)	(1.0)	(2.0)	196
Varieties									
IWP 72	201 (23)	332 (45)	520 (64)	669 (83)	818 (93)	990 (104)	1251 (118)	1537 (133)	3314
PBW 175	198 (22)	320 (43	527 (64)	956 (82)	844 (94)	1032 (106)	1276 (119)	1537 (134)	3471
WH 542	202 (24)	341 (47)	580 (67	708 (86)	850 (95)	1038 (107)	1325 (121)	1540 (136)	3477
RAJ 3765	198 (23)	332 (44)	542 (66)	674 (84)	818 (94)	1012 (105)	1276 (119)	1515 (132)	3102
PBW 343	202 (23)	331 (44)	527 (64)	710 (86)	861 (96)	1050 (107)	1347 (122)	1617 (137)	3538
UP 2338	204 (25)	341 (47)	537 (68)	720 (88)	899 (97)	1070 (109)	1407 (124)	1645 (139)	3171
CD at 5%	(1.0)	(1.0)	(1.1)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	172

* The values in parenthesis are days after sowing

Table 2 : Effect of shade level on RUE (g MJ^{-1}) and TUE (g $m^{-2}day^{-1}$°C) at different phenological stages in wheat genotypes

Treatments	Germination to CRI		CRI to tillering		Tillering to jointing		Jointing to heading		Heading to anthesis		Anthesis to milking		Milking to dough		Dough to maturity		Mean	
	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE	RUE	TUE
Shades																		
S_6	0.28	0.23	0.53	0.18	0.55	0.36	1.07	0.17	1.46	0.10	1.30	0.13	1.28	0.42	1.22	0.43	0.96	0.25
S_{12}	0.24	0.24	0.52	0.18	0.54	0.47	1.04	0.23	1.34	0.13	1.26	0.14	1.25	0.49	1.19	0.51	0.92	0.30
S_{18}	0.23	0.30	0.51	0.20	0.51	0.54	1.03	0.24	1.22	0.17	1.24	0.21	1.19	0.51	1.16	0.63	0.89	0.35
S_{24}	0.19	0.37	0.50	0.22	0.50	0.68	1.01	0.29	1.08	0.19	1.16	0.26	1.12	0.53	1.08	0.65	0.83	0.40
Mean	0.24	0.29	0.52	0.20	0.53	0.51	1.04	0.23	1.28	0.15	1.24	0.19	1.21	0.49	1.16	0.56		
Varieties																		
IWP 72	0.21	0.28	0.51	0.19	0.48	0.54	1.04	0.22	1.23	0.13	1.23	0.16	1.20	0.50	1.16	0.59	0.88	0.33
PBW175	0.26	0.30	0.51	0.22	0.53	0.51	1.06	0.25	1.29	0.19	1.26	0.21	1.24	0.46	1.20	0.61	0.92	0.34
WH 542	0.19	0.28	0.55	0.27	0.58	0.47	1.03	0.23	1.25	0.15	1.23	0.18	1.20	0.55	1.16	0.56	0.90	0.34
RAJ 3765	0.18	0.28	0.49	0.19	0.50	0.51	1.02	0.24	1.24	0.16	1.20	0.17	1.19	0.47	1.13	0.52	0.87	0.32
PBW 343	0.25	0.29	0.48	0.20	0.52	0.52	1.05	0.24	1.27	0.16	1.26	0.16	1.25	0.49	1.18	0.54	0.91	0.33
UP 2338	0.28	0.31	0.50	0.18	0.52	0.48	1.07	0.26	1.33	0.19	1.28	0.23	1.26	0.51	1.20	0.52	0.93	0.34

(Table 2). The TUE was lowest at anthesis and highest at maturity followed by jointing and dough stage of the wheat. It decreased with increase in shade level at all the phenophases except anthesis and milking, where, these were slightly lower in S_{12} and S_6. The 33.8 per cent lower TUE under severely shaded environment than control may be attributed to low biomass production due to low availability of radiant energy. Sastry *et al.* (1985) and Rao *et al.* (1999) also reported similar results. Among the genotypes, the variations in TUE were comparatively low particularly at CRI, heading, anthesis and milking stages.

The RUE increased from CRI till anthesis and than declined slightly upto maturity stage (Table 2). The highest RUE was recorded in highest shade level (S_6) followed by S_{12} and it was minimum in S_{24} at most of the phenological stages due to shade in morning hours. The lowest RUE in S_{24} showed that the available radiation was higher than that utilized by the crop. Among the genotypes, highest RUE was observed in UP 2338 followed by PBW 175 and it was minimum in RAJ 3765 at almost all the phonological stages. The maximum RUE was between heading- anthesis with a little decline thereafter. This followed the trend of sigmoid growth curve where slight decline at maturity stage was due to longer day length and more radiation received at the time of crop maturity.

The grain yield of wheat decreased significantly with each successive increase in shade level from S_{24} to S_6 (Table 1) with reduced grain yield by 44.6, 21.2 and 10. 8 percent in S_6, S_{12} and S_{18}, respectively. Dhillon *et al.* (1982) found that Eucalyptus tree planted in east-west direction lead to yield reduction in wheat, which varied from 50.1 per cent at 1m to 0.3 per cent at 16m from the tree base. Similar results were also reported by Singh *et al.* (1993) and Gill (1994). Among the genotypes, the highest grain yield was recorded in PBW 343 followed by WH 542 and PBW 175, which were statistically at par. Nandal *et al.* (1999) also observed similar variation in grain yield of wheat due to difference in their genetic constitution and yield potential.

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