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UPPER EXPOSED PEDUNCLE LENGTH VARIATION STUDIES IN WHEAT CULTIVARS IN RESPONSE TO HEAT STRESS AT VARIED SOWING TIMES

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ABSTRACT

Wheat is the very important source of food all around the world. In the present changing climate scenario, environmental temperature is increasing day by day due to global warming. Heat stress cause severe yield loss by impairing normal morphological, physiological, biochemical and molecular functions and thus possess the biggest threat to world food security. So, it is important to consider all the contributing factors to develop wheat varieties with better heat stress tolerance attributes. The peduncle length is very less explored yet very important yield contributing factor which may be very important in understanding the plant response and adaptation to the heat stress. Peduncle especially its upper exposed part exhibit important role in storage and mobilization of photosynthetic reserve to the developing wheat grains and thus has important impact on wheat yield. In the present study, we have studied the variations in length of upper exposed part of peduncle or PL(Ue) of eight wheat cultivars under heat stress (+ 5ºC up than control conditions) for different dates of sowing, i.e. DOS1 timely sown (TS), November 24th, 2016; late sown (LS), December 24th, 2016; DOS3 very late sown (VLS) January 24th, 2017 and very-vey late sown conditions (VVLS), February 24th, 2017 in the crop year 2016-17. The present study can provide an idea about the morphological variations in comparatively less explored trait like peduncle length (upper exposed part) under heat stress which further can be utilized in understanding the effects of heat stress on wheat and thus help in breeding programmes involved in heat stress tolerance.

***Keywords*:** Wheat, Heat stress, Morphological trait, Peduncle length variations.

Introduction

Heat or increased temperature stress results in catastrophic wheat productivity loss. it is estimated that every one degree rise in temperature may reduce the wheat production by 6% (Akter and Islam, 2017). Heat stress adversely affects the vital biological processes and thus results in poor growth and development in plant (Fahad *et al.,* 2017). Normal morphological, phenological, physiological, biochemical and molecular processes of wheat plant got affected by the heat stress (Wahid *et al*, 2007; Hasanuzzaman *et al.,* 2013; Bita and Gerats, 2013; Panwar *et al*., 2013; 2016 Shanker *et al.,* 2020). Phenotypic or morphological traits are the oldest and very important selection criteria for the breeding programmes. Right trait selection and precise phenotypic data collection is very important for study the effect of any biotic or abiotic stress on plant as it clearly shows the response of plant to the stress.

The part of wheat plant between the first internode to just bottom of the spike is called peduncle. Peduncle plays crucial role in grains filling and thus overall productivity as it possess the vascular system for mobilizing the photosynthetic assimilate to the developing wheat grains (Wardlaw, 1990). Moreover longer exposed part of peduncle reduces the spread of leaf born pathogen to the wheat spike (Gebbing, 2003). Peduncle; particularly upper exposed part of peduncle also exhibit comparatively higher water potential as compared to flag leaf under limited water or heat stress conditions (Wardlaw *et al.,* 2002). During stress conditions water soluble carbohydrates are mainly stored in peduncle (Blum, 1998). It was reported that peduncle and penultimate internode along with leaf sheath store the most of photosynthetic reserve in wheat and barley (Daniels and Alcock, 1982; Wardlaw and Willenbrink, 1994). This part also under high irradiance conditions can perform photosynthesis (Wardlaw, 1965) and can contribute up to 12% grain dry weight in wheat (Wang *et al.,* 2001). Kong *et al.,* 2010 studied the photosynthetic ability along with various associated properties viz. chloroplast ultrastructure, high stomata numbers and the highly active PEPCase during later grain filling stages under heat stress conditions. It has been also been reported that peduncle length is positively correlated with the heat stress tolerance as it support proper grain filling (Elbashir *et al.,* 2017).

Thus, peduncle length seems to have very important role in synthesis, storage of photosynthetic reserve and its mobilization to developing grain during grain filling particularly at later stages and heat stress conditions. As heat stress leads to the total biomass reduction and yield reduction thus variations in the peduncle length can be considered as important morphological trait which may contribute and affect the overall yield in wheat during heat stress conditions.

Materials and Methods

Experimental conditions

The present study was carried out at ICAR-Indian Institute of Wheat and Barley Research (IIWBR)-Karnal Haryana India during i.e. 2016-17. Eight wheat spring wheat varieties (table 1) were selected for the study and the seeds were procured from ICAR-IIWBR. Four staggered sowing was done following Randomized Block Design (RBD) at one-month interval starting from November, 21, to February 21 in both the experimental years in control (without heat stress) and heat stress (+ 5ºC up than control conditions) in TCPF (temperature control phenotyping facility) in 1 m^2 plot size in three replications (Table 1). The other factors *viz.* no. of plant per plot, plant to plant distance and moisture etc. exactly same as in both the environments. The length of upper exposed part of Peduncle i.e. PL (Ue) measured with graduated scale (in cm) for inner eight plants of the plot in three replications.

Table 1: Details of the experiment carried out during crop year 2016-17.

Experimental Conditions	Date of Sowing (DOS)	Wheat Cultivar
Control (without Heat stress)	DOS1 (November 24th, 2016)	UP2425
	DOS2 (December 24th, 2016)	WR544
	DOS3 (January 24th , 2017)	Sonara-64
	DOS4 (February 24th, 2017)	K7903 (Halna)
TCPF (Heat stress i.e. (+ 5◦C up than control conditions)	DOS1 (November 24th, 2016)	WH730
	DOS2 (December 24th, 2016)	DBW14
	DOS3 (January 24th , 2017)	Raj4014
	DOS4 (February 24th, 2017)	DBW71

Data Collection

Present study was conducted for crop year (2016-17). The length of upper exposed part of peduncle (in cm) was measured using a measuring scale. Data was collected from eight inner plants during morning hours just before the onset of maturity. Data was taken for all the three replication. The obtained data was statistically analyzed using Web Based Agricultural Statistics Software Package WASP. 1 (https://ccari.res.in / waspnew.html) for the level of significance at P=0.05.

Results and Discussion

Wheat response to heat stress is very complex. Many factors contribute in heat stress tolerance and thus maintaining yield under elevated temperature conditions. As plant response to heat stress and yield is influenced by many factors so it is important to consider all contributing factors to develop varieties with better heat stress tolerance. The peduncle length is very less explored yet very important yield contributing factor which may be very important in understanding the plant response and adaptation to the heat stress. Peduncle plays crucial role in photosynthesis, storage and mobilization reserve food and grain filling especially under heat stress (Wardlaw, 1965; Wardlaw, 1990; Daniels and Alcock, 1982; Wardlaw and Willenbrink, 1994; Blum, 1998; Kong *et al.,* 2010) which can be utilized in understanding the plant response and its adaptability to tolerate heat stress and maintain good yield. Farooq *et al.,* 2018 reported that peduncle length is less explored but important morphological has significant influence on plant morphology and inheritance of major yield contributing factors and hence important in late generation selection of cultivar selection.

In the present study, we presented the variations in the length of upper exposed part peduncle among eight different wheat genotypes among four different dates of sowing under control and heat stress (+ 5ºC up temperature than control is maintained in TCPF) conditions. Mean peduncle length was calculated for each date of sowing for both control and TCPF conditions for all the eight wheat cultivars (Table 1). The range for mean peduncle length was (22.1-8.5) for UP2425 (26.0-9.0) for WR544; (17-6.16) for Sonara64; (19.0-12.0) for K7903 (Halna); (14.8-10.2) for WH730; (11.3-8.3) for DBW14; (25.0-14.3) for Raj4014 and (14.6-8.8) for DBW71 under control condition while under heat stress condition (TCPF) the range was (21.8-7.3) for UP2425, (24.5-8.0) for WR5444, (17.1-4.4) for Sonara64, 17.5-9.3) for WH730, 13.0-7.5) for DBW14, (10.0-4.5) for Raj4014 and (18.8-13.6) for DBW71. The coefficient of variation (CV) was also calculated. All the treatments are found significant at $p < 0.05$ level of significance (Table 1).

Table 2: Mean peduncle length (upper exposed part) of different wheat cultivars.

	UP2425	WR544	Sonara64	K7903(Halna)	WH730	DBW14	Raj4014	DBW71
Control (DOS1)	22.1a	26.5a	17.6a	19.0	14.8a	11.3a	25.0a	14.5a
Control (DOS2)	18.5b	25.3a	17.3a	17.6a	12.1c	10.8ab	21.6b	13.1bc
Control (DOS3)	18.0c	19.0c	12.8b	16.6b	11.3cd	9.6bc	16.1d	11.8d
Control (DOS4)	8.5cd	9.2d	6.1d	12.0d	10.2de	8.3d	14.2de	8.8f
TCPF (DOS1)	21.8	24.5a	17.1a	17.4b	13.0b	10.0b	18.8c	14.1ab
TCPF (DOS2)	16.5b	21.6b	13.1b	13.5c	11.0c	8.6cd	15.1de	12.6cd
TCPF (DOS3)	10.3c	9.3d	8.2c	11.1d	9.5e	6.2e	14.2de	10.5e
TCPF (DOS4)	7.3d	8.0d	4.4d	9.3e	7.5f	4.5f	13.6e	6.7g
***CV**	8.1	7.9	8.8	8.1	5.6	7.5	8.2	7.0
CD(p<0.05)	2.2	2.4	1.8	2.2	5.6	1.4	1.2	2.1

*Coefficient of variations (CV) and CD (p<5.0% Level of significance).

The comparative graphical representation of mean length variation was depicted in fig. 2. The percent reduction in peduncle length under heat stress in all the cultivars under study was also calculated and results are represented in fig. It is clear that the PL(Ue) was showing a decreasing trend as date of sowing advanced. Similar trend was also observed in the wheat varieties under heat stress (in TCPF). But the decrease in length was more under heat stressed plant under different sowing conditions. This may be due the additive effect of heat stress as the environmental temperature increases in the latter dates of sowing. We also calculated Percent Reduction in Peduncle length (upper exposed part) (PL(Ue)) under Heat stress. We found that three wheat cultivars (DBW14, WH730 & DBW71) showed maximum decrease in percent PL(Ue) in DOS4 while three wheat cultivars (UP2425, WR544, Sonara-64 & K7903 (Halna) exhibited maximum percent reduction in3. Only one wheat cultivar (Raj4014) showed maximum PL(Ue) reduction in DOS2. In DOS1; UP2425 showed minimum percent reduction (1.5%) while Raj4014 exhibited maximum percent reduction among all eight wheat cultivars.

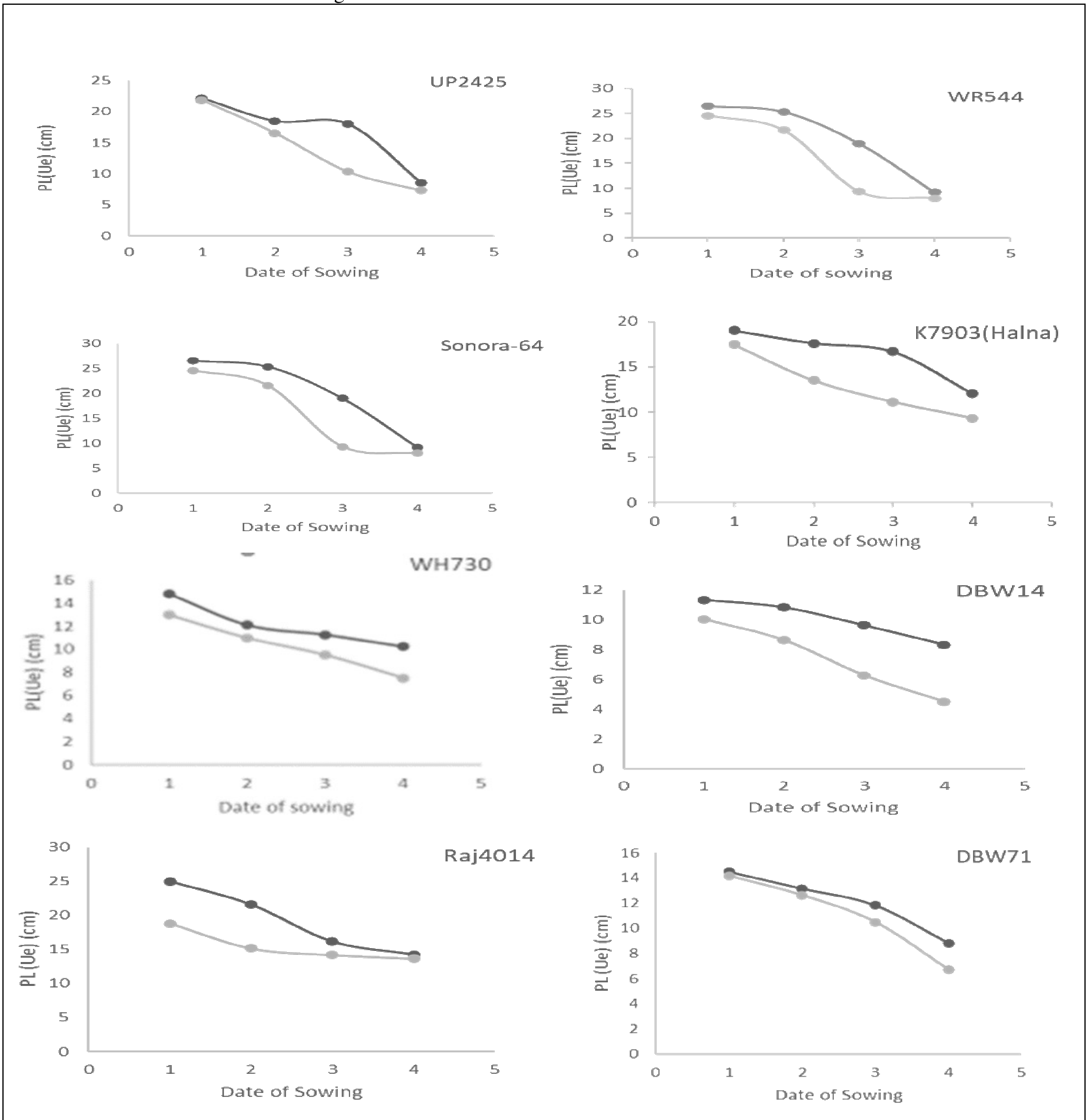

Fig. 1: Graphical representation of variations in upper exposed part of peduncle among wheat cultivars under control and heat stressed (TCPF) conditions.

In DOS2, DBW71 showed minimum reduction (4.1%) while Raj4014 showed maximum percent reduction (29.8%) in DOS3, minimum PL(Ue) percent reduction (11.3%) was recorded for Raj4014 while maximum value (50.9%) was recorded for WR544.

Table 3: Percent reduction in peduncle length (upper exposed part) PL(Ue) under Heat stress.

	UP2425	WR544	Sonara64	K7903(Halna)	WH730	DBW14	Raj4014	DBW71
DOS1	1.5	7.3	2.8	8.1	12.4	11.5	24.7	2.3
DOS2	10.5	14.7	24.1	23.3	6.3	20.3	29.8	4.1
DOS3	42.6	50.9	36.1	33.2	15.9	34.9	12.2	11.3
DOS4	13.7	13.0	27.5	22.4	26.7	46.0	4.2	23.8

In DOS4; Raj4014 showed minimum percent reduction (4.2%) while DBW14 exhibited maximum percent reduction (46%) among all eight wheat cultivars. Above results conclude that various wheat cultivars may show a varied response to heat stress conditions for peduncle length trait on the basis of their natural heat stress tolerance attributes. On the basis of the variance we can select the genotypes for early and late sown conditions.

Our results provide the primary data on peduncle length variations under heat stress which further can further be utilized to understand the plant response to heat stress and utilization in breeding programmes for the indirect selection of morphologically well adapted wheat cultivars for heat stress.

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Disclosure statement

The authors declare no conflict of interest.

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