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MOBILIZATION OF PRE-ANTHESIS STEM, LEAF AND CHAFF RESERVES (PR) TO FINAL GRAIN WEIGHT OF WHEAT GENOTYPES

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Abstract

A field experiment was conducted at the Crop Physiology and Ecology Department of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh for two consecutive years 2011-12 and 2012-13 with eight wheat genotypes under three growing conditions viz., 27 November, 17 December and 7 January to determine changes of reserve mobilization of wheat .At different growing conditions, heat sensitive genotypes showed higher pre-anthesis stem, leaf and chaff reserves (PR) mobilization (14.82% to 18.92% and 13.75% to 17.32% for the first and second year, respectively) *to the final grain weight compared to moderate heat tolerant (MHT) and heat tolerant genotypes. Each genotype showed a common tendency of higher PR mobilization to grain under late and very late growing heat stress conditions. But the increased values of PR were lower in heat tolerant genotypes than those of MHT and heat sensitive genotypes.*

Key words*:* Reserve mobilization, Wheat and Heat stress.

INTRODUCTION

Wheat is a C_3 plant that thrives well in cool environments. According to Reynolds *et al*., (2001) wheat is, however, a widely-grown crop from temperate, irrigated to dry and high rainfall areas and from warm, humid to dry cold environments. However, the production of this important cereal is limited by a number of abiotic stress factors such as drought, heat and salinity. Battisti and Naylor (2009) reported that heat stress is the most important stress factor that affects between 25 and 30 million hectares of wheat annually in the world and thereby causing significant grain yield reduction. Under the high temperature, the wheat crop completes its life cycle much faster than under normal temperature conditions (Fischer, 1985). Since the wheat crop has continues growth stages, consequently there are fewer days to accumulate assimilate during life cycle and production of biomass is reduced (Fischer and Maurer, 1976). It ultimately affects grain filling and lastly the yield of crop. Responses to high temperature of plant vary with plant species, variety and phenological stages. The accumulative heat units and system or adopted for determining the dates of flowering/heading and maturity of different field crops (Sikder, 2009). Reproductive processes are markedly affected by high temperature in most plants; which ultimately affect fertilization and post fertilization processes leading to reduced crop yield (Wahid *et al.*, 2007). Mobilized stem reserves enhance grain filling when the current photosynthetic source is inhabited by stress (Blum, 1988). Stored assimilates are important source for grain filling in

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wheat (Blum *et al.* 1994). Up to 0.78 gm of grain may be produced from 1 gm of assimilates stored in wheat stover (Kiniry, 1993). The present study was undertaken to determine changes of reserve mobilization of wheat under different growing conditions.

MATERIAL AND METHODS

The experiment was carried out at the research farm of Crop Physiology and Ecology Department, HSTU, Dinajpur during 2011-12 and 2012-13. It was laid out in a split plot arrangements with three replications. The unit plot size was 3 m × 2 m having a plot-to-plot and block-to-block distance of 0.75 m and 1.0 m, respectively. For crop cultivation, the management practice recommended by Wheat Research Center (WRC) was followed.

A. **Main plot treatment:** Three growing conditions

1. Normal sowing: (27 November 2011 and 2012)
2. Late sowing or post- anthesis heat stress: (17 December 2011 and 2012)
3. Very late sowing or extreme post-anthesis heat stress: (7 January 2011 and 2012)

B. **Sub plot treatment:** Eight wheat genotypes viz. Prodip, BARI Gom-25, BARI Gom-26, BAW-1143, BAW-1146, BAW-1147, BAW-1148 and Pavon-76 (as check).

For determination of pre-anthesis leaf, chaff and stem contribution towards the final grain weight, the method of Gallaghar *et al*., (1975) was used. This is based on the net loss in weight of above ground vegetative organs between anthesis stage and harvesting maturity with the difference yield and net assimilation.

Pre-anthesis contribution/Translocation (%) = $\frac{S1-S2}{G2-G1}$ x 100

Where**,** S_1= Stem/leaf/chaff dry weight (g) at anthesis

S_2= Stem/leaf/chaff dry weight (g) at maturity

G_1= Grain dry weight (g) at anthesis

G_2= Grain dry weight (g) at maturity

Current photosynthates (%) was calculated by the following formula-

% contribution of current photosynthates = 100-translocation % (Rahman, 2010)

After four weeks of sowing, the main stem of 5 plants in each plot was marked by colored thread for easy identification of main stem during subsequent sampling. Five main stems were taken from each plot as sample at anthesis as well as at final harvest for measuring weights. After collection, spike, stem and leaf were separated and dried at 70°C for 48 hours in an electrical oven (Model–E28# 03-54639, Binder, Germany) and the dry weights of these plant parts were taken by an electrical balance (Model-AND EK-300i) and expressed in grams.

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT-C computer package (Russell, 1994). The treatment means were compared using Duncan’s Multiple Range Test (DMRT) (Duncan, 1955) at $P \leq 0.05$. Correlation and Regression analysis was also done and level of significance was tested with t-test (Singh and Choudhary, 1985).

RESULTS AND DISCUSSIONS

Pre-anthesis reserves (PSR) mobilization to final grain weight of eight wheat genotypes is presented in Table 1.1 for first year (2011-12) and Table 1.2 for second year (2012-13). Results showed that the combined effect of sowing times and wheat genotypes significantly influenced the PR mobilization. Under normal growing condition, the contributions of pre-anthesis stem reserves to the final grain weight varied from 14.82% to 18.92% and 13.75% to 17.32% for the first and second year, respectively in heat tolerant (HT) genotypes (BAW-1143, Prodip, BARI Gom-25, BARI Gom-26, BAW-1146 and BAW-1147) while in heat sensitive genotype (Pavon-76) it was 26.94% for first year and 25.97% for second year. In this growing condition, the highest pre-anthesis stem reserves mobilized from stem to grain in heat sensitive (HS) genotype Pavon-76 (25.97% and 26.94 for the first and second year respectively). Therefore, the lowest PR mobilization was found in HT genotype BAW-1143 (14.82% for first year and 13.75 % for second year). Variety BARI Gom-26, BARI Gom-25 and Prodip showed 16.43%, 16.53% and 17.33% PSR mobilization to the final grain weight respectively. Under late and very late growing condition, reserve mobilization was increased in different magnitude in different genotypes. Under late growing condition, Pavon-76 attained the highest pre-anthesis stem reserves contribution to the final grain weight (22.73 % for first year and 29.56% for second year). Whereas, in HT genotypes (BAW-1143, BARI Gom-26, BARI Gom-25 and Prodip) the ranges of PSR contribution to the final grain weight were 24.11% to 27.20% for first year and for second year it was 17.82% to 19.23 %.

Table 1.1. Pre-anthesis contribution (%) of stem, leaf and chaff materials to the final grain weight of eight wheat genotypes as affected by growing condition in 2011-2012

Genotypes	Contribution (%) to grain of								
	Stem			**Leaf**			**Chaff**		
	Growing condition			Growing condition			Growing condition		
	Normal	Late	Very late	Normal	Late	Very late	Normal	Late	Very late
Prodip	17.33jk	21.28de	27.2c	5.28eh	6.79bh	7.6ae	3.09mo	3.98ik	6.40cd
BARI Gom-25	16.53kl	20.38gi	26.59cd	5.01ei	6.32dh	7.14af	2.79op	3.81km	5.80de
BARI Gom-26	16.43kl	20.24hi	26.70cd	4.83fi	5.47eh	7.31ah	2.55p	3.66km	6.15ef
BAW-1143	14.82lm	18.64ik	24.11ef	3.09gi	4.74hi	5.03fi	2.91p	3.89jl	4.57hi
BAW-1146	18.56ik	21.95fh	27.18cd	5.77i	7.17ag	8.64ac	3.29lo	4.51hj	6.76bc
BAW-1147	18.92ij	21.42fh	27.95c	6.31dh	7.95ad	8.86ab	3.38ko	4.50hi	6.96ac
BAW-1148	20.8gi	22.73eg	28.71c	6.81cg	7.87bc	9.35a	3.48kn	4.89gh	7.06ab
Pavon-76	26.94c	31.65b	40.10a	6.93bh	7.82ab	9.33a	4.90gh	5.33fh	7.40a
CV (%)	5.22			5.39			7.17		

Mean followed by same letter(s) did not differ significantly at 5% level of significance.

Under very late growing condition, again HS genotype Pavon-76 attained the highest pre-anthesis stem reserves contribution to the final grain weight (31.65 % for first year and 38.45% for second year). Whereas, in HT genotypes (BAW-1143, BARI Gom-26, BARI Gom-25 and Prodip) the ranges of PSR contribution to the final grain weight were 18.64% to 27.2 % for first year and 23.85 % to 25.87 % for second year. In moderately heat, tolerant genotypes (BAW-1146, BAW-1147 and BAW-1148) these ranges were 27.18% to 28.71% for first year and 26.57 % to 27.15 % for second year. These results indicate that under late and very late environment longer post-anthesis durated genotypes were less dependent and shorter post- anthesis durated genotypes were more dependent on stem reserve. This might be due to that under normal condition onset of senescence occurred more or less in the same time in both the heat tolerant and heat sensitive genotypes. But in case of late condition onset of senescence occurred much later in heat tolerant genotypes than those of heat sensitive.

In normal growing condition, the per cent contribution of leaf to the grain was maximum in genotype Pavon-76 (6.93% for first year and 6.63 % for second year) and minimum in genotype BAW-1143 (3.05 % for first year and 2.95 % for second year). In late growing condition, it was maximum in

BAW-1147 (7.95%) for first year and in second year it was 6.56% in Pavon-76. The minimum value of 4.74% and 4.52% of this parameter was found for BAW-1143 for both years. Under very late condition, the per cent contribution of leaf to grain was maximum in genotype BAW-1148 (9.35% for first year) and in second year it was maximum in Pavon-76 (8.76%). On the other hand, the minimum contribution of leaf to grain was (5.03%) in BAW-1143 for first year and in second year it was5.72% in same genotype.

In normal growing condition, the % contribution of chaff to grain was higher in genotype Pavon-76 (4.90% for first year and 4.78 % for second year) and the per cent contribution of chaff to the grain was minimum in genotype BARI Gom-26 (2.55 % for first year and 2.72 % in BAW-1143 for second year). In late growing condition the maximum value of this trait was in Pavon-76 (5.33% for first year) and 5.25 % in second year. The minimum contribution of chaff to the grain was in genotype BARI Gom-26 (3.66% for first year) and genotype BAW-1143 attained 3.78% in second year. Under very late condition, the per cent contribution of leaf to grain was maximum in genotype Pavon-76 (7.40% and 6.33% for first and second year, respectively) and minimum in BAW-1143 (4.57% and 4.13% for first year, respectively).

Table 1.2. Pre-anthesis percent contribution of stem, leaf and chaff materials to the final grain weight of eight wheat genotypes as affected by growing condition in 2012-2013

Percent contribution to grain of									
Genotypes	**Stem**			**Leaf**			**Chaff**		
	Growing condition			Growing condition			Growing condition		
	Normal	Late	Very late	Normal	Late	Very late	Normal	Late	Very late
Prodip	15.13p	19.23k	25.87e	4.68lm	6.72dg	6.92cf	2.96mo	4.03fj	4.87bg
BARI Gom-25	14.72q	18.76l	24.72f	3.58n	5.78hk	5.92hj	2.91no	3.96gl	4.72be
BARI Gom-26	14.65q	18.55l	24.17f	3.13no	5.23kl	5.87hk	2.83o	3.86hm	4.56bf
BAW-1143	13.75r	17.82m	23.85g	2.95o	4.52m	5.72ik	2.72no	3.78im	4.13ek
BAW-1146	16.58o	20.51 j	26.57d	5.37jk	6.97cf	7.35bd	3.17lo	4.35dj	5.13bd
BAW-1147	17.32n	21.32i	26.92c	6.19gi	7.13be	7.56bc	3.38ko	4.67ci	5.52ac
BAW-1148	18.58l	22.17 h	27.15c	6.38fh	7.25be	7.72b	3.58jn	4.72ci	5.72ab
Pavon-76	25.97e	29.56b	38.45a	6.63eg	7.56bc	8.76a	4.78ch	5.25bd	6.33a
CV (%)	6.34			5.76			7.31		

Mean followed by same letter(s) did not differ significantly at 5% level of significance

From the results, it was found that sowing time had profound effect on pre-anthesis stem reserves (PSR) mobilization to final grain weight of different wheat varieties. Similar results were found by Blum *et al.*, (1994), Sikder and Paul (2010), Al-Khatib and Paulsen (1990) in wheat. Higher PSR mobilization indicated their more dependence on the pre-anthesis stem reserves to grain weight and more heat sensitivity (Sikder *et al.*, 1999). However, Harding *et al.*, (1990) reported that heat stress injury of photosynthetic apparatus during the reproductive growth of wheat diminished source activity and sink capacity reducing productivity. Environment and different combination of genotypes on the other hand may have variable responses (Ullah *et al.* 2016). Enhanced mobilization of stem reserves may be an effective mechanism of tolerance of heat and drought especially for determinant crops like wheat. However, using certain microbes or application of fertilizers may affect assimilate (Adnan *et al.*, 2016). Results from other studies indicated that wheat grain filling depended upon two major sources of carbon: current photosynthesis in leaves and shoot and the mobilization of stored carbohydrate from the stem into the growing grain (Blum *et al.*, 1994). Photosynthesis decreased sharply at heat stress (Blum, 1986; Rawson, 1986). When the current photosynthesis source is inhibited by drought or any stress grain filling becomes more dependent on mobilized stem reserves (Blum, 1988). Grain filling of wheat is seriously impaired by heat stress due to reduction of current leaf and ear photosynthesis at high temperature (Blum *et al.*, 1994). Gallagher *et al.*, (1975) observed an increase of pre-anthesis stem reserves translocation up to 74% to the final grain weight under stressful environment. To better understand wheat crop in stressful environment, those parameters will be taken in consideration, which are expressing well (Ullah *et al.* 2014). Post-anthesis stem reserve mobilization is an important assimilate contributing source for grain filling in wheat under temperature stress condition invariably encountered in the major wheat growing regions of the world (Al-Khatib and Paulsen, 1990; Blum *et al.*, 1994). High yielding genotypes showed more dry matter accumulation in grain whereas low grain yielding genotypes retained much dry matter in stem, leaves and chaff (Sanghera and Thind, 2014).

Contribution of current Photo assimilate: Per cent contribution of current photosynthesis to grain weight of eight wheat genotypes is presented in Table 2.1 for first year (2011-12) and Table 2.2 for second year (2012-13). At normal growing condition, the contribution of current photosynthesis to the grain was higher (79.18) in genotype BAW-1143, which was followed by genotypes BARI Gom-25, BARI Gom-26 and the lowest in genotype Pavon-76 (61.23%) for first year. In second year, it was higher (80.58%) in genotype BAW-1143 and lowest in Pavon-76 (62.62%). At late growing condition, the contribution of current photosynthesis to grain was higher (72.73%) in genotype BAW-1143 and lowest in genotype Pavon-76 (54.20%) for first year. In second year, higher (73.88%) in BAW-1143 and lower in Pavon-76 (57.63%).

Table 2.1. Contribution (%) of current photosynthesis to the final grain weight of eight wheat genotypes in 2011-2012.

Genotypes	Contribution (%) current photosynthesis to grain under		
	Normal growing condition	Late growing condition	Very late growing condition
Prodip	74.30bd	67.95fi	58.81lm
BARI Gom-25	75.67ac	69.49eg	59.84lm
BARI Gom-26	76.19ab	70.63dg	60.47kl
BAW-1143	79.18a	72.73be	66.29gi
BAW-1146	72.38bf	66.37gi	57.32ln
BAW-1147	71.39cf	65.21hj	55.46mn
BAW-1148	68.90ei	64.43ik	55.64mn
Pavon-76	61.23jl	54.20n	43.07o
CV (%)	3.83		

Mean followed by same letter(s) did not differ significantly at 5% level of significance.

At very late growing condition, the contribution of current photosynthesis to grain was highest in genotype BAW-1143 and lowest in genotype Pavon-76 for both the years. It is clear from the above results that under late seeding environment most of the long grain filling duration genotypes were less dependent on photosynthetic reserve, whereas more dependent on current photosynthesis. On the other hand, most of the short grain filling duration genotypes was more dependent on photosynthetic reserve, whereas less dependent on photosynthesis compare to long grain–filling duration genotypes under late seeding environment.

Table 2.2. Contribution (%) of current photosynthesis to the final grain weight of eight wheat genotypes in 2012-2013

Genotypes	Contribution (%) current photosynthesis to grain under		
	Normal growing condition	Late growing condition	Very late growing condition
Prodip	77.23ab	70.02df	62.34ik
BARI Gom-25	78.79a	71.50ce	64.64gj
BARI Gom-26	79.39a	72.36cd	65.40gi
BAW-1143	80.58a	73.88bd	66.30fh
BAW-1146	74.88bc	68.17eg	60.95jl
BAW-1147	73.11cd	66.98fg	60.00kl
BAW-1148	71.46ce	65.86gi	59.41kl
Pavon-76	62.62hk	57.63l	46.46m
CV (%)	5.43		

Mean followed by same letter(s) did not differ significantly at 5% level of significance

This result is agreed with Rahman *et al*., (2010). High yielding genotypes showed more dry matter partitioning accumulation in grain whereas low grain yielding genotypes retained much dry matter in stem, leaves and chaff. So, timely sown genotypes had more percentage of dry matter partitioned to grain as compared to late sown conditions. Evans *et al.,* (1975) also reported that the per cent of assimilates contribution is different depending on the cultivar and environmental conditions.

CONCLUSION

The effect of heat stress and wheat genotypes significantly influenced the PR mobilization. Under normal growing condition, the highest pre-anthesis stem reserves mobilized from stem to grain in heat sensitive (HS) genotype Pavon-76. Similarly, the lowest PR mobilization was found in heat tolerant (HT) genotype BAW-1143. Under late and very late growing conditions, genotype Pavon-76 attained the highest pre-anthesis stem reserves contribution to the final grain weight. Whereas genotypes BAW-1143, BARI Gom-26, BARI Gom-25 and Prodip which were heat tolerant, attained the lowest pre-anthesis stem reserves contribution to grain. On the other hand, leaf and the chaff highest reserve were in genotype Pavon-76 and minimum in genotype BARI Gom-26 at normal growing condition but it was increased at late and very late growing conditions.

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