Partitioning of Accumulated Dry Matter Along the Seed Fill Duration of some Wheat Varieties (*Triticumaestivuml.*)

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ABSTRACT

Seven wheat varieties were cultivated during the winter seasons of 2013 and 2014 in Sulaimani Crop Research Center – Bakrajo. A Field experiment was conducted each year as CRBD with three replications. The most important vegetative and reproductive criteria were studied as well as dry matter accumulation and its partitioning through destructive samples. They were taken every 10 days in order to study the partitioning of assimilates to different parts of the plant leaf, stem, and spike under different environmental factors of the two years. The influence of the duration length of seed filling on the accumulated dry matter and its partitioning to the spike, the Spike Partitioning Coefficient and growth parameters such as Seed Growth Rate (SGR) and Seed Filling Duration (SFD) were studied. Environmental factors influenced the Dry matter accumulation and the partitioning of assimilates as well as the length of the growth stages especially SFD.

Keywords: *DM accumulation, partitioning, SFD, SGR, Wheat varieties.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is considered as a widely adapted crop, it is grown in different environments with various environmental stresses, particularly heat and water deficit that may shorten or lengthen the wheat growth between phases. Thus final yield is therefore the product of cumulative seasonal biotic and abiotic factors (FAO, 2015). In most seed crops, individual seed weight is commonly analysed as the product of the individual seed growth rate by the duration of seed filling (Munier-Jolain, *et al.* 1998). The environmental conditions and there is genetic variation in most crops, Seed-fill duration in many crops increases as temperature decreases below 30°C. Water stress during the seed filling accelerates leaf senescence and shortens the seed filling period. The response of seed-fill duration to alterations in source-sink ratios is inconsistent.

It probably depends on whether the supply of assimilate to the seed is affected and if the seed can respond to changes in assimilation supply. Stem reserves offer a powerful resource for grain filling under any type of stress which inhibits current assimilation that can be supplied by photosynthesis (Blum, 1998; Egli, 2004).

Accumulated dry matter varies according to wheat growth stages and the environmental factors that will exceed during the growth stages along the life-cycle from emergence to physiological maturity. Environmental factors could effect dry matter accumulation and its partitioning through the effect on the energy balance between photosynthesis and respiration. Temperature is one of the main driving forces for wheat growth and development. Several phenological stages are manifested throughout its development, high temperature could affect SGR directly by affecting

seed metabolism or by affecting the supply of assimilate to the seeds (Egli, 1998). Total dry matter accumulation was adversely affected by heat stress and reduces the dry matter production (Nicolas *et al.*, 1984; Sanghera and Thind 2014). Dry matter accumulation and cell division proceeded at a higher rate but had a shorter duration of the high temperature treatments (Nicolas *et al.*, 1984). The dry matter partitioned to stem and Spike, in particular, responded quantitatively in different manners to changes in environmental resources, and provided insights into how single plants interact with their environment, adjust their dry matter partitioning, and determine grain yield (Jaradat, 2009).

MATERIALS AND METHODS

Seven wheat varieties included Aras local variety and six foreign varieties were cultivated in the winter season of 2013 November and repeated in winter 2014. Field experiment was conducted in both years by CRBD with three replications at the Sulaimani Research Center- Bakrajo. All agricultural processes were practiced as required. Vegetative criteria such as length of growth season, within growth stages and reproductive criteria, 1000 grain weight, biological weight, grain yield, and Harvest index were studied as well as the rate of dry matter accumulation and its partitioning to plant parts stem, leaves and spike each every 10 days (from anthesis) were determined in order to study the Seed Growth rate (SGR) with an equation:

$$SGR = \ln W_2 - \ln W_1 / t_2 - t_1 \quad (1)$$

Where: $\ln W_2$ is natural logarithm of weight number 2 of the sample.

$\ln W_1$ is natural logarithm of weight number 1 of the sample.

t_2 is the time (number of days 2.)

t_1 is the time (number of days 1.)

In order to study the effect of seed filling duration (SFD) on the biomass and yield increasing and the effect of partitioning to the spike, the parameter Spike partitioning coefficient (SPC) was estimated according to the following relations (Donaldson, 1999 cited by Kumar *et al.*, 2006):

$$SPC\% = SDW / DMT \times 100 \quad (2)$$

Where SDW-spike dry weight

DMT-amount of dry matter translocated

RESULTS AND DISCUSSIONS

Vegetative Growth Characters

Tab. 1 reveals significant differences among some of studied vegetative traits of the seven wheat varieties in the first season, while there were no significant differences among varieties due to number of days of filling period. However significant differences were recorded between the length of growth stages no. of days to 50% heading, no. of days to 50% flowering, and no. of days to 50% maturity in which the local variety (Aras) as an adapted cultivar showed minimum durations for the three stages by (123.333, 128.000, and 167.000) days, respectively.

Tab. 1, indicates to significant differences in the required days to maturity which was between (170 to 171.666) days of the six foreign varieties with only 1.666 day difference, while the local variety (Aras) needed 167 days as well as the intervals between the different growth stages of the local variety was shortest than other

Tab. 1. Vegetative growth traits studied in the 1st year

Varieties	No of leaves	Plant height (cm)	No of tillering	No. of days to 50% heading	No. of days to 50% flowering	No. of days to 50% maturity	Filling period (day)
D30	4.500	76.000	3.666	124.000	129.666	170.000	40.334
D31	5.000	84.666	3.666	127.333	131.333	171.333	40.000
Ayorio	4.166	67.666	3.333	131.333	130.666	171.667	41.001
Addna99	5.000	78.666	3.000	126.333	131.000	171.333	40.333
Azar	4.333	112.666	4.000	127.333	132.000	171.667	39.667
Cehan99	5.333	79.333	3.666	128.000	131.666	171.667	40.001
Aras	4.766	83.000	3.333	123.333	128.888	167.000	39.000
LSD	N.S	6.172 *	N.S	1.267 *	3.823*	1.326*	NS

varieties that might be due to its adaptation (Liu *et al.*, 2010). There was similar result for SFD, in which there were not significant differences among all varieties. According to the previous results the differences between varieties in the reproductive criteria should be sourced from the partitioning of dry matter accumulated during the life-cycle of the wheat varieties (Salazar-Gutierrez *et al.*, 2013).

Tab. 2 reveals the response of wheat varieties to environmental factors of the second season, in which there were significant differences among wheat varieties in vegetative growth criteria except no. of leaves. The local variety Aras showed similar result of first season that required minimum days required to 50% heading, 50% flowering, and 50% maturity with (136.666, 141, and 171) days respectively. In case of number of days of filling period were decreasing in the number of days was realized for all varieties in this season (climatic factors might affect the decrease in filling period, appendix 2), and the Azar variety exceeded others

by 37.333 days, while D30 variety passed the stage with minimum days of 33.333 days. The results agree with what were investigated by (Egli, 2004; FAO, 2015).

Reproductive Criteria

Tab. 3 indicates significant differences among seven wheat varieties responses to reproductive criteria in first season. Variety D31 exceeded other varieties in the criteria of yield, Biological Yield, and HI giving (3491.667 kg ha⁻¹, 10500 kg ha⁻¹, and 0.33) respectively. No significant difference in 1000 grain weight was observed between D31 and Azar varieties that recorded maximum weight by 32.533g. However, the minimum records of previous characters were shown by Azar, D30, Azar, and cehan99. Tab. 4, shows significant response of the seven wheat varieties to the environmental conditions for the second season in which variety D31 exceeded all variety in producing maximum yield and largest Harvest Index by (4679.667 kg ha⁻¹ and 0.323, respectively, while the minimum

Tab.2. Vegetative growth traits studied in the 2nd year

Varieties	No of leaves	Plant height (cm)	No of tillering	No. of days to 50% heading	No. of days to 50% flowering	No. of days to 50% maturity	Filling period (day)
D30	4.500	92.000	4.000	139.333	143.666	177.000	33.333
D31	5.000	94.666	4.000	140.333	143.000	178.000	35.000
Ayorio	4.166	78.333	5.000	143.000	149.000	183.000	34.000
Addna99	5.000	93.000	4.333	140.333	143.666	178.333	34.666
Azar	4.333	115.333	4.333	140.000	143.666	181.000	37.333
Cehan99	5.333	90.000	3.000	141.000	143.666	178.666	35.000
Aras	4.766	94.666	4.333	136.666	141.000	177.000	36.000
LSD	N.S	5.289*	0.989*	0.989*	0.951*	0.896*	1.186*

Tab. 3. Reproductive traits studied in the 1st year

Varieties	Wt. of 1000 grain (g)	Yield kg ha ⁻¹	Biological yield(g)	HI
D30	29.133	3491.667	10500.000	0.33
D31	29.800	4144.166	12416.667	0.33
Ayorio	28.266	3899.167	11833.333	0.32
Addna99	27.533	4065.833	12500.000	0.32
Azar	32.533	3400.000	12000.000	0.28
Cehan99	27.266	4007.500	12250.000	0.32
Aras	29.733	3950.000	11250.000	0.35
LSD	2.986	472.617	NS	0.043

yield production and the shortest HI were recorded by Azar variety with (2248kg ha⁻¹ and 0.163) respectively. Although the maximum weight of 1000 grain weight was recorded by this variety but its impact on the variety final yield was not effective. It may be due to the variation in number of grains produced by varieties as another important yield component (Egli, 1998).

Dry Matter Accumulation and Partitioning

Tabs. 5, 6, and 7 indicate significant differences among seven varieties in the rate of dry matter accumulation which partitioned to the leaves, stem, and spike in both seasons from April 14th, in which 50% flowering occurred, to May 25th that all varieties were in physiological maturity stage. There was an increasing in dry matter partitioned to the spike in both seasons. However according to the result data of table 5 there were significant differences in allocating assimilates to the spike during the beginning of the seed filling period in April. There were no significant differences in

the amount of DM partitioned to spike in the mid and the later weeks of seed filling period. At the beginning period of seed filling April 14th of the first season the V1 variety exceeded others in the amount of dry matter, partitioned to spike by 2.633 g. While V4 variety recorded the smallest amount by 1.4 g. At the mid season in which there was no significant differences among varieties there was increasing in seed Growth Rate (SGR) recorded by all varieties from the beginning of SFD to the mid of the period with variation among varieties. The maximum SGR was recorded by V2(D31) in the mid of filling period by 0.143 g d⁻¹, while the minimum SGR was presented by V7 recording 0.062 d⁻¹. The SGR from the mid of SFD to PM revealed a great variation among seven varieties, while the V1 variety showed maximum SGR. There was declining in the SGR of the varieties V3 and V7 by 0.007 and 0.070 g d⁻¹ respectively. This declining may be manifested because of PM of the two varieties were occurred much earlier genetically

Tab. 4. reproductive traits studied in the 2nd year

Varieties	Wt. of 1000 grain (g)	Yield kg ha ⁻¹	Biological yield (g)	HI
D30	26.333	4154.667	14166.67	0.29
D31	27.000	4679.667	14583.333	0.32
Ayorio	25.000	3054.000	13083.33	0.23
Addna99	26.666	3990.667	16250.000	0.26
Azar	32.333	2248.000	13333.333	0.16
Cehan99	26.666	3914.667	16083.333	0.24
Aras	32.666	3443.667	13250.000	0.26
LSD	2.585*	600.126	1935.777	0.046*

Tab. 5. Dry matter accumulation partitioned to spike in both seasons

Varieties	Accumulated Dry Matter Partitioned to Spike									
	First Season					Second Season				
	14/4	24/4	5/5	15/5	25/5	14/4	24/4	5-May	15/5	25/5
V1	2.633	3.733	5.467	5.133	8.567	4.000	1.767	3.933	6.200	8.167
V2	1.667	2.833	4.667	5.233	5.567	4.000	1.067	5.367	4.700	2.400
V3	2.400	1.633	3.933	2.900	3.800	5.000	3.033	5.067	4.967	2.800
V4	1.400	2.800	3.400	4.867	4.567	4.333	1.100	4.567	5.267	4.667
V5	2.133	2.733	4.167	4.100	5.267	4.333	1.800	2.200	4.167	3.667
V6	2.300	2.533	4.667	4.667	4.833	3.000	1.067	3.967	4.300	3.667
V7	2.133	4.067	4.800	3.467	3.400	4.333	1.600	6.367	5.267	6.633
L.S.D	1.685	2.402	NS	NS	3.626	0.989	1.633	2.244	NS	2.873

or as response to environmental factors. The results agree with some other (Meng *et al.*, 2013; Sanghera and Thind, 2014). Tab. 5 reveals significant differences among seven varieties in accumulating and partitioning of assimilates to spike in the second year across the SFD. Variety V3 has superiority in compare to others in April, 14th and April 24th. The local variety exceeded others at the mid of season by 6.367g, while V1 exceed all varieties at May 15th and May 25th by 6.2g and 8.167g, respectively, however varieties (V6, V5, and V2) recorded the smallest amount of DM accumulation. Differences in SGR were observed among varieties along the SFD, the maximum SGR from the beginning of SFD to the mid of season was recorded by local variety with 0.097g d⁻¹ but at the period from mid of the SFD to PM the superiority was to V1 variety by 0.212 g d⁻¹ the environmental factors that exceeded the period of seed filling may influenced the accumulating

of assimilates and daily SGR, in which the period was much shorter than first season and the rising of temperature especially in the later weeks of the period (appendix, 2). These Results are in accordance to what were found by (Munier-Jolain, *et al.* 1998; Ehdaie and Waneis, 2010; Sanghera and Thind, 2014). Tabs. 6 and 7, and Figs. 1 and 2 reveals the significant differences among seven varieties in spike Partitioning Coefficient (SPC), in both seasons, there were general declining in DM partitioning to the stem and leaves from the beginning of SFD to the PM for all varieties as well as increasing in spike weight, Figs. 1 and 2, showed maximum SPC recorded in the first season by V1 at week before PM, While in the second season V2 variety was the best in SPC at the PM recording 0.667%. The higher partitioning of assimilates may affected the seed size as a very important factor of yield component which resulted in the highest grain yield production of this variety. Wheat

Tab. 6. Dry matter accumulation partitioned to stem in both seasons

Varieties	Accumulated Dry Matter Partitioned to Stem									
	First Season					Second Season				
	14/4	24/4	5/5	15/5	25/5	14/4	24/4	5-May	15/5	25/5
V1	4.567	5.133	5.900	2.900	3.133	4.800	4.800	4.167	5.300	3.600
V2	3.167	5.400	5.733	3.233	3.933	4.033	4.033	6.933	3.800	0.667
V3	3.467	3.167	2.200	1.267	2.300	4.267	4.267	4.000	3.200	1.667
V4	3.500	6.500	3.300	2.600	2.133	3.667	3.667	4.967	4.933	3.333
V5	6.667	6.333	5.833	3.533	3.800	6.333	6.333	5.333	4.700	3.667
V6	5.733	4.300	5.100	2.800	2.767	3.233	3.233	5.700	3.467	1.633
V7	4.367	5.567	3.700	1.733	1.433	4.867	4.867	7.500	4.300	3.633
L.S.D	2.637	2.436	2.833	1.964	1.957	N.S	N.S	2.259	1.747	1.521

Tab. 7. Dry matter accumulation partitioned to leaves in both seasons

Varieties	Accumulated Dry Matter Partitioned to Leaves									
	First Season					Second Season				
	14/4	24/4	5-May	15/5	25/5	14/4	24/4	5-May	15/5	25/5
V1		1.633	1.467	0.333	3.333		1.900	1.333	1.267	0.667
V2		2.067	1.333	0.633	3.667		1.433	2.233	0.733	0.533
V3		1.533	0.700	0.700	3.333		2.767	1.300	1.033	0.900
V4		2.333	1.167	0.867	3.000		1.433	1.800	1.367	0.700
V5		1.967	1.233	0.767	4.000		2.233	1.267	0.517	0.667
V6		2.067	1.233	0.700	3.667		1.567	1.800	0.800	0.500
V7		2.133	1.067	0.200	3.333		2.133	3.200	1.033	0.700
L.S.D		N.S	N.S	0.516	NS		N.S	0.964	NS	NS

productivity depends on dry matter accumulation and the alteration in source-sink especially during the seed filling period, significant differences in the SPC among seven varieties may result under the differences in photosynthetic efficiency as well as the efficiency converting light energy to dry

matter and allocating of accumulated DM to the spike, and the reserve mobilization from wheat plant parts such as stem. Similar results were obtained by (Blum, 1998; Kumar *et al.*, 2006).

Tab. 8 and Annexes 1 and 2, indicate the significant differences between the environmental

Fig. 1. Spike Partitioning Coefficient at different periods post-Anthesis in the first season

Fig. 2. Spike Partitioning Coefficient at different periods post-Anthesis in the second season

Tab. 8. Effect of years on the accumulated dry matter partitioned to different parts of the plant, leaf, stem and spike

Year	14/4			24/4			5/5			15/5			25/5		
	leaf	stem	spike	leaf	stem	spike	leaf	stem	spike	leaf	stem	spike	leaf	stem	spike
Y1	4.495	4.495	2.095	1.962	5.200	2.904	1.171	4.538	4.442	0.600	2.561	4.338	3.524	2.785	5.142
Y2	3.299	3.299	4.142	1.923	4.457	1.633	1.847	2.259	4.495	0.965	4.243	4.981	0.666	1.521	4.571
LSD	NS	NS	0.783	NS	NS	0.768	0.237	1.449	NS	NS	0.735	NS	1.084	NS	NS

ANNEXES

Annex 1. Meterological data for the period April 16 - May 31- 2013

Date	Rate	Windvane Degree	Humidity	Air Temp. C	Energy m ⁻²	W	Pressure mb	Wind speed ms-1	Rainfall mm
16/4 - 23/4	Average	205.3	38.9	15.8	214.6		823	1.4	520.8
	Max.	355	95	24.4	1034.3		850.9	4.7	528.6
	Min.	0.1	15.4	7.5	0		814.3	0	518.6
24/4- 30/4	Average	180.9	18.3	21.2	332.4		829.9	0.9	528.6
	Max.	354.4	82.4	31.8	1060.9		850.4	3.9	528.6
	Min.	0.1	12.7	8.4	0		822.6	0	528.6
1/5- 7/5	Average	194.9	32.5	22.1	245.3		826.8	1	531.8
	Max.	351.7	95	30.5	1056.5		854.3	4.3	548
	Min.	0.1	14.8	14.4	0		818.7	0	528.6
8/5- 15/5	Average	181.9	49.5	21.1	231.5		826.3	1.3	557.3
	Max.	347.1	95	33.7	1074.5		850.9	5.3	571.8
	Min.	0.1	10.0	12.4	0		817.7	0	548.2
16/5 -23/5	Average	197	28.8	21.8	291.6		828	1.3	572.4
	Max.	354.5	75.5	32.2	1123.1		869.4	4.6	572.4
	Min.	0.1	11.3	12	0		818.2	0	572.4
24/5- 31/5	Average	195.3	14.8	27.1	333.2		846.6	1.3	572.4
	Max.	355.1	35.2	37.5	1069.8		875.3	5.4	572.4
	Min.	0.1	10.2	16.9	0		817.7	0	572.4

Annex 2. Meterological data for the period April 16 - May 31- 2014

Date	Rate	Windvane Degree	Humidity %RH	Air Temp. C	Energy m ⁻²	W	Pressure mb	Wind speed ms-1	Rainfall mm
16/4 - 23/4	Average	109.7	41	20	260.6		838.9	1.2	601.2
	Max.	347.7	80.5	29.6	1012.1		872.4	3.8	602.2
	Min.	0.1	10.7	11.5	0		819.1	0	600.6
24/4- 30/4	Average	221.1	41.8	21.6	283.9		838.2	1.1	607.2
	Max.	353.1	93.5	31.6	1060.9		866	4.3	617
	Min.	0	11.4	12.5	0		819.1	0	602.2
1/5- 7/5	Average	224.1	22.2	23.1	320.1		834.1	1	617
	Max.	354.1	50.3	35.1	1096.4		866	4.2	617
	Min.	0	9.0	13	0		818.7	0	617
8/5- 15/5	Average	236.5	25.2	24	281.7		835.4	1.1	620.8
	Max.	236.5	71.4	34.1	1074.2		880.2	3.9	627.2
	Min.	236.5	9.1	14.3	0		817.2	0	617
16/5 -23/5	Average	236.5	13.9	24.2	276.2		837.9	1	627.3
	Max.	236.5	56.1	34.5	1096.4		875.3	4.5	629
	Min.	236.5	10.2	14	0		818.2	0	627.2
24/5- 31/5	Average	236.5	12.6	27.2	311.1		833.2	1.1	631.8
	Max.	236.5	48.1	38.1	1087.5		868.9	4.2	634
	Min.	236.5	10.0	17	0		816.7	0	629

and climatic factors of the two years on the rate of dry matter accumulating and the partitioning to different parts leaf, stem, and spike along the period of seed filling SFD. While the second year exceeded the first in more partitioning of assimilates and photosynthesis to spike by 4.142g at the beginning of SFD at April 14th, there was exceeding of first year in partitioning to spike at April 24th, by 2.904g. There were no significant differences between the two years in the mid of the period of SF and also at May 15th, and May 25, however there were significant differences between the two years in partitioning to leaf and stem at May 5th, May 15th, and May 25th. In which the first year exceeded the second in partitioning to stem and leaf at May 5th, and May 25th by (4.538g and 3.524)g, respectively. The superiority of second year was at May 5th and May 15th in partitioning to stem and leaf by (1.847 and 4.243)g, respectively. The results agree with some other researches (Egli, 2004; Jaradat, 2009; Liu, 2010.)

CONCLUSION

Variation was noticed in the length of the period of seed filling for all varieties in both seasons, but the SFP of the second season was much shorter than the first. The environmental factors that exceeded during the period of seed filling of the second season may had influenced the accumulating of assimilates and daily SGR, especially temperature rising in the later weeks of the period. Dry matter accumulation and its partitioning were influenced according to the length of growth stages pre and post flowering much more than the length of SFD which genetically regulated. Climatic factors especially temperature and RH% play a great role in the rate of dry matter accumulation and its partitioning.

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