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Relationship Between Source and Sinke in some Different Durum Wheat Cultivars

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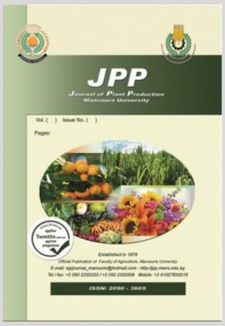

ABSTRACT

Source and sink relationship determine the growth and development in cereals, and can serve as reliable indicator to estimate durum wheat yield. A multi-year field trial was executed on ICARDA farm, Sids Agricultural Research Station farm, Agricultural Research Center (ARC), Egypt, during the two successive growing seasons of 2018/2019 and 2019/2020 to determine the effect of defoliation (source and sink limitation) on the yield attributes and grain yield of eight durum wheat cultivars. Eight defoliation treatments viz., i) control (no defoliation), ii) flag leaf blade removed, iii) flag leaf blade and the secondary leaf removed, iv) secondary leaf removed, v) spike awns and secondary leaf removed, vi) spike awns and flag leaf blade removed, VII) spike awns removed, and viii) Spike awns, flag leaf blade and secondary leaf removed were applied on eight durum wheat cultivars viz. i) Bani Suef 1, ii) Bani Suef 3, iii) Bani Suef 4, iv) Bani Suef 5, v) Bani Suef 6, vi) Sohag 3, vii) Sohag 4 and viii) Sohag 5. The study was comprised of wheat cultivars as the main plot while, defoliation (source and sink limitation) treatments as the sub-plots. Cultivars and treatments had significant effect on the number of grains spike-1, 1000-grain weight and grain yield. However, the highest grain yield was obtained from 'Bani-suef-1under all wheat defoliation treatment. On the other hand, the removal of spike awns and the secondary leaf treatment produced the highest 1000-grain weight and grain yield.

Keywords: *Triticum durum*, Cultivars, Awns, Flag leaf, Sink, Source.

INTRODUCTION

Globally, climate change, skyrocketing human population, hiking prices of staple foods and decreasing agricultural land necessitate boosting the productivity of cereals in a sustainable way (Iqbal *et al*. 2018, Siddiqui *et al*. 2019 and Hossain *et al*. 2021) Wheat is vital strategic crop globally for being the staple food of over half of world population (Yassin *et al*. 2019). Across the world, it is the leading food crop in terms of grain production each year, and its trade represents a significant component of the trade balance of national economy of Egypt (Yassin *et al*. 2019). Wheat is utilized and processed for many products, reflecting its importance for large quantities produced by people of diverse cultures and social groups (Täfee 1996 and Mussarat *et al*. 2021). Description of the parental genotypes is very important to wheat breeders. Some studies have been carried out attempting to determine whether yield of grain crops is sink/source-limited after the heading stage, with wheat being the most studied (Borrás *et al*.2004)**.**

While numerous studies have reported the defoliation impact on the biomass production of wheat (Paez-Garcia *et al*. 2019 and El-Sabagh *et al*. 2019), but very little is known about the fundamental changes which occur in wheat reproductive growth stage when plants get subjected to different leaf clipping. The degree of carbohydrates synthesis and distribution from leaves (source) through remobilization tend to influence the grain weight (sink) and yield of cereals including wheat. Conventional, the area of flag leaf has been considered as the main photosynthetic contributor to increase yield formation (Evans *et al*. 1972). However, it has been reported that defoliation at anthesis had only small effects on grain yield of wheat, rather source-sink relationship determined the grain number and weight (Liboon and Fischer 1990 and Ahmadi *et al*. 2009). There is guide that when a photosynthetic part of plant is separated, the compensation will be occurred by remaining photosynthesis (Chanishvili *et al*. 2005). Thus, the source limitation of grain yield in previous works (Ahmadi *et al*. 2009) may be because of the fact that the photosynthetic role of spike was neglected. The contribution role of spike photosynthesis in grain yield formation in wheat and barley has been reported from 10% to 76%, respectively (Biscoe *et al*. 1975). A recent study showed that the spike photosynthesis makes a significant contribution to wheat grain yield by 13-33% in normal condition and 22-45% under drought stress condition (Maydup *et al*. 2012). "Identifying the physiological mechanisms of grain filing is desirable for increasing wheat yield" (liu *et al*. 2021).

Many different durum wheat cultivars are realized in Egypt, and these cultivars perform differently under stress, we have observed different performance between the Egyptian durum wheat cultivars under heat and water deficit stress harmony with Yang *et al*. 2022. It was hypothesized that different cultivars of wheat can potentially differently respond to defoliation under agro-climatic conditions of Egypt. To test the postulated hypothesis, a study was designed on artificial manipulation of the source: sink ratio and evaluation of the variation in dry matter partitioning in

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eight durum wheat cultivars. The main objective of this investigation was to estimate the performance of source-sink interactions after heading, including the role of spike awns as a source material for grain growth, and to evaluate the possible factors limiting grain filling of wheat in yield optional conditions.

MATERIALS AND METHODS

Experiment location and conditions

This study was carried out during two successive growing seasons, of 2018/2019 and 2019/2020, at The International Center for Agricultural Research in the Dry Areas (ICARDA Farm), Sids Agricultural Research Station, Agricultural Research Center, Cairo, Egypt (29°04´ N and 31°06´ E) situated at 28.4 m elevation. The research was carried out in a field where the previous crop was cotton. The experiment was comprised of two factors including eight durum wheat cultivars and source/sink limitations (eight levels) employed through defoliation.

Durum wheat genotypes

Tested cultivars included Bani Suef-1, Bani Suef 3, Bani Suef 4, Bani Suef 5, Bani Suef 6, Sohag 3, Sohag 4 and Sohag 5 (Table 1).

Treatments

For the application of sink and source limitation during heading, the middle rows of each plot for each cultivar, 480 similar stems were selected and treatments were applied on 60 stems for each treatment. The treatments included I) Control (without defoliation), II) Flag leaf blade removed, III) Flag leaf blade and secondary leaf removed, IV) Secondary leaf removed, V) Spike awns and secondary leaf removed, VI) Spike awns and flag leaf blade removed, VII) Spike awns removed, and VIII) Spike awns, flag leaf blade and secondary leaf removed. The experiment was laid out in a split-plot design arranged in a randomized complete block design (RCBD) with three replications. Tested cultivars were sown in the main-plots while sink and source limitation treatments were arranged in sub-plots

Table 1. Names, pedigree and source of the eight durum wheat cultivars under investigation

SN	Name	Pedigree	Source
1	Bani Suef 1	Jo"S" / AA//g "S"	CIMMYT
2	Bani Suef 3	Corm"S"/Rufo"S" CD4893-10y-1M-1Y-0M	CIMMYT
3	Bani Suef 4	RoK"S"/Mexi 75/a/"S"//Ruff"S"/FG"S"/3/Mexi 75.SDD1462-2sd-1sd-0sd	CIMMYT
4	Bani Suef 5	Dipperz/bushen3 CDSS92B128-1M-0Y-0M-0Y-3B-0Y-0SD	CIMMYT
5	Bani Suef 6	Boomer-21/Busca-3. CDSS95Y001185-8Y-0M-0Y-0B-1Y-0B-0SD	CIMMYT
6	Sohag 3	Mexi"S"/Mgh/51792/Durum 6	CIMMYT
7	Sohag 4	AJAIA-16//HORA/JRO/3/GAN/4/ZAR/5/SUOK-7/6/STOT//ALTAR 84/ALD CDSS99B00778S-0TOPY-0M-0Y-129Y-0M-0Y-1B-0SH	CIMMYT
8	Sohag 5	MEXICALI/MAGHREBI 72//51792/DURUM#6	CIMMYT

Crop management

Durum wheat cultivars were seeded on 25th November, 2018 and 19th November, 2019. Spacing details of plot at sowing were as follows: number of rows: 4; row length: 4m; row width: 20cm. Plot area: 3.2m2. The crop was maintained weed free by herbicide (Derby 175% SC) after one month from planting. All other recommended production technology practices were applied for wheat production in the region.

Data collection

Yield and yield components were recorded, *ie*, number of spikes m^{-2}, number of grains spike^{-1}, 1000-grain weight (g) and grain yield plant^{-1}(g).

Statistical analysis

The collected data were statistically analyzed through a computer soft-ware program Genstat. The experiment was laid out in a split-plot design arranged in a randomized complete block with three replications. The treatment means were compared through least significant difference test (LSD) at 5% and 1% probability levels (Henley 1983).

RESULTS AND DISCUSSION

Number of spikes m^{-2}

The results of analysis of variance revealed that number of spikes m^{-2} was not significantly influenced by cultivars and defoliation, whereas interaction effect of cultivars and flag leaf defoliation on the number of spike m^{-2} was recorded significant effect in both seasons (Table 2). However, the highest number of spikes (485.5 and 452.9 m^{-2}) were observed in 'Sohag-4' during 2017-18 and 2018-19 seasons, respectively, while the lowest one (424.8 spikes m^{-2}) were observed in 'Bani-suef-1' during the first season and in 'Sohag-3'(420.1 spikes m^{-2}) in the second season (Table 3). As far as source-sink limitations employed through defoliation was concerned, there are no difference between treatments for number of spikes per m^2 because these defoliation do was applied after tillering stage (Table 4). These findings are in agreement with those of (Slafer and Savin 1994 and Shah and Paulsen 2003).

Table 2. Analyses of variance for studied traits of the number of spikes m^{-2}, number of grains spike^{-1}, 1000-grain weight and grain yield in the two growing seasons.

SOV	DF	No. of spikes m^{-2}		No. of grains Spike^{-1}		1000-grain weight(g)		Grain yield plant^{-1}(g)	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Cultivars (C)	7	9207^{ns}	3914^{ns}	325.56*	185.28^{ns}	51.105**	50.761**	2011.6**	1462.4**
Error A	14	6161	4421	117.16	130.8	2.338	2.292	47.05	21.249
Defoliation (D)	7	5029^{ns}	3683^{ns}	261.2**	254.87**	171.15**	347.67**	2796.2**	2274.7**
C x D	49	12864**	9294**	270.52**	242.25**	1.164^{ns}	1.949^{ns}	60.68**	21**
Error B	112	5406	4379	93.49	77.61	2.464	1.485	16.01	8.014

***,** significant at 0.05 and 0.01 level of probability, respectively.**

Number of grains spike^{-1}

The individual effect of durum wheat cultivars and defoliation treatments significantly influenced the number of grain spike^{-1} in first season, while their interaction effect was highly significant during both seasons (Table 2). The results revealed that the highest number of grain spike^{-1} was observed for Bani-suef-5 (71.97 and 75.15 grains during 2017-18 and 2018-19, respectively) while the lowest (59.97) was recorded for Bani-suef-1 during 2017-18 and Sohag-4 (66.58) in 2018-19 season (Table 3). Regarding the defoliation treatments, the maximum number of grain spikes^{-1} was observed for flag leaf blade removal (II) during both seasons, while spike awns removal (VII) (in the first season, and awns + flag leaf blade + secondary leaf removal (VIII) in the second season remained the least performing defoliation treatment (Table 4). These findings are in line with those of (Ahmadi *et al*. 2009, Shah and Paulsen 2003, Saeidi *et al*. 2011 and Sinclair and Jamieson (2006), who suggested that the relative limitation of source or sink is influenced by several botanical characteristics and defoliation factors which tended to vary in different environments. They also concluded that flag leaf removal initiated more vigorous photosynthesis, which resulted in higher accumulation of photosynthates compounds that were portioned to boost growth of cereals.

Table 3. Mean values of durum wheat cultivars on yield and yield components of the eight durum wheat genotypes during the two growing seasons.

Cultivars	No. of spike m^{-2}		No. of grains Spike^{-1}		1000-grain Weight(g)		Grain yield plant^{-1}(g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Bani Suef 1	424.80	421.10	59.97	69.88	46.20	45.57	111.14	101.23
Bani Suef 3	435.00	420.40	62.35	69.18	46.74	43.94	97.22	92.89
Bani Suef 4	446.70	439.90	68.22	70.48	44.04	40.77	86.48	83.50
Bani Suef 5	447.30	436.90	71.97	75.15	43.59	44.65	104.99	100.63
Bani Suef 6	454.90	435.80	63.89	67.07	46.15	43.39	98.15	95.03
Sohag 3	436.90	420.10	65.12	68.34	46.17	43.26	88.00	84.35
Sohag 4	485.80	452.90	63.58	66.58	43.25	42.29	91.30	85.56
Sohag 5	468.10	447.90	65.72	67.11	43.67	43.69	86.19	82.03
Average	449.94	434.38	65.10	69.22	44.98	43.44	95.43	90.65
$LSD_{0.05}$	48.60	41.17	6.70	7.11	0.95	0.94	4.25	2.85
$LSD_{0.01}$	67.45	57.14	9.30	9.83	1.31	1.30	5.89	3.96

Table 4. Mean values of source and sink reduction treatments on yield and yield components during the two growing seasons.

Treatments	No. of spike m^{-2}		No. of grains Spike^{-1}		1000-grain Weight(g)		Grain yield plant^{-1}(g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
I	466.10	435.70	64.34	71.35	49.85	49.48	111.63	106.35
II	448.50	434.30	70.49	72.40	45.88	45.32	100.83	96.24
III	464.80	449.80	67.41	71.35	44.31	42.36	93.51	85.81
IV	427.20	413.10	62.66	67.53	46.90	46.31	103.09	97.39
V	450.00	438.70	65.56	70.76	43.43	42.77	92.38	85.74
VI	431.40	420.00	67.67	70.88	42.92	39.99	88.38	84.61
VII	461.10	446.70	60.95	66.71	45.32	44.12	98.09	94.07
VIII	450.50	436.60	61.75	62.82	41.18	37.18	75.54	75.01
Average	449.95	434.36	65.10	69.22	44.97	43.44	95.43	90.65
$LSD_{0.05}$	42.05	37.85	5.53	4.89	0.89	0.697	2.288	1.62
$LSD_{0.01}$	55.62	50.06	7.31	6.66	1.19	0.922	3.026	2.14

1000-grain weight

The main effects of cultivars and defoliation treatments remained significant on 1000 grain weight in the two seasons, and there were non-significant for their interaction effects in the two seasons (Table 2). However, the highest 1000 grains weight (46.74 g) was recorded for ‘Bani Suef 3’ and the lowest for ‘Sohag 4’ with an average of 43.25g in the first season. In the second season, the cultivar Bani-suef-1 showed the highest value (45.57g) while Bani-suef-4 showed the lowest value of 40.77g (Table 3). On the other hand, the defoliation treatments exhibited that control treatment had the highest 1000-grains weight during two seasons (49.85 and 49.48g, respectively), while treatment VIII gave the lowest values (41.18 and 37.18g during 2017-18 and 2018-19, respectively). The results of interaction effects between durum wheat cultivars and source-sink reduction on 1000-grain weight are shown in Table 5. According to the results of mean values, the highest 1000-grain weight was observed in Bani Suef 1 under control condition in the two seasons (51.25 and 51.93 g, respectively) and the lowest value for Sohag 5 with treatment VIII in the first season. Meanwhile, the lowest value of 1000-grain weight in the second season was recorded by Sohag 3 with treatment VIII. Similar results were observed by (Slafer and Savin 1994, Shah and Paulsen 2003, Saeidi *et al*. 2011 and Felekori *et al*. 2014). It could be due to producing less number of grains. Because increasing the number of grains produces the grains that further away than the spike center, and this could reduce thousands grain weight (Duggan *et al*. 2000 and Duggan and Fowler 2006). Previously, the vital role of photosynthesis has been reported for spike development and on the grain yield, which was strongly influenced by the rate of photosynthesis going on in the leaves (Maydup *et al*. 2012 and Saeidi *et al*. 2011). Contrastingly, (Radmehr *et al*. 2004) reported the reduction in grain yield by removal of flag leaf, has been emphasized that the flag leaf has important role in grain filling period, while its removal had adverse effects on the grain yield and 1000 grain weight. Similarly, (Melahat 2005) reported that the leaves especially flag leaf as source material for production of photosynthates, the most influential factors on the growth of the seeds. Photoassimilate supply is associated with final grain weight and grain-filling rate (Kobata *et al*. 1992). The reduction of 1000-grain weight and grain yield due to defoliation was also reported by (Melahat 2005 and Alam *et al*. 2008).

Table 5. Mean values of the interaction between durum wheat cultivars and source-sink reduction treatments on 1000-grain weight (g) during the two growing seasons.

1st Season	Treatments							
Cultivars	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Bani Suef 1	51.25	46.80	46.77	47.02	44.93	44.87	45.70	42.27
Bani Suef 3	49.68	48.03	46.68	49.45	45.70	44.90	46.72	42.72
Bani Suef 4	50.10	45.03	42.92	46.43	41.52	41.30	45.12	39.90
Bani Suef 5	49.37	44.03	42.02	45.60	41.90	41.75	43.60	40.42
Bani Suef 6	50.77	47.48	45.30	47.70	44.27	43.97	47.00	42.70
Sohag 3	50.95	46.97	45.50	48.05	45.35	44.30	46.73	41.53
Sohag 4	47.93	44.18	42.40	45.25	41.43	41.00	43.70	40.08
Sohage 5	48.77	44.50	42.93	45.72	42.33	41.27	44.03	39.80
CV				3.5				
$LSD_{0.05}$				2.53				
$LSD_{0.01}$				3.34				
2nd Season								
Bani Suef 1	51.93	46.97	45.77	48.18	45.37	41.25	45.85	39.20
Bani Suef 3	49.87	45.78	43.53	46.35	42.17	41.13	44.15	38.52
Bani Suef 4	46.72	42.15	40.03	43.30	37.90	38.18	41.72	36.12
Bani Suef 5	51.58	46.42	43.22	48.37	44.93	41.00	45.38	36.28
Bani Suef 6	48.82	45.88	42.02	46.90	42.97	39.57	44.00	37.00
Sohag 3	49.03	45.38	42.32	46.17	44.13	38.93	44.37	35.77
Sohag 4	48.25	44.12	40.18	44.75	41.62	39.35	43.10	36.93
Sohag 5	49.67	45.88	41.83	46.48	43.08	40.52	44.40	37.67
CV				2.8				
$LSD_{0.05}$				2.03				
$LSD_{0.01}$				2.69				

Grain yield

Variance analysis is demonstrating that there are variations among cultivars, and defoliation treatments as well as interaction between durum wheat cultivars and defoliation treatments and it was highly significant in the two seasons (Table 2). In our study, Bani-suef-1 and Bani-suef-5 cultivars produced the maximum grain yield of 111.14 and 104.99g per plant, respectively in 2017-18, and 101.23 and 100.63g per plant, respectively in 2018-19 season. In contrary, the cultivar Sohag-5 gave the lowest values of 86.19 and 82.03g grain yield plant^{-1} in the two seasons, respectively (Table 3).

The highest grain yield plant^{-1} (111.63 and 106.35g) was recorded in control treatment (I) in the consecutive two seasons, respectively, while the lowest grain yield of 75.54 and 75.01g was recorded in the treatment involving removal of awns, flag leaf and secondary leaf gave in the two seasons, respectively. The results for mean values of interaction between wheat cultivars and defoliation treatments on grain yield are presented in Table 6. According to the results of mean comparisons, the highest grain yield plant^{-1} (127.15g) was observed in Bani Suef 1 under control condition (I), and the lowest one (67.5g) was for Bani Suef 3 under spike awns, flag leaf blade and secondary leaf removed treatment (VIII) in the first season. On the other hand, the highest value of grain yield plant^{-1} in the second season was observed for Bani Suef 5 in treatment I (118.47g) and the lowest value was found in Sohag 5 under VIII treatment (70.27g). These findings were supported by (Shah and Paulsen 2003 and Saeidi *et al*. 2011). Reports of various investigations show the source and sink relationship either increased or decreased yield components and economic yields of cereals including wheat (Yang and Zhang 2006, Ehdaie *et al*. 2006, Mahfoozi and Jasemi 2010 and Abdoli *et al*. 2013). The reduction in grain yield under source reduction treatments could be related to the lower grain number and 1000-grain weight. Higher grains need more carbohydrates stored in vegetative organs before pollination and current photosynthesis in grain filling period. With defoliation of leaves, the leaf area and leaf area duration decreased, which resulted in shortened grain filling period. These results confirm the results of (Abdoli and Saeidi 2013). Some researchers reported the function of photosynthesis of the spike on the sink, which is more than photosynthesis of leaves (Saeidi *et al*. 2011 and Maydup *et al*. 2012). Radmehr *et al*. 2004 have reported reduction of grain yield caused by removal of flag leaf. The removal of flag leaf had important effects on the grain weight and grain yield, and both are reduced due to removal of flag leaf. The flag leaf is often regarded as the most important source of the assimilate supply to the ear, and was associated with spikelet sterility, grains with high-density, grain weight and grain yield. The reduced values of number of grains, grain weight and grain yield may be due to defoliation treatment are matched with the other reports including (Melahat 2005, Alam *et al*. 2008 and Alizadeh *et al*. 2013).

Table 6. Mean values of the interaction between durum wheat cultivars and source-sink reduction treatments on grain yield plant^{-1} during the two growing seasons.

1st Season	Treatment							
Cultivars	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Bani Suef 1	127.15	116.83	111.38	118.03	106.62	105	120.23	83.87
Bani Suef 3	120.48	109.00	88.35	114.22	87.55	83.55	107.10	67.50
Bani Suef 4	99.57	90.15	87.45	91.78	86.40	83.08	83.78	69.58
Bani Suef 5	124.27	110.82	104.07	112.03	102.92	101.33	103.90	80.62
Bani Suef 6	115.78	103.82	96.10	108.32	94.58	88.65	99.93	78.02
Sohag 3	98.48	91.77	89.22	95.1	85.9	80.33	89.12	74.12
Sohag 4	107.6	94.28	90.9	96.65	88.35	85.4	91.87	75.33
Sohag 5	99.72	90	80.65	88.58	86.73	79.68	88.8	75.32
CV				4.2				
$LSD_{0.05}$				7.23				
$LSD_{0.01}$				9.57				
2nd Season								
Bani Suef 1	117.72	109.6	94.88	110.55	94.75	93.68	107.33	81.28
Bani Suef 3	112.97	96.38	88.07	97.45	87.92	86.87	95.78	77.7
Bani Suef 4	100.22	86.68	78.58	87.93	78.17	77.38	85.72	73.28
Bani Suef 5	118.47	109.05	94.87	110.22	94.72	93.67	105.77	78.28
Bani Suef 6	109.73	102.1	91.48	103.2	91.32	89.43	98.58	74.37
Sohag 3	94.93	88.05	80.97	89.2	80.82	79.77	87.08	74.02
Sohag 4	102.87	91.5	79.03	92.88	79.78	78.73	88.87	70.85
Sohag 5	93.88	86.55	78.63	87.67	78.43	77.38	83.45	70.27
CV				3.1				
$LSD_{0.05}$				5.04				
$LSD_{0.01}$				6.06				

The ratio of different plant organs on 1000-grain weight in durum wheat cultivars was showed in Table 7 and Table 8. On the other hand relatively ratio in 1000-grain weight was relating to photosynthetic spike and the minimum relatively ratio in this trait was related to the cutting of the secondary leaves. The minimum result was obtained from Table 7 and Table 8 illustrated that with manipulating phenotypic 1000-grains weight was reduced. This results indicated that none of cultivars showed sink limitation while all of them were source limitation. Grain weight is the most important factor for increasing yield potential (Alizadeh *et al.* 2013). However, grain weight potential of such cultivars was not always realized due to their low grain filling rate (GFR). Grain filling is quite often interrupted under unfavorable weather conditions during grain filling stage. According to source/sink theory, grain filling rate can be limited by source or sink, including sink size (grain number per hectare) and sink strengths such as phloem unloading , enzyme activity, hormone control etc. (Farrar 1993). In comparison of different levels of flower and leaf elimination at stage of flowering for wheat plant, the study showed that flower elimination 33 % resulted the maximum 1000-grains weight (Alizadeh *et al.* 2013).

Table 7. Relatively ratio (%) of different wheat organs on 1000-grain weight in first season

Treatment	Cultivar							
	Bani Suef 1	Bani Suef 3	Bani Suef 4	Bani Suef 5	Bani Suef 6	Sohag 3	Sohag 4	Sohag 5
(I) Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(II) Flag leaf cutting	-8.7	-3.3	-10.1	-10.8	-6.5	-7.8	-7.8	-8.8
(III) Flag and secondary leaf cutting	-8.7	-6.0	-14.3	-14.9	-10.8	-10.7	-11.5	-12.0
(IV) Secondary leaf cutting	-8.3	-0.5	-7.3	-7.6	-6.0	-5.7	-5.6	-6.3
(V) Awns and secondary leaf cutting	-12.3	-8.0	-17.1	-15.1	-12.8	-11.0	-13.6	-13.2
(VI) Awns and flag leaf cutting	-12.4	-9.6	-17.6	-15.4	-13.4	-13.1	-14.5	-15.4
(VII) Awns cutting	-10.8	-6.0	-9.9	-11.7	-7.4	-8.3	-8.8	-9.7
(VIII) Awns, flag & secondary leaf cutting	-17.5	-14.0	-20.4	-18.1	-15.9	-18.5	-16.4	-18.4

Table 8. Relatively ratio (%) of different wheat organs on 1000-grain weight in second season

Treatment	Cultivar							
	Bani Suef 1	Bani Suef 3	Bani Suef 4	Bani Suef 5	Bani Suef 6	Sohag 3	Sohag 4	Sohag 5
(I) Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(II) Flag leaf cutting	-9.6	-8.2	-9.8	-10.0	-6.0	-7.4	-8.6	-7.6
(III) Flag and secondary leaf cutting	-11.9	-12.7	-14.3	-16.2	-13.9	-13.7	-16.7	-15.8
(IV) Secondary leaf cutting	-7.2	-7.1	-7.3	-6.2	-3.9	-5.8	-7.3	-6.4
(V) Awns and secondary leaf cutting	-12.6	-15.4	-18.9	-12.9	-12.0	-10.0	-13.7	-13.3
(VI) Awns and flag leaf cutting	-20.6	-17.5	-18.3	-20.5	-18.9	-20.6	-18.4	-18.4
(VII) Awns cutting	-11.7	-11.5	-10.7	-12.0	-9.9	-9.5	-10.7	-10.6
(VIII) Awns, flag & secondary leaf cutting	-24.5	-22.8	-22.7	-29.7	-24.2	-27.1	-23.5	-24.2

Relatively ratio of different wheat plant organs on the grain yield was showed in Table 9 and Table 10. Relatively ratio in grain yield was relating to photosynthesis spike, while the minimum relatively ratio in this character was relating to cutting of the leaves which is below the flag leaf treatment (Table 9 and Table 10). The flag and secondary leaves are the primary source, and the florets are the primary sink for photosynthesis, Slafer and Savin 1994 and Abid *et al.* 2018 reported that the wheat breeders have increased grain yield potential mainly through increasing the number of spike per m^2 rather than through increasing individual grain mass. Blade and Baker 1991 confirmed large-seeded cultivars are more sensitive to supply assimilates. The yield is correlated with grain number but not with grain size, although the size of grain is larger than the control (Alizadeh *et al.* 2013 and Marzban *et al.* 2011).

Table 9. Relatively ratio (%) of different wheat organs on grain yield (%) in the first season

1st Season	Cultivar							
Treatment	Bani Suef 1	Bani Suef 3	Bani Suef 4	Bani Suef 5	Bani Suef 6	Sohag 3	Sohag 4	Sohag 5
(I) Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(II) Flag leaf cutting	-8.1	-9.5	-9.5	-10.8	-10.3	-6.8	-12.4	-9.7
(III) Flag and secondary leaf cutting	-12.4	-26.7	-12.2	-16.3	-17.0	-9.4	-15.5	-19.1
(IV) Secondary leaf cutting	-7.2	-5.2	-7.8	-9.8	-6.4	-3.4	-10.2	-11.2
(V) Awns and secondary leaf cutting	-16.1	-27.3	-13.2	-17.2	-18.3	-12.8	-17.9	-13.0
(VI) Awns and flag leaf cutting	-17.4	-30.7	-16.6	-18.5	-23.4	-18.4	-20.6	-20.1
(VII) Awns cutting	-5.4	-11.1	-15.9	-16.4	-13.7	-9.5	-14.6	-11.0
(VIII) Awns, flag & secondary leaf cutting	-34.0	-44.0	-30.1	-35.1	-32.6	-24.7	-30.0	-24.5

Table 10. Relatively ratio (%) of different wheat organs on grain yield (%) in the second season.

2nd Season	Cultivar							
Treatment	Bani Suef 1	Bani Suef 3	Bani Suef 4	Bani Suef 5	Bani Suef 6	Sohag 3	Sohag 4	Sohag 5
(I) Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(II) Flag leaf cutting	-6.9	-14.7	-13.5	-8.0	-7.0	-7.2	-11.1	-7.8
(III) Flag and secondary leaf cutting	-19.4	-22.0	-21.6	-19.9	-16.6	-14.7	-23.2	-16.2
(IV) Secondary leaf cutting	-6.1	-13.7	-12.3	-7.0	-6.0	-6.0	-9.7	-6.6
(V) Awns and secondary leaf cutting	-19.5	-22.2	-22.0	-20.0	-16.8	-14.9	-22.4	-16.5
(VI) Awns and flag leaf cutting	-20.4	-23.1	-22.8	-20.9	-18.5	-16.0	-23.5	-17.6
(VII) Awns cutting	-8.8	-15.2	-14.5	-10.7	-10.2	-8.3	-13.6	-11.1
(VIII) Awns, flag & secondary leaf cutting	-31.0	-31.2	-26.9	-33.9	-32.2	-22.0	-31.1	-25.1

CONCLUSION

Durum Wheat genotypes have different potential to respond to defoliation of various vegetative and reproductive plant parts at heading stage. The results revealed that cultivars differed significantly as Bani suef 1 and Bani Suef 5 outperformed rest of cultivars in terms of yield attributes and grain yield, while the cultivar Sohag 5 remained the least performing cultivar. In addition, defoliation of flag leaf blade performed better while treatment-involving removal of awns, flag leaf blade and secondary leaf remained the inferior treatment. Thus, cultivation of Bani Suef 1 or Bani Suef 5 might be recommended for general adoption along with defoliation of flag leaf blade for achieving higher grain yield under stress that come suddenly. However, there is need to conduct further in-depth studies pertaining to defoliation of vegetative parts during different growth stages in order to establish the influence of defoliation on source-sink relationship and grain yield of durum wheat cultivars**.** Also durum wheat breeders must consider the source and sink is very important trait in breeding field.

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العلاقة بين المصدر والمصب فى بعض أصناف قمح المكرونة المختلفة

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أجريت هذه التجربة فى مزرعة المركز الدولى للبحوث الزراعية بالمناطق الجافة (إيكاردا) بمحطة البحوث الزراعية بسدس خلال موسمين زراعيين متتاليين ٢٠١٨/٢٠١٩ و ٢٠١٩/٢٠٢٠ لتقدير تأثير إزالة الأوراق على صفات المحصول ومكوناته فى ثمانية أصناف من قمح المكرونة وكانت المعاملات عبارة عن ثمانية معاملات كالتالى؛ (١) المعاملة الأولى عبارة عن معاملة المقارنة وهى بدون إزالة أى أجزاء ،(٢) المعاملة الثانية وهى عبارة عن إزالة ورقة العلم فقط ،(٣) المعاملة الثالثة وهى عبارة عن إزالة ورقة العلم والورقة التى تليها ،(٤) المعاملة الرابعة وهى عبارة عن إزالة الورقة التى تلى ورقة العلم فقط ،(٥) المعاملة الخامسة عبارة عن إزالة السفا والورقة التى تلى ورقة العلم ،(٦) المعاملة السادسة وهى عبارة عن إزالة السفا وورقة العلم ،(٧) المعاملة السابعة وهى عبارة عن إزالة السفا فقط ،(٨) المعاملة الثامنة وهى عبارة عن إزالة السفا وورقة العلم والورقة التى تلى ورقة العلم. وتم تطبيق المعاملات على الأصناف الثمانية تحت الدراسة وهى بنى سويف ١ وبنى سويف ٣ وبنى سويف ٤ وبنى سويف ٥ وبنى سويف ٦ وسوهاج ٣ وسوهاج ٤ وسوهاج ٥ وتم وضع الأصناف فى القطع الرئيسية والمعاملات فى القطع الفرعية. وأوضحت النتائج أن للأصناف والمعاملات تأثير معنوى علي صفة عدد الحبوب في السنبلة ووزن الألف حبة ومحصول الحبوب، وكان الصنف بنى سويف ١ أعلى الأصناف بالنسبة لصفة محصول الحبوب تحت ظروف جميع المعاملات الخاصة بإزالة الأجزاء الخضرية ، ومن ناحية أخرى فقد أعطى الصنف بنى سويف ١ أعلى قيمة بالنسبة لصفة وزن الألف حبة فى المعاملة الخامسة (إزالة السفا والورقة التى تلى ورقة العلم. كان الهدف الرئيسي من هذا البحث هو تقدير مساهمة بعض اجزاء النبات في المحصول ، بما في ذلك دور سفا السنبلة كمصدر لمادة نمو الحبوب ، وتقييم العوامل المحتملة التي تحد من تعبئة الحبوب بالقمح في الظروف المثالية للمحصول. كما يتعين على مربي القمح القاسي النظر في المصدر و مدى مساهمة كل جزء خضري في المحصول أثناء الانتخاب في برنامج التربية.