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# Influence of source limitation on yield and yield components of wheat

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**Key words:** Sources limitation, sphericity, flag leaf, seed length, seed width.

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## Abstract

To study the response of wheat spike growth, final grains weight and seed traits to increase assimilate availability by modifying source-sink relationships during the grain growth period in a wheat cultivar "Pirsabak-2013". A field experiment was conducted to study the influence of source limitation on yield and yield component of wheat at Amir Muhammad Khan Campus, Mardan, Khyber Pakhtunkhwa, Pakistan, during winter season, 2015. At anthesis stage eight source reduction treatments (normal plant (N) as control, removal of 2$^{nd}$ + 3$^{rd}$ leaf, removal of 2$^{nd}$ + 3$^{rd}$ + 4$^{th}$ leaf, removal of 2$^{nd}$ +4$^{th}$ +5$^{th}$ leaf, removal of 4$^{th}$ + 5$^{th}$ + 6$^{th}$ leaf, removal of 4$^{th}$ + 5$^{th}$ leaf, removal of flag leaf (FLR), removal of all leaves (ALR) were applied. The results indicated that all source limitations significantly affected all observed parameters. Shortest spike (8.9 cm), lowest spike weight (1.4 g), grain spike$^{-1}$ (32.6 d), thousand grain weight (21.2 g), grain yield (1569 kg ha$^{-1}$) and biological yield (4588 kg ha$^{-1}$), seed length (5.4 mm), seed width (2.3 mm), seed thickness (2.2 mm) and lower sphericity (0.55) was recorded in case of all leaves removal followed by flag leaf removal, highest percent deduction was also observed for most of the above parameters in these treatments, while removal 2$^{nd}$ +3$^{rd}$ leaves increased most of the observed parameters followed by or statistically similar with normal. From the results it was concluded that flag leaf is the most important photosynthetic organ during grain filling stage and wheat verity "Pirsabak-2013" is source limited during grain filling, further genetic improvement is needed to increase photosynthetic efficiency of this verity under agro-climate condition of central region of Khyber-Pakhtunkhwa, Pakistan.

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## Introduction

Wheat (*Triticum aestivum* L.) is one of the prime food cereal crops in the world. Wheat grain yield is complex characteristic and influence by photosynthate production, its translocation to the seed, partitioning and accumulation of assimilates during grain filling period (Imranuddin *et al.,* 2017). It is highly related to sink-source relationships under different environments (Alam *et al.*, 2008). Also, photosynthetic activity of leaves (sources) and storage ability of the grains (sink), or both are the important factors limiting grain yield (Bijanzadeh and Emam, 2010). Leaves and spikes in wheat are two main photosynthetic tissues and have very important roles in grain filling and yield production (Birsin, 2005). Movement of photo-assimilates from sources (leaves, spikes and stems) to sinks (grains) are dependent on both source and sink strength (Felekari *et al.*, 2014).

Ahmadi *et al.* (2009) and Borrás *et al.* (2004) reported that defoliation at anthesis stage had small effects on grain yield of wheat, and they stated that the yield of cultivars used under those conditions was more effected by sink than source strength. Zhu *et al.* (2004) found that in wheat cultivars, leaves defoliation at tillering period had no significant effect on grain yield production, but at the stage of the jointing it significantly reduced it. Leaves are not only the main source of photosynthesis but also a good source for nutrients absorption like Sulphur etc (khalid *et al.,* 2016, khalid *et al.,* 2017 Anjum *at al.,* 2016) Some authors concluded that wheat final grain weight was limited by the ability of the source to provide assimilate during grain filling (Alam *et al.*, 2008). Blum *et al.* (1988) found that, one way to increase grain yield in wheat is manipulation of sink (grain) capacity (Acreche and Slafer, 2006). Duggan *et al.* (2000) reported that in wheat cultivars under water stress condition by reducing number of spikelets (artificial removing), the weight of remaining grains was increased. In other studies, increasing of grain weight and grain yield of wheat cultivars under removal of some spikelets in each spike was expressed in other reports (Calderini and Reynolds, 2000, Mahfoozi and Jasemi, 2010).

Ehdaie *et al.* (2008) reported that grain growth is dependent on three sources (a) carbohydrates produced after anthesis that transfer directly to grain, (b) carbohydrates produced after anthesis that temporarily stored in the stem and during the grain filling period are transferred and (c) carbohydrates produced before anthesis mainly stored in the stem and during the grain filling period are transferred. The contribution of leaves and spike photosynthesis affect the final grain weight. There is evidence that when a photosynthesis organ of plant is detached, the compensations in the remaining photosynthesis tissues or remobilization may occur and diminish the photo assimilate (Chanishvili *et al.*, 2005).

Keeping in view the importance of the source (leaves) the current was conducted to study the effect of individual leaf and combination of leaves on yield, yield components and seed traits of wheat.

## Materials and methods

A field experiment was directed to "study the influence of source limitation on yield and yield components of wheat, at Amir Muhammad khan Campus, Mardan, Khyber Pakhtunkhwa, Pakistan in 2015.

The crop was sown at the end of November 2015. Field was ploughed with a cultivator three times and then with a rotavator to breakdown the clods to prepare a fine seedbed to ensure uniform and good germination. Wheat cultivar "Pirsabaq-2013" seeds were sown in lines with a recommended isolation (30 cm row to row). Fertilizers (nitrogen at the rate of 120 kg $ha^{-1}$ and Phosphorus at the rate of 90 kg $ha^{-1}$) were applied at recommended rate i.e. total phosphorus and half nitrogen was applied at sowing time while remaining half of nitrogen was applied after first irrigation. Weeds were removed manually. Irrigations were applied according to the crop need.

The experiment was composed of three replications with RCB design" (Khalid *et al.*, 2018). There were eight subplots per replication. Data were recorded from each plot by selected ten plants in each plot. The crops were harvested at harvest maturity at the end of April 2016.

At anthesis stage eight source reduction treatments were applied

1. Normal plant (N) as a control
2. 2nd +3rd leaves removal (bottom leaves)
3. 2nd +3rd +4th leaves removal
4. 4th +5th +6th leaves removal
5. 4th +5th leaf removal
6. Flag leaf removal (FLR)
7. All leaves removal (ALR)

Data were recorded on the spike length (cm), spike weight (g), grains spike$^{-1}$, 1000 grain weight (g), seed length (mm), seed width (mm), seed thickness (mm), seed sphericity, grain yield (kg ha$^{-1}$), biological yield (kg ha$^{-1}$) of wheat.

*Spike length (cm)*

Grains length were recorded with help of ruler by randomly selected ten spikes in each plot and measured the length of those selected spikes and then averaged at physiological maturity.

*Spike weight (g)*

Spike weight was recorded of wheat by randomly selected ten spikes for spike length were combinely weighted through electronic balance and then averaged

*Grains spike$^{-1}$*

Grains spike were recorded in wheat spike, randomly selected ten spikes for spike length were manually trashed and counted grains in those selected spikes and then averaged.

*Thousand grain weight (g)*

Thousand grains were counted after threshing of wheat crop in each plot and then weighed with the help of electronic balance.

*Grain yield (kg ha$^{-1}$)*

Three central rows of wheat crop in each harvested for biological yield were threshed and grains cleaned for measuring grain yield. The data were converted into kg ha$^{-1}$ by using the following formula;

$$\text{Grain Yield (kg ha}^{-1}) = \frac{(\text{Grain yield in three central rows})}{(\text{Row to Row distance x Number of Rows})} \text{x}10000$$

*Biological yield (kg ha$^{-1}$)*

In each plot, three central rows of wheat crop were harvested, and sun dried for five days and then weighed through spring balance. The data were converted into (kg ha$^{-1}$) by using the following formula;

$$\text{Biological Yield (kg ha}^{-1}) = \frac{(\text{Biological yield in three central rows})}{(\text{Row to Row distance x Number of Rows})} \text{x}10000$$

*Seed traits*

The seed length (mm), width (mm) and thickness (mm) of wheat grains were measured by digital vernier caliper by selecting ten seed of wheat randomly and measured the length, width and thickness of each grain and then averaged.

*Seed length/ width ratio*

Seed length/ width ratio was calculated by the dividing length on width of seed.

*Sphericity*

Sphericity of the wheat grain was calculated by the following formula

$$\text{Sphericity} = \frac{(\text{Length x Width x Thickness})^{1/3}}{\text{Length}}$$

*Percent reduction*

Percent reduction was worked out according to the procedure followed by khalid *et al.,* (2017).

*Statistical analysis*

The data were analyzed statistically according to RCB design. Least significant differences (LSD) test was employed upon obtaining significant F-value (Steel *et al.*, 1997).

**Results and discussion**

*Spike length (cm)*

Spike length of wheat was significantly affected by sources limitation. Control vs result, N vs FL and ALF and N was found significant while ALR vs FL was found statistical similar (table 1). Highest number of spike length was recorded in case of 1st and 2nd leaves removal, followed by normal plant (no source reduction) then followed by 2nd + 3rd +4th leaves removal, 4th +5th + 6th leaves removal and 4th +5th leaves removal while the lowest spike length was found in case of all leaf's removal (table 2). Percent reduction in case of spike length showed that removal of all leaves followed by removal of flag leaf then followed by 4th +5th+ 6th leaves removal and 2nd + 3rd +4th leaves removal while lowest reduction was observed in case of removal of 2nd +3rd leaves (fig 1).

Spike length showed strong positive correlation with all others studied component, especially with grain yield.

**Table 1.** Mean square data of grain spike$^{-1}$, 1000 grain weight (g), spike weight (g), spike length (cm), grain yield (kg ha$^{-1}$) and biological yield (kg ha$^{-1}$) as affected by source limitation at anthesis stage.

| Source of Variance | Spike length (cm) | Spike weight (g) | Grains spike$^{-1}$ | 1000 Grain weight (g) | Grain yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| Replication | 0.07 | 0.05 | 7.08 | 1.3 | 177916.7 | 8311.03 |
| Treatments | 0.31* | 0.72* | 54.19** | 157.3* | 2249989* | 4684321.33* |
| Control vs rest | 0.02* | 0.73** | 18.60** | 102.2* | 3486148** | 4665276.77** |
| N vs FL | 0.04* | 0.77* | 0.67* | 387.9* | 4828192* | 4411700.30* |
| ALR r vs FL | 0.18* | 0.53ns | 95.20* | 3.4ns | 991502.3* | 5075575.99* |
| ALR vs N | 0.40* | 2.57** | 111.80** | 463.6** | 10195612** | 18951296.61** |
| Error | 0.05 | 0.00 | 0.12 | 16.3 | 24107.14 | 41137.87 |

Note: N, FLR, ALR, represent normal plant, flag leaf removal, and All leaves remove, respectively.
* and ** represent significant at 5% and 1 % probability level, respectively.

Increase in spike length increase grain spike$^{-1}$, which ultimately increase grain yield. Spike length had significant and positive correlation coefficients with grain yield, indicating its importance for selection higher yields Cultivars (Leilah and Al-Khateeb, 2005, Mohammadi *et al.*, 2012).

Dağüstü (2008) also indicated significant and positive correlation between grain yield and spike length. This result was also like the research of Ahmadizadeh *et al.* (2011) that showed spike length had more direct positive effects on grain yield.

The reduction in spike length might be due to suddenly reduction in photosynthesis rate and transport of photosynthate from source to the sink as result fertilization and growth of grains were not effectively happened on time. Similar results were reported by (Zhenlin *et al.*, 1998) who stated that removal of leaves at anthesis stage decrease number of grains spike. Alam *et al.* (2008) also reported that at anthesis stage reduction in source significantly decrease spike length.

*Spike weight*

Data regarding spike weight are shown in table 2. Statistical analysis of the data showed that sources reduction was significantly affected spike weight of weight. Maximum spike weight was recorded in case of 2nd and 3rd leaves removal followed by normal (no sources reduction), then 4th and 5th leaves removal and lowest spike weight was recorded in case of all leaf's removal.

In case of percent reduction highest spike weight reduction was observed in case of removal of all leaves followed by removal of flag leaf, then followed by 4th +5th leaves removal and 2nd + 3rd +4th leaves removal while an increase was observed in case of removal of 2nd +3rd leaves. Spike weight showed strong positive correlation with all others studied component, especially with grain yield. It might be due their parasitic properties of the bottom leaves due heavily shaded by middle and uppermost leaves of the plant as well as the shading effect of the other nearby plant in crop community under field condition. Crops during grain filling duration are generally limited by the source of assimilates (Sandana *et al.*, 2009). Source reductions were similar to those carried out in earlier valuations of wheat where the calculated assimilate availability per grain was decreased by up to 70% (Borrás *et al.*, 2003, Sala *et al.*, 2007, Felekari *et al.*, 2014, Harcha and Calderini, 2014). Removal of flag leaf decrease number of grains spike, thousand grain weight and spike weight (Bijanzadeh and Emam, 2010, Abdoli *et al.*, 2013).

**Table 2.** Mean data of grain spike$^{-1}$, 1000 grain weight (g), spike weight (g), spike length (cm), grain yield (kg ha$^{-1}$) and biological yield (kg ha$^{-1}$) as affected by source limitation at anthesis stage.

| Description | Spike length (cm) | Spike weight (g) | Grain spike$^{-1}$ | 1000 grain weight (g) | Grain yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| Normal (Control) | 9.9 a | 2.8 b | 40.7 b | 38.8 a | 3760 a | 8142 b |
| 2+3rd leaf removed | 9.8 a | 3.1 a | 42.8 a | 38.0 a | 3876 a | 8522 a |
| 2+3+4th leaf removed | 9.0 c | 2.3 d | 37.6 c | 35.6 a | 2912 c | 7292 c |
| 4+5+6th leaf removed | 9.3 bc | 2.1 d | 36.9 c | 33.6 a | 2667 cd | 6144 e |
| 4+5th leaf removed | 9.2 bc | 2.4 c | 36.9 c | 38.7 a | 3279 b | 7180 c |
| Flag leaf removed | 9.0 c | 2.0 d | 32.8 d | 22.7 b | 2382 d | 6427 d |
| All leaves removed | 8.7 c | 1.4 e | 32.6 d | 21.2 b | 1569 e | 4588 e |
| LSD ($P \leq 0.05$) | 0.4 | 0.3 | 0.7 | 7.0 | 343 | 355 |

*Grains spike$^{-1}$*

Grains spike$^{-1}$ of wheat was significantly affected by sources limitation (table 1). Control vs result, N vs FL and ALF and N was found significant while ALR vs FL was found statistical similar (table 1). Highest number of grains spike was recorded in case of 1st and 2nd leaves removal, followed by normal plant (no source reduction) then followed by 2nd + 3rd +4th leaves removal, 4th + 5th + 6th leaves removal and 4th + 5th leaves removal while the lowest number of grain spike was found in case of all leaf's removal. Percent duction in number of grains spike showed that removal of all leaves followed by removal of flag leaf then followed by 4th +5th leaves removal and 2nd + 3rd + 4th leaves removal while a small increase was observed in case of removal of 2nd +3rd leaves (table 2), it might be due their parasitic properties of the bottom leaves due heavily shaded by middle and uppermost leaves of the plant as well as the shading effect of the other nearby plant in crop community under field condition. Grains spike showed strong positive correlation with all others studied component, especially with grain yield. Reduction in grains spike might be due to suddenly reduction in photosynthesis rate and transport of photosynthate from source to the sink as result fertilization and growth of grains were not effectively happened on time. Similar results were reported by (Zhenlin *et al.*, 1998) who stated that removal of leaves at anthesis stage decrease number of grains spike. (Alam *et al.*, 2008) also reported that at anthesis stage reduction in source significantly decrease grain spike$^{-1}$.

*Thousand grain weight (g)*

Analysis of variance regarding thousand grain weight of wheat shown in table 1. Data showed that sources reduction was significantly affect thousand grain weight of wheat. Lowest grain weight was recoded in case of removal of all leaves and flag leaf removal, while the other treatments were statistically similar (table 2).

Percent reduction data showed that all source reduction treatment had negatively affected thousand grain weight of wheat, removal of all leaves and flag leaf Couse 46% and 40% reduction in thousand grain weight of wheat, followed by 19% reduction in grain weight Cause by removal of 4th + 5th +6th leaves, while lowest percent reduction in thousand grain weigh was observed in case of removal of 2nd +3rd leaves (fig 1).

Thousand grain weight showed strong positive correlation with all others studied component, especially with grain yield (table 3). Thousand grain weight had positive correlation with grain yield of wheat (Mohammadi *et al.*, 2012). Sen and Toms (2007) also revealed that 1000 weight showed a direct effect on wheat grain yield. Gulmezoglu *et al.* (2010) revealed that grain yield of wheat depended on plant height, length of spike and spike weight. Similar results were reported by Alizadeh *et al.* (2013) who reported that removal of flag leaf and other leaves reduced thousand grain weight of wheat. source-sink relationship determines grain weight, source availability per spikelet.

Spikelet to leaf area ratio represent existing source spikelet$^{-1}$ (Khalid *et al.*, 2018) and might be an important physiological parameter manipulating thousand grain weight (Alizadeh *et al.*, 2013).

Defoliation reduction thousand grain weight (Mohammadi *et al.*, 2014).

**Table 3.** Correlations among grain spike$^{-1}$, 1000 grain weight, spike length, grain yield and biological yield of wheat.

| | Grains spike$^{-1}$ | 1000 grain weight (g) | Spike weight (g) | Spike length (cm) | Grain Yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| Grains spike $^{-1}$ | 0 | - | - | - | - | - |
| (P-Value) | 0 | - | - | | - | - |
| 1000 grain weight (g) | 0.864* | 0 | - | - | - | - |
| | (0.0122) | 0 | - | - | - | - |
| Spike weight (g) | 0.9401** | 0.8386* | 0 | - | - | - |
| | (0.0016) | (0.0184) | 0 | - | - | - |
| Spike length (cm) | 0.8882** | 0.7185$^{ns}$ | 0.9428** | 0 | - | - |
| | (0.0075) | (0.0689) | (0.0015) | 0 | - | - |
| Grain yield (kg ha$^{-1}$) | 0.9246** | 0.8998** | 0.9853** | 0.9279** | 0 | - |
| | (0.0029) | (0.0058) | (0.000) | (0.0026) | 0 | - |
| Biological yield (kg ha$^{-1}$) | 0.8675* | 0.8512* | 0.9733** | 0.9089** | 0.9784** | 0 |
| | (0.0114) | (0.0151) | (0.0002) | (0.0046) | (0.0001) | 0 |

Note: ** and * stand for Correlation is significant at the 1% and 5%. ns for non-significant.

Leaves area main photosynthetic organs and responsible for photosynthate production and acts as main factor in grain filling (Cruz-Aguado *et al.*, 1999) who stated that defoliation Leaves are the major sources of assimilate production. (Jiang *et al.*, 1999) reported that defoliation of leaves increases the sink needs in the remained leaves sufficient photosynthate result higher final weight and increase grain filling percentage and consequently grain yield (Kobata *et al.*, 1992).

Flag leaf is main source of photosynthate due to its nearness position to the sink and exposure to the sunlight and closely related to the thousand-grain weight, spikelet sterility, and grain yield (Felekari *et al.*, 2014). (Birsin, 2005, Alam *et al.*, 2008) reported reduction in thousand grain weight by defoliation.

*Seed traits*

Highest seed thick seeds were observed in case of 2$^{nd}$ + 3$^{rd}$ leaves removal followed by normal (no source reduction) then 2$^{nd}$ + 3$^{rd}$ + 4$^{th}$ leaves removal, while the lowest thick was recorded in case of all leaf's removal (fig 2). Similar train was observed for seed width, and seed length, in which highest width and maximum length seeds were recorded in case of 2$^{nd}$ + 3$^{rd}$ leaves removal followed by normal (no source reduction) then 2$^{nd}$ + 3$^{rd}$ + 4$^{th}$ leaves removal, while the lowest thick was recorded in case of all leaf's removal. Seed sphericity is the trait of seed mostly needed to design mechanical thrashing and flouring of wheat. It can simply define as the similarity of the grain shape with perfect sphere. sphericity was also affected by sources, highest value of sphericity was recoded for normal followed by 2$^{nd}$ + 3$^{rd}$ leaves removal, while lowest sphericity was recorded for all leaf's removal. In case of length/width ratio, higher value was recoded for those plots in which all leaves removal was applied, followed by flag leaf removal, while lowest length/width ratio was recorded for normal and 2$^{nd}$ +3$^{rd}$ leaves removal (fig 2). Removal of photolytically active leaves decrease photosynthate production, as result the seed cannot fill sufficiently, and remain shrink, which affect seed length, seed width, thickness, sphericity of the seed which result low quality grain, which affect the final grain yield (Felekari *et al.*, 2014). Source reduction had significant effect on grain width, Grain shape (and size), density, and uniformity are important attributes for determining the market value of wheat grain since they influence the milling performance (i.e., flour quality and yield). Kernel size is closely related to kernel weight and would be expected to influence flour yield (Alka-Sharma, 1999).

One of the main components of the domestication syndrome in cereals (i.e., the set of characters that distinguishes the domesticated species from its wild ancestors) is an increase in grain size (Fuller, 2007, Brown *et al.*, 2009).

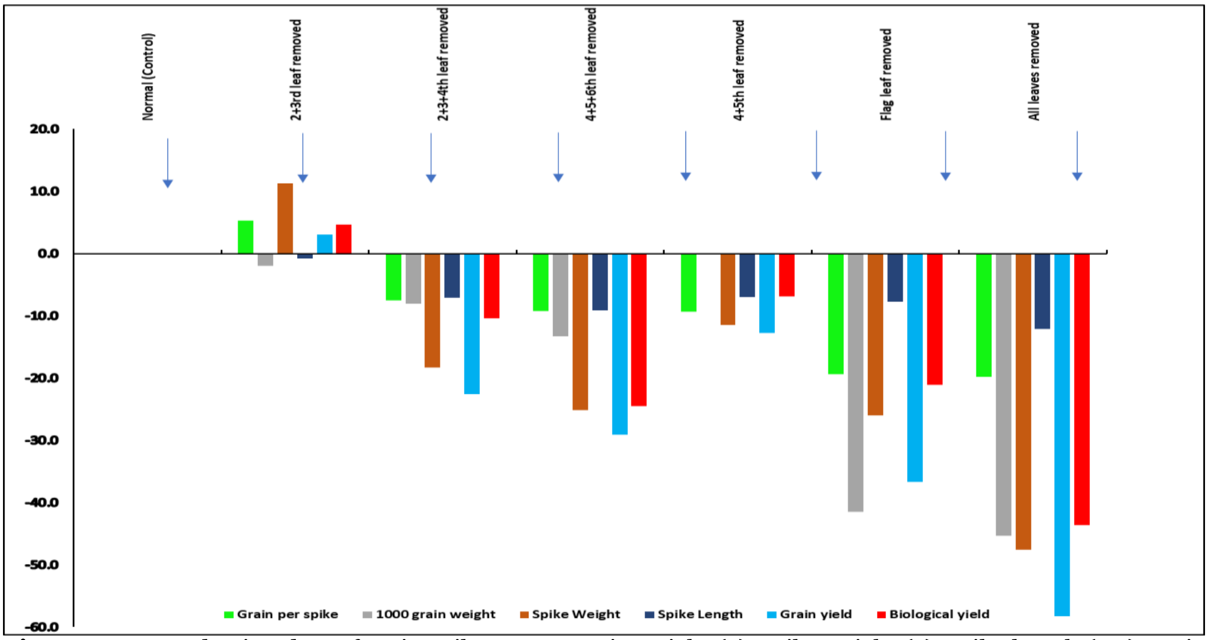


**Fig. 1.** Percent reduction date of grain spike$^{-1}$, 1000 grain weight (g), spike weight (g), spike length (cm), grain yield (kg ha$^{-1}$) and biological yield (kg ha$^{-1}$) as affected by source limitation at an thesis.

*Grains yield (kg ha$^{-1}$)*

Analysis of variance of the data showed that grain yield of wheat was significantly affected by sources limitation (table 1). Control vs result, N vs FL, ALR vs FL and ALF and N were found significant. maximum grain yield was recorded in case of 1$^{st}$ + 2$^{nd}$ leaves removal followed by normal plant (no source reduction) then followed by 2$^{nd}$ + 3$^{rd}$ +4$^{th}$ leaves removal, 4$^{th}$ +5$^{th}$ leaves removal while the lowest grain yield was found in case of all leaf's removal (table 2). In case of percent reduction, highest reduction in grain yield was recorded in case of all leaf's removal followed by flag leaf then 4$^{th}$ +5$^{th}$ leaves removal then followed by 2$^{nd}$ + 3$^{rd}$ +4$^{th}$ leaves removal while a small increase was observed in case of removal of 2$^{nd}$ +3$^{rd}$ leaves then control (fig 1). Grain yield showed strong positive correlation with all others studied yield components component i.e. spike weight, spike length, grains spike$^{-1}$ and thousand grain weight. Several researchers had reported that grain yield had Positive correlation Spike length, spike weight, grains spike and thousand grain weight (Leilah and Al-Khateeb, 2005, Ahmadi *et al.*, 2009, Mohammadi *et al.*, 2012). Dağüstü (2008) also indicated significant and positive correlation, between grain yield and spike length. The reduction in grain yield might be due to suddenly reduction in photosynthesis rate and transport of photosynthate from source to the sink as result fertilization and growth of grains were not effectively happened on time. Similar results were reported by (Zhenlin *et al.*, 1998) who stated that removal of leaves at anthesis stage decrease grain yield. (Alam *et al.*, 2008) also reported that at anthesis stage reduction in photosynthetic source significantly decrease grain yield. Leaves and spikes in wheat are two primary photosynthetic tissues and have essential role in grain filling and yield production (Birsin, 2005).

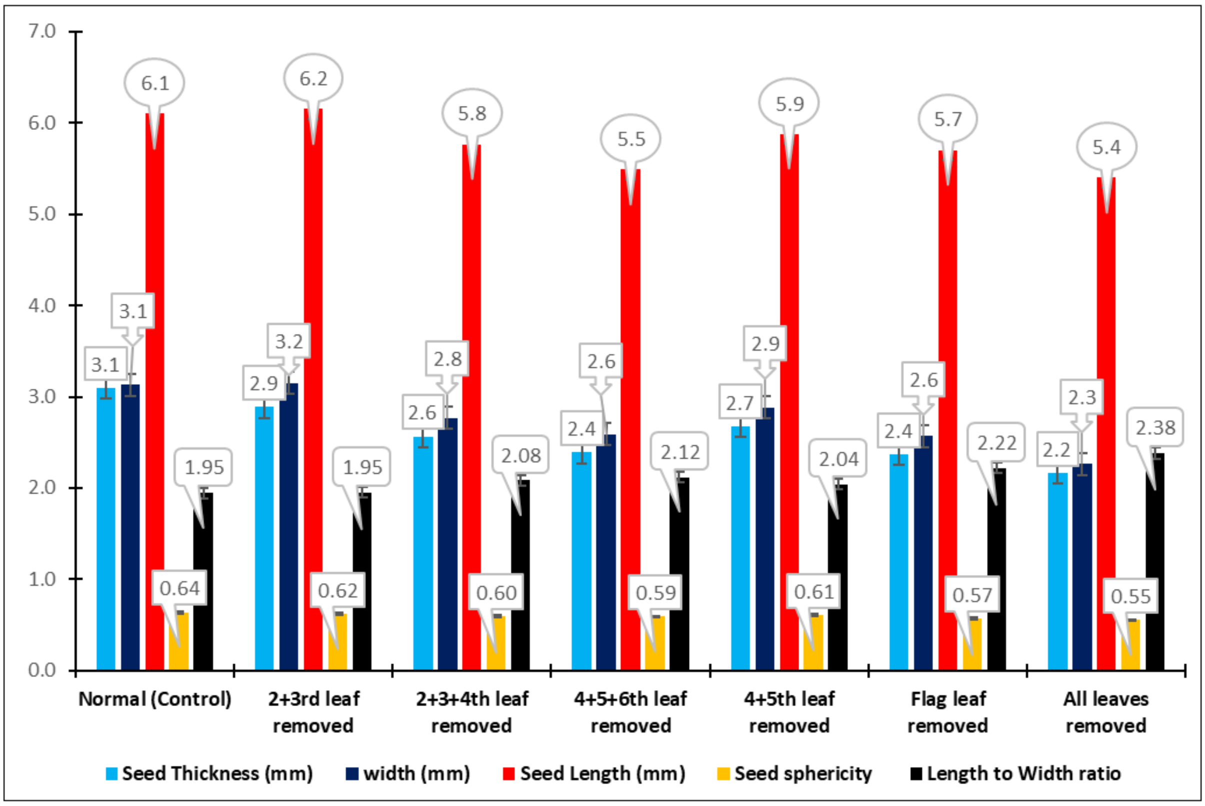


**Fig. 2.** Seed traits i.e. seed length, seed width, seed thickness, seed sphericity and seed length to width ratio as affected by sources reduction.

Development of photosynthates from sources (leaves, spikes and stems) to sinks (grains) are reliant on both source and sink quality. Wheat grain weight was restricted by the capacity of the source during grain filling (Alam *et al.*, 2008). (Borrás *et al.*, 2004, Ahmadi *et al.*, 2009) detailed that defoliation at anthesis less affected grain yield of wheat, and they expressed that the yield of cultivars utilized under those conditions was more affected by sink than source quality. (Zhu *et al.*, 2004) found that in wheat cultivars, leaves defoliation at tillering period had no critical impact on grain yield production, yet at the phase of the jointing it essentially decreased it. (Ehdaie *et al.*, 2006) detailed that grain development is reliant on three sources (a) starches transported after anthesis that exchange specifically to grain, (b) sugars formed after anthesis that briefly put away in the stem and amid the grain filling period are exchanged and (c) glucose production before anthesis primarily put away in the stem toward grain.

Leaves and spike photosynthesis influence the last grain weight. There is proof that when a photosynthesis organ of plant is disengaged, the remunerations in the rest of the photosynthesis tissues or remobilization may happen (Chanishvili *et al.*, 2005, Falihzade *et al.*, 2013, Felekari *et al.*, 2014). Decrease of grain yield caused by removal of flag leaf has been accounted for by (Radmehr and Naderi, 2004). Flag leaf has vital role in grain filling period, at that point removal of flag leaf considerably affected grain yield and 1000 grain weight. Correspondingly, (Birsin, 2005) reports leaves, particularly flage leaf as source material for photosynthate production and the most compelling component on the development of the seeds. photosynthate supply is related with definite grain weight and grain-filling rate and subsequently with grain yield (Kobata *et al.*, 1992).

The flag leaf is regularly viewed as the most critical source of the photosynthate supply to the spike, and was related with spikelet sterility, grains with high-thickness, 1000 grain weight and grain yield. Defoliation decrease thousand grain weight and grain yield of wheat (Birsin, 2005) and (Alam *et al.*, 2008).

*Biological yield*

Data regarding biological yield of wheat was significantly affected by sources limitation (table 1). Control vs result, N vs FL, ALR vs FL and ALF and N were found significant. Simlair trans like grain yield was observed in biological yield, maximum biological yield was recorded in case 1st + 2nd leaves removal then followed by normal plant (no source reduction), then by 2nd + 3rd +4th leaves removal, 4th +5th leaves removal, 4th +5th + 6th leaves removal while the lowest biological yield was found in case of all leaf's removal (table 2).

In case of percent reduction, highest reduction in biological yield was recorded in case of all leaf's removal followed by 4th +5th + 6th leaves removal then removal of flag leaf then followed by 2nd + 3rd +4th leaves removal while a small increase was observed in case of removal of 2nd +3rd leaves then control (fig 1). Biological yield showed strong positive correlation with all others studied components component, especially with grain yield. Similar results were reported by Ghaderi *et al.* (2009). Kandić *et al.* (2009) also stated that grain yield had biological yield had positive correlation.

The reduction in biological yield was might be due to reduction in photosynthesis rate (Zhenlin *et al.*, 1998). However, the gain from the remobilization of assimilate could not compensate the loss of biomass production, leading to the reduction in grain yield and grain size.

This explained the trend of lower grain yield, grain size, and filled grain when 50% portion of flag leaf was cut during the present study (Shahruddin *et al.*, 2014).

**Conclusion**

From the above result it is concluded that flag is the most important photosynthetic organ and responsible for grain formation during grain filling stage. Wheat verity "Pirsabaq-2013" is source limited during grain filling, further genetic improvement is needed to increase photosynthetic efficiency of this verity under agro-climate condition of central Khyber-Pakhtunkhwa, Pakistan.

**References**

**Abdoli M, Saeidi M, Jalali-Honarmand S, Mansourifar S, Ghobadi ME, Cheghamirza K.** 2013. Effect of source and sink limitation on yield and some agronomic characteristics in modern bread wheat cultivars under post anthesis water deficiency. Acta Agriculturae Slovenica **101,** 173-182. doi.org%2F10.12692%2Fijb%2F5.5.52-59

**Acreche MM, Slafer GA.** 2006. Grain weight response to increases in number of grains in wheat in a Mediterranean area. Field Crops Research **98,** 52-59. http://dx.doi.org/10.1016/j.fcr.2005.12.005

**Ahmadi A, Jodi M, Tavakoli A, Ranjbar M.** 2009. Investigation of yield and its related morphological traits responses in wheat genotypes under drought stress and irrigation conditions. JWSS-Isfahan University of Technology **12,** 155-165.

**Ahmadizadeh M, Shahbazi H, Valizadeh M, Zaefizadeh M.** 2011. Genetic diversity of durum wheat landraces using multivariate analysis under normal irrigation and drought stress conditions. African Journal of Agricultural Research **6,** 2294-

2302.

**Alam M, Rahman A, Nesa M, Khan S, Siddquie N.** 2008. Effect of source and/or sink restriction on the grain yield in wheat. Journal of Applied Sciences Research **4,** 258-261.

**Alizadeh O, Farsinejad K, Korani S, Azarpanah A.** 2013. A study on source-sink relationship, photosynthetic ratio of different organs on Yield and Yield Components in bread wheat (Triticum aestivum L.). International Journal of Agriculture and Crop Sciences **5,** 69-79. http://dx.doi.org/IJACS/2013/5-1/69-79

**Anjum MM, Afridi MZ, Iqbal MO, Akhtar K, Khan K, Khalid S, Zahid M.** 2016. Foliar spray of ammonium sulphate on yield and yield components of canola. International Journal of Current Trends in Pharmacobiology and Medical Sciences **1(1),** 56-60.

**Bijanzadeh E, Emam Y.** 2010. Effect of defoliation and drought stress on yield components and chlorophyll content of wheat. Pakistan Journal of Biological Sciences **13,** 699-705. http://dx.doi.org/10.3923/pjbs.2010.699.705

**Birsin MA.** 2005. Effects of removal of some photosynthetic structures on some yield components in wheat. Tarim Bilimleri Dergisi **11,** 364-367.

**Blum A, Mayer J, Golan G.** 1988. The effect of grain number per ear (sink size) on source activity and its water-relations in wheat. Journal of Experimental Botany **39,** 106-114.

**Borrás L, Slafer GA, Otegui MaE.** 2004. Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal. Field Crops Research **86,** 131-146. https://doi.org/10.1016/j.fcr.2003.08.002

**Borrás L, Slafer GA, Otegui ME.** 2004. Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal. Field Crops Research **86,** 131-146. http://dx.doi.org/10.1016/j.fcr.2003.08.002

**Borrás L, Westgate M, Otegui M.** 2003. Control of kernel weight and kernel water relations by post-flowering source–sink ratio in maize. Annals of Botany **91,** 857-867.

**Brown TA, Jones MK, Powell W, Allaby RG.** 2009. The complex origins of domesticated crops in the Fertile Crescent. Trends in Ecology & Evolution **24,** 103-109. http://dx.doi.org/10.1016/j.tree.2008.09.008

**Calderini DF, Reynolds MP.** 2000. Changes in grain weight as a consequence of de-graining treatments at pre-and post-anthesis in synthetic hexaploid lines of wheat (Triticum durum x T. tauschii). Functional Plant Biology **27,** 183-191.

**Chanishvili SS, Badridze GS, Barblishvili T, Dolidze M.** 2005. Defoliation, photosynthetic rates, and assimilate transport in grapevine plants. Russian Journal of Plant Physiology **52,** 448-453. https://doi.org/10.1007/s11183-005-0066-x

**Cruz-Aguado JA, Reyes F, Rodes R, Perez I, Dorado M.** 1999. Effect of source-to-sink ratio on partitioning of dry matter and 14 C-photoassimilates in wheat during grain filling. Annals of Botany **83,** 655-665.

**Dağüstü N.** 2008. Genetic analysis of grain yield per spike and some agronomic traits in diallel crosses of bread wheat (Triticum aestivum L.). Turkish Journal of Agriculture and Forestry **32,** 249-258.

**Duggan B, Domitruk D, Fowler D.** 2000. Yield component variation in winter wheat grown under drought stress. Canadian Journal of Plant Science **80,** 739-745.

**Ehdaie B, Alloush G, Madore M, Waines J.** 2006. Genotypic variation for stem reserves and mobilization in wheat. Crop Science **46,** 2093-2103.

**Ehdaie B, Alloush G, Waines J.** 2008. Genotypic variation in linear rate of grain growth and contribution of stem reserves to grain yield in wheat. Field Crops Research **106,** 34-43. http://dx.doi.org/10.1016/j.fcr.2007.10.01

**Falihzade F, Mojadam M, Lack S.** 2013. The effect of source-sink restriction and plant density changes on the role of assimilate remobilization in corn grain yield. International Journal of Agriculture and Crop Sciences **5,** 24-59.

**Felekari H, Ghobadi ME, Ghobadi M, Jalali S, Honarmand MS.** 2014. The effect of post anthesis source and sink limitation in wheat cultivars under moderate condition. International Journal of Biosciences **5,** 52-59. http://dx.doi.org/10.12692/ijb/5.5.5259

**Fuller DQ.** 2007. Contrasting patterns in crop domestication and domestication rates: recent archaeobotanical insights from the Old World. Annals of Botany **100,** 903-924.

**Ghaderi M, Zeinaali KH, Hosseinzadeh A, Taleei A, Naghavi M.** 2009. Evaluation of relationships between grain yield, yield components and the other characteristics associated with grain yield in bread wheat using multivariate statistical analysis.

**Gulmezoglu N, Alpu O, Ozer E.** 2010. Comparative performance of triticale and wheat grains by using path analysis. Bulgarian Journal of Agricultural Science **16,** 443-453.

**Harcha CI, Calderini DF.** 2014. Dry matter and water dynamics of wheat grains in response to source reduction at different phases of grain filling. Chilean journal of agricultural research **74,** 380-390. http://dx.doi.org/10.4067/S071858392014000400002

**Imranuddin, Muhammad Arif, Shah Khalid, Nadia, Saddamullah, Muhammad Idrees, Muhammad Amir.** Effect of seed priming, nitrogen levels and moisture regimes on yield and yield components of wheat. Pure and Applied Biology. http://dx.doi.org/10.19045/bspab.2017.60036

**Jiang J, Hua G, Xu H, Ji C.** 1999. Effects of different leaf-cutting treatments on dry matter production after heading and grain yield in wheat. Acta Agriculturae Shanghai **15,** 83-86.

**Kandić V, Dodig D, Jović M, Nikolić B, Prodanović S.** 2009. The importance of physiological traits in wheat breeding under irrigation and drought stress. Genetika 41**,** 11-20.

**Khalid S, Imranuddin, Nadia, Nadeem F, Saddamullah, Aamir M, Ghani F.** 2017. Allolophatic effect of Parthenium liquid extract on mung bean germination ability and early growth. International Journal of Agronomy and Agricultural Research **11(4),** 31-36.

**Khalid S, Munsif F, Imranuddin N, Nadeem F, Ali S, Ghani F, Idrees M.** 2018. Influence of source limitation on physiological traits of wheat. Pure and Applied Biology (PAB) **7,** 85-92. http://dx.doi.org/10.19045/bspab.2018.70011

**Khalid, S, Afridi MZ, Imranuddin, Nadia, Nadeem F, Aamir M, Saddamullah.** 2017. Effect of sulfur foliar fertilization on reproductive growth and development of canola. International Journal of Agronomy and Agricultural Research **11(3),** 61-67.

**Khalid S, Afridi MZ, Munsif F, Imranuddin, Nadia.** 2016. Effect of Sulphur foliar application on yield and yield components of brassica napus. International Journal of Agricultural and Environmental Research **2(3),** 282-287.

**Kobata T, Palta JA, Turner NC.** 1992. Rate of development of postanthesis water deficits and grain filling of spring wheat. Crop Science **32,** 1238-1242.

**Leilah A, Al-Khateeb S.** 2005. Statistical analysis

of wheat yield under drought conditions. Journal of Arid Environments **61,** 483-496.
http://dx.doi.org/10.1016/j.jaridenv.2004.10.011

**Mahfoozi S, Jasemi S.** 2010. Study of the possibility of increasing grain yield by increasing grain weight in winter and facultative wheat genotypes with manipulating sink capacity. Iranian Journal of Crop Sciences **12,** 76-84.

**Mohammadi M, Karimizadeh R, Shfezadeh MK.** 2014. Source Sink Limitation on Spring Bread Wheat Genotypes in High and Low-Production Environments. Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi **24,** 1-6.
http://dx.doi.org/10.29133/yyutbd.235909

**Mohammadi M, Sharifi P, Karimizadeh R, Shefazadeh MK.** 2012. Relationships between grain yield and yield components in bread wheat under different water availability (dryland and supplemental irrigation conditions). Notulae Botanicae Horti Agrobotanici Cluj-Napoca **40,** 195-200.
http://dx.doi.org/10.15835/nbha4017350

**Radmehr M, Naderi A.** 2004. A study on source-sink relationship of wheat genotypes under favourable and terminal heat stress conditions in Khuzestan.

**Sala RG, Westgate ME, Andrade FH.** 2007. Source/sink ratio and the relationship between maximum water content, maximum volume, and final dry weight of maize kernels. Field Crops Research **101,** 19-25.
http://dx.doi.org/10.1016/j.fcr.2006.09.004

**Sandana PA, Harcha CI, Calderini DF.** 2009. Sensitivity of yield and grain nitrogen concentration of wheat, lupin and pea to source reduction during grain filling. A comparative survey under high yielding conditions. Field Crops Research **114,** 233-243.

**Sen C, Toms B.** 2007. Character association and component analysis in wheat (Triticum aestivum L.). Crop Research-Hisar- **34,** 166-172.

**Shahruddin S, Puteh A, Juraimi AS.** 2014. Responses of source and sink manipulations on yield of selected rice (Oryza sativa L.) varieties. Journal of Advanced Agricultural Technologies **1,** 125-131.
http://dx.doi.org/10.12720/joaat.1.2.125-131

**Zhenlin W, Yanping Y, Mingrong H, Hongming C.** 1998. Source-sink manipulation effects on postanthesis photosynthesis and grain setting on spike in winter wheat. Photosynthetica **35,** 453-459.

**Zhu GX, Midmore DJ, Radford B, Yule D.** 2004. Effect of timing of defoliation on wheat (Triticum aestivum) in central Queensland: 1. Crop response and yield. Field Crops Research **88,** 211-226.