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Effect of sowing dates, seeding rates, awn and flag leaf removal on yield and its components of Adana-99 bread wheat cultivar

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Abstract

The experiment was performed, to assess the effect of different planting dates (15th Nov. 2015 to 25th Feb. 2016) each 20 days interval, different plant densities (120, 140, 160,180, 200 and 220) kg/ha and different removal treatments (control, awn, flag leaf and both- awn+flag leaf) removal and their interaction on grain yield and yield components of bread wheat cultivar (Adana-99). The experimental arrangement was a (6×6×4) factorial RCBD with three replicates. Grain yield with some of its components was measured such as (spike length, spike weight, number of spikelet/spike, number of grain/spike, weight of grain/spike, 1000- grain weight, harvest index, biological yield and grain yield).

The results of grain yield and its components can be summarized as follows: the planting dates significantly affect on these characters, (15th Nov. 2015) showed maximum values for all characteristics with the exception of harvest index produced by (25th Dec. 2015). The result of the effect of plant density on studying characters was significant, plant density 120 kg/ha produced maximum values for all characters with the exception of harvest index recorded by 180 kg/ha, biological yield produced by 220 kg/ha and grain yield recorded by 200 kg/ha. While the effect of removal treatments on yield and its components significantly responded to these effects. The control treatments produced maximum values for all characters with the exception of harvest index produced by both (awn+flag leaf) removal treatments.

Introduction

Wheat (*Triticum aestivum* L.), an autogamous annual plant considered to be among the staple crop worldwide as a food source ***[1].*** However, the production of a wheat plant has also been affected by proving constraints. For instance, some of the stressing factors that result from the biotic environment in one way or the other contribute to the poor quality production of this wheat plants ***[2]***. Additionally, these stressing factors also decrease the quantity of the wheat plant being produced ***[3]***. Sink–source relations can regulate biomass production and assimilate allocation in plants ***[4]***. Source limited seed yield of winter wheat *(Triticum aestivum* L.*)* under both high and temperate soil water content, but sink restriction was mostly observed under high soil water content ***[5]***. The wheat grain yield mainly depends on the formation, translocation, partitioning and accumulation of assimilates during grain filling period. Also, photosynthetic activity of leaves and storage ability of the grains after anthesis are the main factors limiting wheat grain yield [***6]***. Removal of awn, flag leaf, 1st upper leaf blade, 2nd upper leaf blade, and other leaf blades reduced significantly spike weight, number of grains/spike, grain weight/spike and 1000-grain weight except for the number of spikelet/spike ***[7]***. Long awns are considered to be an important component sign of the high- yielding wheat ideotype, particularly for wheat grown under water- limited

conditions ***[8]***. The contribution of flag leaf is diverse too, and it was reported to vary between (0 to 43%). Flag leaf removal affected the number of grains/spike, grain weight, and spike grain yield ***[9, 10, 11*** and ***12]***. The effect of awns and 5 upper leaf blades on grain yield of wheat grown under different environments were determined. Yield was increased in the awned crops than in the awn removal (awnless) crops under all environmental conditions. Flag leaf made the greatest contribution to yield ***[13]***. One of the most important objectives in agriculture is identifying best plant density to obtain desired yield. Optimum yield would be gained when the canopy has a maximum leaf area to absorb sunlight at the onset of reproductive stage ***[14]***. Both plant density and row spacing have a big influence on the agricultural production by improving absorption of sufficient sunlight ***[15]***. Distributing of plant affected the amount absorbed sunlight across the canopy. Thus the main effect of planting pattern and plant density on a crop is mainly due to difference how sunlight would distribute through the canopy and increasing sunlight absorption would cause improving yield ***[16]***. Radiation absorbing is low at thick densities and the coefficient of their photosynthetic output is very low, on the other hand, sufficient sunlight isn't absorbed in thicker densities, but photosynthetic output is very lower due to mutual shadowing leaves, therefore, maximum sunlight absorption for a period longer than a growing season is very important in the canopy. Desirable density gained when a canopy has a maximum leaf area for absorbing sunlight ***[14]***. Wheat yield is low on account of many biotic and abiotic factors. Among these, the time of sowing and planting density are of great significance which limit the proper stand establishment of growing crops through balancing the plant to plant competition and at the latest affected the yield ***[17; 18]***. It has been observed that early sowing gives high yield than late sowing due to longer growing period ***[19; 20]***. Earlier sowing resulted in the better development of grain due to longer growing period ***[21]***. Early planting of wheat gives higher yield than delay in planting due to long planting in period ***[20]***. The sowing of the crop from (early November to early December) produced a higher grain yield as compared to late sowing. Late wheat crop sown from mid to end of December produced a reduced yield from 27-59% ***[22]***. Results specified that delayed sowing is accompanied by essential losses in grain yield evaluated by 7.98% as compared with early and the affected number of days to flowering, maturity and grain filling period ***[23, 24*** and ***25]***.

Hence, the objectives of this study were to determine the role of flag leaf and awns of bread wheat varieties (Adana-99) under rainfed conditions of different planting density, different planting dates and participation of the flag leaf, and awns on yield and its components.

Materials and Methods

The experiment was conducted, under rainfed conditions, in the College of Agricultural Science Research Station at Qlyasan, College of Agricultural Science, University of Sulaimani, during the winter seasons of 2015-2016. The present research carried out by employing the use of bread wheat cultivar (Adana-99). In order to study the response of the cultivar under six planting dates (15th Nov. 2015 to 25th Feb. 2016) with 20 days interval, six plant densities (120, 140, 160,180, 200 and 220) kg/ha and four removal treatments which were (control, awns removal, flag leaf removal and both- flag leaf + awns removal) and their interaction on yield and yield components. The experimental design was conducted according to the (6×6×4) factorial CRBD with three replications. Each plot comprised five rows of 2.0 m length with row-row distance of 0.2 m and the plot size was 2 m^2. The land was well prepared by plowing 2 times in order to make a convenient seedbed for better germination and emergence.

The data were statistically analyzed according to the methods of analyses of variance as a general test, and combined analysis of variance across locations was conducted. All possible comparisons among the means were carried out using L. S. D. Test (Least Significant Difference) at a significant level of 5 % whenever significant they show their significant differences ***[26]***.

Studied characters:

Yield and its components:

1- Spike length (cm): Ten spikes were randomly selected from each treatment. Each spike was measured from the base (neck) of the spike to the apex excluding awn to record the spike length in centimeters..

2- Spike weight (g): Spike weight (g) was recorded by using digital electronic balance at harvest.

3- No. of spikelet/spike: All fertile and sterile spikelets were measured.

4- No. of grains/spike: Number of grains/spike were counted from ten randomly selected spikes in each replication at harvest.

5- Weight of grains/spike (g): Weight of grain/spike (g) was recorded by using digital electronic balance at harvest.

6- 1000- Grain weight (g): 1000-grain weight (g) was obtained at random from each treatment and weighted were taken by digital electronic balance.

7- Grain yield (tons/ha): One (m^2) was harvested for each treatment, then converted to grain yield (ton/ha).

8- Biological yield (ton/ha): Biomass (shoot) yield was recorded in kg and then converted into ton/ha at harvest.

9- Harvest index (H.I.): Measured by separating the grains from the straw (above ground biomass without roots) yield and weighted to calculate the H.I. according to the following equation [27].

$$H.I. = \frac{\text{Grain yield}}{\text{biomass yield}}$$

Results and Discussion

Table (1) yield and yield components significantly affected by planting date, for example planting date at (15th Nov. 2015) recorded maximum value for spike length, spike weight, number of spikelets/spike, number of grains/spike, weight of grains/spike, 1000- grain weight, biological yield and grain yield with (7.844 cm, 1.562 g, 14.231, 33.015, 1.296 g, 33.617 g, 11.666 tons/ha and 4.774 tons/ha), respectively, with the exception of harvest index (0.456 tons/ha) produced by (25th Dec. 2015), One of the most important factors influencing the wheat yield is sowing time. Many researchers have carried out some studies on sowing times of wheat and found different results ***[28; 29]***. The sowing wheat on 25th October- and 10th November produced the highest spike length, 1000-grain weight and the grain yield, which subsequently decreased with consecutive sowing dates ***[30]***. These results indicated that a moderate plant density had a positive effect on grain yield, while a low and high plant density could negatively affect grain yield ***[31]***.

Table- 1: Effect of planting dates on the studied characters.

Planting Dates	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelets/ Spike*	*No. of grains/ Spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (tons/ha)*	*Grain yield (tons/ha)*
15th Nov. 2015	7.844	1.562	14.231	33.015	1.296	33.617	0.414	11.666	4.774
5th Dec. 2015	7.179	1.348	13.745	29.788	1.214	28.925	0.453	10.516	4.726
25th Dec. 2015	6.299	1.245	11.913	27.851	1.054	31.388	0.456	10.377	4.714
15th Jan. 2016	6.093	0.990	11.005	20.889	0.839	28.437	0.438	8.876	3.884
5th Feb. 2016	5.263	0.963	10.037	20.723	0.832	26.607	0.428	6.720	2.878
25th Feb. 2016	4.589	0.822	10.021	17.853	0.714	24.566	0.351	5.483	1.931
L.S.D (P≤0.05)	0.188	0.025	0.183	0.214	0.012	0.214	0.006	0.081	0.045

Data in (Table 2) it was noticed that the plant density significantly affected on all measured characters. Plant density (120 Kg/ha) recorded maximum value for spike length, spike weight, number of spikelets/spike, number of grains/spike, weight of grains/spike and 1000- grain weight, with (6.640 cm, 1.408 g, 12.678, 28.051, 1.258 g and 30.142 g), respectively, with the exception of harvest index (0.438) recorded by 180 kg/ha, biological yield (10.099 ton/ha) produced by 220 kg/ha and grain yield 4.337 ton/ha) recorded by 200 kg/ha. Plant density is an important factor that affect the growth and yield formation in wheat ***[32; 33]***. Previous studies have focused on identifying the optimal density for wheat cultivation. But the results differ based on the experimental conditions and tested parameters ***[34; 35]***. In wheat, the number of spikelets/spike changes under different planting densities ***[36]***. With enough photosynthetic matter during the grain filling stage in thicker density is possible reason to lessening 1000-grain weight due to increasing density ***[37]***.

Table- 2: Effect of plant density on the studied characters.

Plant Density (Kg/ha)	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelets/ Spike*	*No. of grains/ Spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (tons/ha)*	*Grain yield (tons/ha)*
120	6.640	1.408	12.678	28.051	1.258	30.142	0.397	7.759	3.100
140	6.221	1.315	12.390	26.793	1.134	29.519	0.425	7.816	3.382
160	6.252	1.167	12.099	25.728	1.012	29.230	0.425	8.732	3.749
180	6.262	1.051	11.408	24.442	0.908	28.834	0.438	9.146	4.018
200	6.073	1.009	11.294	23.056	0.846	28.432	0.427	10.086	4.337
220	5.820	0.978	11.082	22.049	0.793	27.383	0.427	10.099	4.321
L.S.D $_{(P\leq 0.05)}$	0.188	0.025	0.183	0.214	0.012	0.214	0.006	0.081	0.045

Table (3) shows the effect of removal treatments on grain yield and its components, indicating the presence of the significant effect of removal treatments on all characters. Control treatment recorded the highest value for spike length, spike weight, number of spikelets/spike, number of grains/spike, weight of grains/spike, 1000- grain weight, biological yield and grain yield with (6.768 cm, 1.330 g, 12.626, 27.873, 1.154 g, 31.384 g, 9.727 tons/ha and 4.119 tons/ha), respectively, with the exception of harvest index recorded by both (awn+flag leaf) removal. Removing of flag leaf and all leaves significantly reduce the number of grain/spike, 1000- grain weight and yield/main spike ***[11]***. The number of grains/spike 1000- grain weight and grain yield/spike decreased with the removal of flag leaf in bread wheat recorded by ***[38]***. Awns play a dominant role in participating to large grains and a high grain yield in awned wheat cultivars, particularly during the grain-filling stages ***[39]***.

Table- 3: Effect of removal treatments on the studied characters.

Removal Treatments	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelet/ Spike*	*No. of grains/ Spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (tons/ha)*	*Grain yield (tons/ha)*
Control	6.768	1.330	12.626	27.873	1.154	31.384	0.419	9.727	4.119
Awn	6.294	1.230	11.966	24.936	1.056	29.704	0.421	9.195	3.911
Flag Leaf	6.037	1.082	11.609	25.238	0.926	28.066	0.423	8.689	3.703
Both	5.745	0.979	11.099	22.032	0.832	26.540	0.430	8.148	3.538
L.S.D $_{(P\leq 0.05)}$	0.154	0.021	0.149	0.175	0.010	0.175	0.005	0.066	0.037

Table (4) explains the combination effect between planting dates and plant density on grain yield and its components, indicating that the studied characters responded significantly to this effect. Where maximum spike length, number of spikelets/spike, number of grains/spike, weight of grains/spike and 1000- grain weight were (8.077 cm, 16.169, 35.793, 1.605 g and 36.100 g), respectively exhibited by the combination between 15th Nov. 2015 under the planting density of 120 kg/ha. Maximum spike weight was 1.912 exhibited by the combination between 15th Nov. 2015 under the planting density of 140 kg/ha. Regarding the character of harvest index maximum harvest index was 0.494 responded to the combined effect between 25th Dec. 2015 under the planting density of 180 kg/ha. Maximum biological yield was 13.490 exhibited by 15th Nov. 2015 and 200 kg/ha, while the maximum grain yield was 5.477 recorded by the interaction between 5th Dec. 2015 and 200 kg/ha. These findings are supported by ***[40]*** who reported significant variation in the number of grains/spike with sowing dates. The possible reason could be due to suitable temperature during seed development and the number of branches/plant with more productive spikes, and this resulted in a greater number of grains/spike. The results were matched with other workers ***[41]*** who observed that the number of grains/spike had significant affected on plant densities. Our result was supported by ***[42]***, who reported that planting dates and seeding rates had a significant effect on the grain yield.

Table- 4: The interaction effect of planting dates and plant density on the studied characters.

Planting dates × Plant Density (Kg/ha)	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelets/ Spike*	*No. of grains/ Spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (tons/ha)*	*Grain yield (tons/ha)*
15th Nov. 2015× 120	8.077	1.786	16.169	35.793	1.605	36.100	0.419	9.805	4.100
15th Nov. 2015× 140	7.906	1.912	14.956	35.287	1.564	34.845	0.470	8.920	4.184
15th Nov. 2015× 160	7.844	1.518	14.738	34.363	1.360	33.932	0.391	12.427	4.845
15th Nov. 2015×180	7.627	1.379	12.625	33.018	1.140	33.002	0.383	13.271	5.086
15th Nov. 2015× 200	7.974	1.489	13.575	31.083	1.121	32.933	0.402	13.490	5.416
15th Nov. 2015× 220	7.634	1.285	13.322	28.544	0.987	30.892	0.416	12.082	5.016
5th Dec. 2015× 120	7.955	1.643	15.124	35.406	1.529	28.806	0.444	8.283	3.642
5th Dec. 2015×140	7.026	1.524	14.840	30.578	1.424	28.681	0.472	9.010	4.248
5th Dec. 2015×160	7.256	1.291	13.758	29.412	1.239	30.418	0.489	9.917	4.851
5th Dec. 2015× 180	7.290	1.293	13.162	29.104	1.099	28.232	0.477	10.267	4.895
5th Dec. 2015× 200	6.608	1.190	12.763	27.108	1.008	28.648	0.427	12.809	5.477
5th Dec. 2015× 220	6.942	1.148	12.823	27.121	0.987	28.765	0.409	12.808	5.244
25th Dec. 2015× 120	6.891	1.471	13.228	31.504	1.347	33.030	0.383	10.413	3.984
25th Dec. 2015×140	6.402	1.359	12.840	31.252	1.114	31.184	0.477	8.909	4.242
25th Dec. 2015×160	6.246	1.305	12.030	29.329	1.101	30.903	0.459	9.803	4.499
25th Dec. 2015× 180	6.251	1.136	10.796	26.339	0.988	31.676	0.494	10.012	4.946
25th Dec. 2015× 200	6.020	1.041	11.278	25.257	0.884	31.469	0.491	10.865	5.330
25th Dec. 2015× 220	5.982	1.160	11.303	23.429	0.891	30.067	0.431	12.260	5.281
15th Jan. 2016×120	6.154	1.347	11.594	24.228	1.173	29.435	0.388	8.137	3.109
15th Jan. 2016×140	5.661	1.144	10.574	22.415	1.002	28.957	0.374	9.209	3.430
15th Jan. 2016× 160	5.843	1.020	10.511	20.623	0.796	28.035	0.456	8.217	3.730
15th Jan. 2016×180	6.959	0.885	11.319	20.152	0.719	27.733	0.476	8.340	3.969
15th Jan. 2016×200	5.815	0.787	10.827	18.294	0.648	27.990	0.451	9.571	4.312
15th Jan. 2016×220	6.129	0.760	11.207	19.618	0.698	28.472	0.486	9.781	4.756

5th Feb. 2016×120	5.664	1.134	10.211	22.614	0.992	27.994	0.416	5.627	2.335
5th Feb. 2016×140	5.786	1.084	10.850	22.100	0.901	27.976	0.418	6.343	2.650
5th Feb. 2016× 160	5.351	0.983	10.751	21.940	0.780	26.923	0.409	6.700	2.737
5th Feb. 2016×180	5.091	0.882	10.058	20.135	0.822	27.231	0.436	7.123	3.106
25th Feb. 2016×200	5.513	0.869	9.579	18.804	0.807	25.721	0.433	7.428	3.214
5th Feb. 2016×220	4.174	0.826	8.771	18.746	0.688	23.797	0.455	7.096	3.227
25th Feb. 2016× 120	5.101	1.069	9.741	18.763	0.899	25.486	0.334	4.288	1.431
25th Feb. 2016×140	4.547	0.870	10.281	19.128	0.797	25.470	0.342	4.503	1.538
25th Feb. 2016×160	4.970	0.889	10.808	18.700	0.796	25.168	0.344	5.330	1.833
25th Feb. 2016×180	4.354	0.734	10.485	17.900	0.677	25.131	0.361	5.862	2.105
25th Feb. 2016× 200	4.507	0.679	9.742	17.792	0.609	23.834	0.359	6.354	2.275
25th Feb. 2016×220	4.057	0.691	9.067	14.838	0.508	22.304	0.366	6.565	2.403
L.S.D (P≤0.05)	0.461	0.062	0.448	0.524	0.029	0.524	0.015	0.198	0.111

Data in Table (5) explained the combination effect between planting dates and removal treatments for grain yield and its components. Spike weight, number of spikelets/spike, number of grains/spike, weight of grains/spike, 1000- grain weight, harvest index, biological yield and grain yield responded significantly to this combination, while it was non-significant only for the character spike length. Maximum values for spike weight, number of spikelets/spike, number of grains/spike, weight of grains/spike, 1000- grain weight, biological yield and grain yield was (1.725 g, 15.093, 36.413, 1.497 g, 36.614 g, 12.796 ton/ ha, and 5.144 tons/ha), respectively produced by the interaction between (15th Nov. 2015 and Control), while maximum value of harvest index was 0.462 produced by the interaction between (25th Dec. 2015 and flag leaf removal treatments). Our results are also proving the finding of ***[21]*** that reported that in late sowing the grain yield ton/ha reduced due to a short growing period.

The harmful effect of delaying sowing on grain yield was maximum with reduction in 1000- grain weight ***[43; 44]***. A reduction in grain yield was reported 3-9% when awnes were removed 10 days after anthesis by ***[45]***.

Table- 5: The interaction effect of planting dates and removal treatments on the studied characters.

Planting dates × Removal treatments	***Spike length (cm)***	***Spike weight (g)***	***No. of spikelets/ Spike***	***No. of grains/ Spike***	***Weight of grains/ spike (g)***	***1000 grain weight (g)***	***Harvest index***	***Biological yield (tons/ha)***	***Grain yield (tons/ha)***
15th Nov. 2015×Control	8.421	1.725	15.093	36.413	1.497	36.614	0.406	12.796	5.144
15th Nov. 2015×Awn	8.067	1.636	14.430	32.543	1.382	34.942	0.412	12.030	4.932
15th Nov. 2015×Flag leaf	7.554	1.501	14.012	33.276	1.213	32.553	0.411	11.448	4.639
15th Nov. 2015×Both	7.333	1.385	13.388	29.827	1.093	30.359	0.426	10.390	4.384
5th Dec. 2015×Control	7.647	1.571	14.592	32.556	1.404	31.032	0.454	11.215	5.073
5th Dec. 2015×Awn	7.169	1.459	13.906	29.638	1.297	29.642	0.452	10.826	4.873
5th Dec. 2015×Flag leaf	7.132	1.258	13.485	30.015	1.137	28.045	0.451	10.183	4.544
5th Dec. 2015×Both	6.770	1.105	12.997	26.944	1.019	26.982	0.455	9.839	4.414
25th Dec. 2015×Control	6.957	1.421	13.197	30.990	1.216	33.671	0.454	11.096	5.018
25th Dec. 2015×Awn	6.453	1.307	12.171	27.442	1.100	31.862	0.452	10.674	4.813
25th Dec. 2015×Flag leaf	6.040	1.147	11.501	28.069	0.992	30.649	0.462	10.028	4.609
25th Dec. 2015×Both	5.745	1.105	10.782	24.904	0.908	29.371	0.456	9.711	4.414

15th Jan. 2016×Control	5.172	1.151	11.988	23.529	0.990	30.970	0.431	9.821	4.233
15th Jan. 2016×Awn	6.128	1.074	11.213	20.936	0.908	28.842	0.430	9.129	3.922
15th Jan. 2016×Flag leaf	5.834	0.931	10.640	21.074	0.768	27.692	0.434	8.700	3.778
15th Jan. 2016×Both	5.594	0.806	10.180	18.015	0.691	26.244	0.459	7.852	3.604
5th Feb. 2015×Control	5.755	1.111	10.486	23.133	0.967	28.943	0.428	7.326	3.141
5th Feb. 2015×Awn	5.246	1.017	10.028	20.991	0.878	27.116	0.428	6.805	2.914
5th Feb. 2015×Flag leaf	5.172	0.907	10.030	20.922	0.780	25.806	0.428	6.530	2.797
5th Feb. 2015×both	4.880	0.817	9.603	17.847	0.702	24.562	0.427	6.217	2.660
25th Feb. 2015×Control	5.014	1.001	10.401	20.619	0.847	27.073	0.343	6.107	2.105
25th Feb. 2015×Awn	4.703	0.886	10.049	18.068	0.767	25.819	0.352	5.705	2.013
25th Feb. 2015×Flag leaf	4.492	0.748	9.986	18.073	0.667	23.648	0.352	5.244	1.852
25th Feb. 2015×Both	4.147	0.654	9.646	14.653	0.577	21.723	0.357	4.878	1.753
L.S.D (P≤0.05)	n.s	0.050	0.366	0.428	0.024	0.428	0.012	0.162	0.091

Table (6) explained the effect of the interactions among plant density and removal treatments on some grain and its components. It was confirmed that the characters of spike weight, number of grains spike, weight of grains/spike, 1000 grain weight, harvest index, biological yield and grain yield responded to this combination significantly, while the character of spike length and number of spikelets/spike responded non significantly to this interaction effect. The maximum values for spike weight, number of grains spike weight of grains/spike, 1000 grain weight were (1.587 g, 31.246, 1.453 g and 32.799 g), respectively produced by the interaction between (120 kg/ha and the treatment of Control). Maximum value for harvest index was 0.450 produced by the interaction between (180kg/ha and both removal treatments). While maximum values for biological yield grain yield were (10.869 tons/ha and 4.661 tons/ha grain yield ton/ha) produced by interaction between (220 kg/ha and the treatment of Control). Plant density affected on grain yield and many characteristic were reported by ***[46]***. Effect of flag leaf removal was significant for all the characters except for spikelets/spike reported by ***[47].***

Table- 6: The interaction effect of plant density and removal treatments on the studied characters.

Plant Density (kg/ ha) x removal treatments	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelets/ spike*	*No. of grains/ spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (tons/ha)*	*Grain yield (tons/ha)*
120 x Control	7.290	1.587	13.733	31.246	1.453	32.799	0.382	8.718	3.359
120 x Awn	6.652	1.505	12.899	27.772	1.344	31.034	0.387	8.191	3.182
120 x Flag leaf	6.502	1.324	12.322	28.108	1.184	29.041	0.405	7.343	3.005
120 x Both	6.117	1.218	11.758	25.079	1.050	27.693	0.415	6.784	2.854
140 x Control	7.039	1.549	13.399	29.779	1.327	32.333	0.423	8.482	3.652
140 x Awn	6.342	1.410	12.460	26.593	1.201	30.560	0.419	8.206	3.495
140 x Flag leaf	5.927	1.211	12.161	27.141	1.062	28.344	0.427	7.514	3.260
140 x Both	5.578	1.092	11.540	23.660	0.943	26.838	0.432	7.061	3.121
160 x Control	6.747	1.348	12.843	28.481	1.172	31.590	0.418	9.495	3.994
160 x Awn	6.168	1.238	12.263	25.473	1.089	29.752	0.428	8.790	3.820
160 x Flag leaf	6.157	1.107	12.027	26.027	0.930	28.563	0.425	8.561	3.683
160 x Both	5.935	0.976	11.264	22.930	0.856	27.015	0.427	8.083	3.500
180 x Control	6.810	1.232	12.187	27.459	1.057	31.171	0.438	9.983	4.401

180 x Awn	6.498	1.121	11.538	24.464	0.964	29.796	0.435	9.442	4.136
180 x Flag leaf	5.968	0.976	11.059	24.569	0.852	28.112	0.430	9.015	3.881
180 x Both	5.772	0.876	10.846	21.274	0.758	26.257	0.450	8.144	3.653
200 x Control	6.546	1.161	11.928	25.775	0.993	30.756	0.426	10.815	4.647
200 x Awn	6.278	1.080	11.500	23.139	0.895	29.022	0.430	10.179	4.419
200 x Flag leaf	5.870	0.958	11.145	23.347	0.793	27.768	0.423	9.874	4.183
200 x Both	5.597	0.838	10.603	19.964	0.704	26.184	0.429	9.477	4.098
220 x Control	6.179	1.101	11.666	24.501	0.919	29.654	0.428	10.869	4.661
220 x Awn	5.827	1.025	11.137	22.177	0.841	28.059	0.425	10.362	4.415
220 x Flag leaf	5.801	0.914	10.939	22.236	0.735	26.565	0.427	9.825	4.207
220 x Both	5.471	0.873	10.586	19.282	0.677	25.253	0.428	9.339	4.002
L.S.D $_{(P\leq 0.05)}$	n.s	0.050	n.s	0.428	0.024	0.428	0.012	0.162	0.091

Table (7) explained the triple combination between the studied factors; Planting dates, plant density, and removal treatments on grain yield and its components. Significantly combination between Planting dates, plant density, and removal treatments, observed for the characteristics; spike weight, number of grains/spike, weight of grains/spike, 1000 grain weight, harvest index, biological yield and grain yield, with the exception of spike length and number of spikelets/spike were found to be non-significant. Maximum value to spike weight was 2.160 g exhibited by the combination between (15th Nov. 2015 under the planting densities of 140 kg/ha, and the treatment of control). Maximum number of grains/spike, weight of grains/spike and 1000 grain weight were 40.098, 1.862 g and 38.916 g, respectively produced by the combination between (15th Nov. 2015 under the planting densities of 120 kg/ha and the treatment of control). Maximum value of harvest index was 0.497 produced by the combination between (15th Jan. 2016 under the planting densities of 220 kg/ha and the treatment of control). While maximum values of biological yield and grain yield were 14.803 tons/ha and 5.844 ton/ha, respectively produced by the combination between (15th Nov. 2015 under the planting densities of 200 kg/ha and the treatment of control).

Like planting dates, balance plant density have also a significant role in the crop production system of wheat. Wheat variety reacts in different ways to various levels of plant densities. Plant density affects the plant population, number of tillers/m^2, 1000 grain weight and straw yield ***[48]***. As a result, the flag leaf, the awned and the second upper leaf blade are the most important photosynthesis part of the plant and nearly half of the dry material which is accumulated by the grain is obtained by these organs ***[49]***.

Table-7: The interaction effect of planting dates, plant density and removal treatments on the studied characters.

Plantig Dates	Plant Density (Kg/h)	Removal Treatmens	Spike length (cm)	Spike weight (g)	No. of spikelet/ spike	No. of grains/ Spike	Weight of grains/ spike (g)	1000 grain weight (g)	Harvest index	Biological yield (tons/ha)	Grain yield (tons/ha)
15th Nov. 2015	120	Control	8.917	1.788	17.083	40.098	1.862	38.916	0.408	10.733	4.378
		Awn	8.093	1.955	16.433	34.867	1.638	37.704	0.405	10.460	4.242
		F. leaf	8.039	1.763	15.993	35.474	1.586	34.484	0.433	9.339	4.033
		Both	7.257	1.639	15.167	32.733	1.335	33.294	0.431	8.687	3.746
	140	Control	8.897	2.160	15.833	39.167	1.824	38.136	0.469	9.651	4.528
		Awn	8.124	1.960	14.773	34.506	1.691	36.263	0.453	9.570	4.331
		F.leaf	7.370	1.824	15.033	35.533	1.462	33.940	0.474	8.607	4.082
		Both	7.233	1.703	14.183	31.941	1.280	31.042	0.483	7.852	3.794
	160	Control	8.767	1.698	15.467	37.633	1.567	37.156	0.374	13.865	5.184
		Awn	7.463	1.600	14.820	33.783	1.487	35.344	0.406	12.344	5.001
		F. leaf	7.853	1.434	14.580	34.650	1.244	33.153	0.383	12.416	4.753
		Both	7.293	1.342	14.087	31.387	1.142	30.073	0.401	11.082	4.443
	180	Control	8.283	1.614	13.833	36.040	1.334	36.122	0.387	14.403	5.566
		Awn	8.430	1.438	12.967	32.633	1.263	34.222	0.389	13.571	5.276
		F. leaf	6.570	1.305	12.067	33.400	1.032	32.025	0.370	13.364	4.936
		Both	7.223	1.161	11.633	30.000	0.931	29.638	0.389	11.746	4.567
	200	Control	8.057	1.661	14.267	34.033	1.305	36.135	0.395	14.803	5.844
		Awn	8.010	1.526	13.900	30.633	1.208	33.961	0.404	13.617	5.492
		F. leaf	7.763	1.437	13.333	31.467	1.042	31.750	0.389	13.268	5.158
		Both	8.067	1.332	12.800	28.200	0.931	29.885	0.422	12.272	5.169
	220	Control	7.603	1.426	14.073	31.509	1.091	33.219	0.403	13.318	5.363
		Awn	8.280	1.338	13.687	28.833	1.007	32.157	0.416	12.619	5.248
		F. leaf	7.727	1.241	13.067	29.133	0.914	29.969	0.417	11.692	4.869
		Both	6.927	1.136	12.460	24.700	0.937	28.222	0.429	10.699	4.586
5th Dec. 2015	120	Control	8.380	1.924	16.000	38.167	1.752	31.969	0.419	9.707	4.056
		Awn	7.560	1.750	15.190	34.618	1.657	29.325	0.414	8.955	3.702
		F. leaf	8.210	1.550	14.853	35.656	1.453	27.590	0.460	7.582	3.484
		Both	7.670	1.349	14.453	33.181	1.255	26.338	0.483	6.889	3.326
	140	Control	7.527	1.856	15.477	33.452	1.646	30.651	0.463	9.502	4.400
		Awn	7.010	1.765	14.847	30.511	1.532	29.771	0.483	9.003	4.344
		F. leaf	6.943	1.346	14.867	30.933	1.350	27.600	0.472	8.822	4.167
		Both	6.625	1.130	14.170	27.417	1.167	26.703	0.468	8.712	4.080
	160	Control	7.593	1.623	14.733	32.233	1.454	32.074	0.488	10.242	5.000
		Awn	7.063	1.436	13.930	29.766	1.356	30.961	0.494	10.017	4.949
		F. leaf	7.263	1.174	13.500	29.333	1.115	30.151	0.491	9.788	4.805
		Both	7.103	0.930	12.867	26.314	1.031	28.486	0.483	9.620	4.648
	180	Control	7.719	1.416	14.273	32.117	1.268	30.116	0.487	11.327	5.515
		Awn	7.403	1.344	13.367	29.033	1.156	29.226	0.462	10.992	5.079
		F. leaf	7.283	1.271	12.657	29.233	1.037	27.333	0.478	9.799	4.678
		Both	6.753	1.139	12.350	26.033	0.934	26.252	0.481	8.950	4.306
	200	Control	7.147	1.294	13.433	30.300	1.170	30.901	0.451	13.160	5.932
		Awn	6.933	1.261	13.233	26.900	1.040	29.412	0.450	12.867	5.791
		F. leaf	6.357	1.153	12.500	27.733	0.949	27.603	0.398	12.694	5.048
		Both	5.993	1.053	11.883	23.500	0.874	26.676	0.411	12.516	5.138
	220	Control	7.513	1.311	13.633	29.067	1.135	30.480	0.415	13.352	5.536
		Awn	7.043	1.198	12.867	27.000	1.041	29.155	0.410	13.121	5.373
		F. leaf	6.735	1.054	12.533	27.200	0.920	27.990	0.410	12.413	5.084
		Both	6.474	1.028	12.257	25.217	0.852	27.434	0.404	12.347	4.983

Continue

Table 7: The interaction effect of planting dates, plant density and removal treatments on the studied characters.

Planting Dates	Plant Density (Kg/ha)	Removal Treatments	Spike length (cm)	Spike weight (g)	No. of spikelet/ spike	No. of grains/ spike	Weight of grains/ spike (g)	1000 grain weight (g)	Harvest index	Biological yield (tons/h)	Grain yield (tons/h)
25th Dec. 2015	120	Control	7.572	1.714	14.803	34.815	1.550	35.945	0.386	11.267	4.341
		Awn	7.270	1.552	13.800	30.689	1.437	33.083	0.367	10.883	3.995
		F. leaf	6.450	1.355	12.433	31.653	1.245	31.704	0.385	9.955	3.829
		Both	6.273	1.262	11.877	28.857	1.154	31.390	0.395	9.548	3.770
	140	Control	7.404	1.550	14.226	34.285	1.329	34.674	0.472	9.874	4.661
		Awn	6.593	1.451	12.984	30.906	1.148	31.780	0.467	9.573	4.473
		F. leaf	5.980	1.273	12.333	32.015	1.025	29.797	0.487	8.226	4.006
		Both	5.630	1.161	11.817	27.800	0.953	28.483	0.481	7.963	3.829
	160	Control	6.578	1.451	13.273	32.333	1.217	33.393	0.446	10.853	4.843
		Awn	6.371	1.349	12.537	28.607	1.132	31.196	0.467	9.830	4.597
		F. leaf	6.261	1.271	11.600	29.559	1.030	30.097	0.478	9.267	4.429
		Both	5.775	1.147	10.710	26.815	1.024	28.927	0.445	9.263	4.126
	180	Control	6.840	1.332	12.657	29.675	1.127	33.557	0.495	10.605	5.243
		Awn	6.438	1.228	10.807	26.319	1.015	32.681	0.494	10.337	5.106
		F. leaf	5.953	1.016	10.100	26.233	0.964	30.828	0.494	9.728	4.804
		Both	5.772	0.966	9.620	23.130	0.847	29.637	0.494	9.379	4.631
	200	Control	6.826	1.245	12.093	28.207	1.049	32.832	0.493	11.236	5.532
		Awn	6.217	1.109	11.533	24.900	0.921	31.837	0.487	11.024	5.365
		F. leaf	5.698	0.923	11.420	25.633	0.843	32.088	0.494	10.868	5.365
		Both	5.340	0.885	10.067	22.287	0.721	29.119	0.489	10.333	5.057
	220	Control	6.524	1.232	12.130	26.626	1.022	31.625	0.431	12.742	5.491
		Awn	5.827	1.154	11.367	23.233	0.948	30.593	0.431	12.399	5.340
		F. leaf	5.897	1.043	11.117	23.322	0.843	29.379	0.431	12.122	5.220
		Both	5.680	1.210	10.600	20.533	0.750	28.672	0.431	11.779	5.073
15th Jan. 2016	120	Control	7.201	1.547	13.203	27.653	1.356	31.878	0.340	9.893	3.369
		Awn	6.133	1.462	11.840	24.527	1.347	29.927	0.373	8.482	3.161
		F. leaf	5.720	1.237	11.233	23.967	1.040	28.689	0.403	7.523	3.030
		Both	5.560	1.142	10.100	20.767	0.950	27.244	0.434	6.651	2.878
	140	Control	6.795	1.362	12.607	25.558	1.164	31.746	0.379	9.919	3.754
		Awn	5.712	1.255	10.757	21.903	1.058	28.892	0.354	9.653	3.417
		F. leaf	5.263	1.032	9.800	22.900	0.932	27.908	0.359	9.199	3.300
		Both	4.873	0.926	9.133	19.300	0.853	27.283	0.403	8.063	3.248
	160	Control	6.303	1.168	11.567	23.333	0.958	31.086	0.441	9.263	4.078
		Awn	5.636	1.071	10.607	20.274	0.866	27.719	0.450	8.237	3.708
		F. leaf	5.571	0.985	10.250	21.342	0.714	27.021	0.452	8.000	3.616
		Both	5.862	0.856	9.619	17.543	0.645	26.315	0.479	7.367	3.519
	180	Control	7.552	1.037	11.423	22.547	0.867	30.379	0.484	9.133	4.418
		Awn	7.051	0.950	11.357	20.430	0.730	28.714	0.488	8.559	4.177
		F. leaf	6.845	0.813	11.000	20.283	0.670	27.135	0.449	8.516	3.817
		Both	6.389	0.740	11.497	17.348	0.609	24.703	0.484	7.151	3.462
	200	Control	6.338	0.939	11.523	20.778	0.755	30.195	0.446	10.197	4.544
		Awn	6.267	0.886	11.383	19.033	0.685	28.451	0.441	9.783	4.315
		F. leaf	5.447	0.777	10.333	17.900	0.622	27.407	0.453	9.300	4.212
		Both	5.207	0.544	10.067	15.467	0.529	25.906	0.464	9.003	4.175
	220	Control	6.715	0.851	11.603	21.304	0.842	30.537	0.497	10.522	5.235
		Awn	5.970	0.819	11.333	19.450	0.763	29.347	0.472	10.061	4.752
		F. leaf	6.159	0.744	11.223	20.052	0.627	27.992	0.486	9.661	4.695
		Both	5.673	0.627	10.667	17.667	0.559	26.011	0.489	8.878	4.341

Continue

Table 7: The interaction effect of planting dates, plant density and removal treatments on the studied characters.

Plantig Dates	Plant Density (Kg/ha)	Removal Treatmens	Spike length (cm)	Spike weight (g)	No. of spikelet/ Spike	No. of grains/ spike	Weight of grains/ spike (g)	1000 grain weight (g)	Harvest index	Biological yield (tons/ha)	Grain yield (tons/ha)
5th Feb. 2016	120	Control	6.069	1.312	10.777	24.664	1.157	29.773	0.416	5.934	2.466
		Awn	5.657	1.160	10.300	22.633	1.042	28.873	0.416	5.755	2.392
		F. leaf	5.653	1.051	10.050	22.643	0.942	27.400	0.413	5.493	2.268
		Both	5.275	1.013	9.717	20.517	0.828	25.930	0.416	5.325	2.214
	140	Control	6.457	1.244	11.533	24.200	1.046	29.719	0.417	6.736	2.813
		Awn	5.933	1.114	10.933	22.400	0.935	28.422	0.419	6.441	2.697
		F. leaf	5.533	1.029	10.667	22.133	0.864	27.265	0.417	6.187	2.582
		Both	5.220	0.948	10.267	19.667	0.759	26.499	0.417	6.007	2.507
	160	Control	5.860	1.100	11.117	23.683	0.922	28.809	0.409	7.078	2.891
		Awn	5.360	1.045	10.853	21.810	0.847	27.444	0.409	6.811	2.782
		F. leaf	5.107	0.957	11.100	22.410	0.717	26.303	0.408	6.602	2.697
		Both	5.077	0.830	9.933	19.856	0.634	25.135	0.409	6.311	2.579
	180	Control	5.757	1.069	10.300	23.675	0.936	29.823	0.435	7.917	3.444
		Awn	5.253	0.923	10.233	20.600	0.863	27.716	0.435	7.079	3.078
		F. leaf	4.933	0.833	9.967	20.333	0.753	26.620	0.440	7.037	3.093
		Both	4.420	0.700	9.733	15.933	0.736	24.764	0.435	6.461	2.810
	200	Control	6.060	0.983	10.133	21.067	0.947	27.994	0.433	8.082	3.501
		Awn	5.463	0.966	9.317	19.100	0.842	25.992	0.432	7.513	3.249
		F. leaf	5.407	0.829	9.567	19.383	0.761	24.900	0.432	7.198	3.113
		Both	5.120	0.700	9.300	15.667	0.679	23.997	0.432	6.920	2.992
	220	Control	4.327	0.956	9.053	21.510	0.793	27.539	0.455	8.210	3.734
		Awn	3.807	0.891	8.533	19.400	0.741	24.251	0.455	7.229	3.288
		F. leaf	4.396	0.744	8.830	18.630	0.641	22.350	0.455	6.665	3.031
		Both	4.167	0.713	8.667	15.444	0.574	21.049	0.455	6.280	2.855
25th Feb. 2016	120	Control	5.600	1.235	10.533	22.077	1.039	28.311	0.324	4.771	1.546
		Awn	5.200	1.148	9.830	19.300	0.940	27.290	0.347	4.609	1.599
		F. leaf	4.938	0.991	9.367	19.257	0.838	24.381	0.333	4.167	1.387
		Both	4.667	0.901	9.233	14.417	0.779	21.964	0.331	3.603	1.193
	140	Control	5.153	1.120	10.720	22.010	0.956	29.069	0.337	5.207	1.756
		Awn	4.680	0.911	10.467	19.333	0.841	28.234	0.341	4.997	1.706
		F. leaf	4.470	0.763	10.267	19.333	0.743	23.557	0.353	4.041	1.422
		Both	3.883	0.684	9.670	15.833	0.648	21.020	0.337	3.766	1.269
	160	Control	5.380	1.049	10.900	21.667	0.915	27.022	0.347	5.669	1.967
		Awn	5.113	0.929	10.833	18.600	0.847	25.845	0.343	5.499	1.883
		F. leaf	4.885	0.824	11.133	18.867	0.762	24.650	0.339	5.294	1.796
		Both	4.500	0.752	10.367	15.667	0.659	23.155	0.347	4.856	1.687
	180	Control	4.709	0.925	10.633	20.700	0.811	27.028	0.341	6.511	2.222
		Awn	4.410	0.844	10.500	17.767	0.755	26.218	0.343	6.117	2.099
		F. leaf	4.220	0.619	10.567	17.933	0.653	24.731	0.347	5.643	1.958
		Both	4.075	0.549	10.240	15.200	0.491	22.549	0.414	5.178	2.142
	200	Control	4.850	0.842	10.117	20.267	0.731	26.481	0.342	7.411	2.532
		Awn	4.777	0.730	9.633	18.267	0.671	24.478	0.368	6.268	2.304
		F. leaf	4.547	0.628	9.717	17.967	0.540	22.859	0.373	5.919	2.206
		Both	3.853	0.516	9.500	14.667	0.492	21.520	0.354	5.815	2.058
	220	Control	4.393	0.833	9.500	16.993	0.629	24.525	0.369	7.069	2.610
		Awn	4.037	0.751	9.033	15.143	0.547	22.850	0.369	6.742	2.488
		F. leaf	3.893	0.661	8.867	15.080	0.465	21.709	0.366	6.398	2.344
		Both	3.903	0.520	8.867	12.133	0.392	20.131	0.359	6.051	2.171
L.S.D (P≤0.05)			n.s	0.123	n.s	1.047	0.058	1.048	0.029	0.396	0.222

Data represented in Table (8) explain mean squares of analysis of variance for the studies characters, It was noticed that the effect of planting dates-A, plant density-B, removal treatments-C and the interaction between planting dates and planting density (A×B) high significantly on all characters. The effect of interaction between planting dates and removal treatments (A×C) high significantly on all characters with the exception of spike length non significant effect and harvest index significantly. While the effect of interaction between plant density and removal treatment (A×C) and triple interaction between planting dates, plant density and removal treatments (A×B×C) high significantly for all characters with the exception of spike length and number of spikelet/spike non- significantly. Wheat yield is low on account of many biotic and abiotic factors. Among these, the time of sowing and planting density are of great significance which determine the proper stand establishment of growing crops through balancing the plant to plant competition and ultimately affected the yield ***[17; 18]***. Long awns are considered to be an important component trait of the high- yielding wheat ideotype, especially for wheat grown under water-limited conditions ***[8]***.

Table- 8: Mean squares of analysis of variance for the studied characters.

S.O.V	*d.f*	*Spike length (cm)*	*Spike weight (g)*	*No. of spikelets/ spike*	*No. of grains/ spike*	*Weight of grains/ spike (g)*	*1000 grain weight (g)*	*Harvest index*	*Biological yield (Tons/ha)*	*Grain yield (tons/ha)*
Replicates	*2*	*0.416*	*0.018*	*3.517*	*3.318*	*0.002*	*16.478*	*0.001*	*0.015*	*0.110*
***Planting Dates* (A)**	*5*	*103.020***	*5.554***	*239.143***	*2614.481***	*3.918***	*758.858***	*0.108***	*415.590***	*100.658***
***Plant Density* (B)**	*5*	*5.197***	*2.207***	*30.681***	*372.230***	*2.289***	*65.596***	*0.013***	*77.786***	*18.327***
***Removal Treatments* (C)**	*3*	*20.347***	*2.610***	*44.448***	*616.573***	*2.168***	*470.802***	*0.002***	*49.484***	*6.871***
(A×B)	*25*	*1.502***	*0.066***	*5.476***	*17.120***	*0.067***	*9.358***	*0.013***	*9.193***	*0.381***
(A×C)	*15*	*0.232 n.s*	*0.017***	*1.400***	*1.516***	*0.014***	*3.398***	*0.001**	*0.869***	*0.091***
(B×C)	*15*	*0.405 n.s*	*0.021***	*0.510 n.s*	*0.873**	*0.014***	*1.158***	*0.001***	*0.425***	*0.041***
(A×B×C)	*75*	*0.207 n.s*	*0.011***	*0.300 n.s*	*0.789***	*0.004***	*1.125***	*0.001***	*0.271***	*0.039***
Exp. Error	*286*	*0.3290*	*0.0059*	*0.3106*	*0.4248*	*0.0013*	*0.4250*	*0.0003*	*0.0608*	*0.0191*

Conclusion:

Late sowing gradually decreased the yield. It is, therefore, suggested that planting of wheat crop in the investigational zone may be completed before 25th February. The postponement of the planting of wheat led to a sharp decrease in grain yield. Density profits more from sunlight because of the distribution of plants and the penetration of light to form a canopy. Timing planting dates and plant densities are essential for maximum production of all wheat cultivars in response to the use of favorable conditions for photosynthesis. As a result, flag leaf was the most important photosynthetic of bread wheat during the grain filling stage. Besides, awns performed and effective role in photosynthesis, especially under the drought conditions. Thus, it was concluded that in order to obtain the maximum yield from bread wheat (Adana-99) it is recommended to grow this cultivar from 15th November with 120 kg/ha plant density and control (non removal treatments) to increase productivity of wheat.

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