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Effect of Sowing Date on Dry Matter Accumulation and Nitrogen Partitioning Efficiency of Some Wheat Cultivars

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ABSTRACT

The principle aim of this study was to investigate the response of the bread wheat cultivars to sowing dates. This study reveals one of the methods to handle the climate changes in Egypt. Two field experiments were carried out in Agric. Expt. Farm at Shalakan, Kaleobia Governorate, Egypt during 2010/2011 and 2011/2012 growing seasons. Each experiment included 15 treatments which were the combination between three wheat cultivars (Giza 168, Sakha 93 and Gemmiza 9) and five sowing dates (October 1, October 16, November 1, November 16 and December 1). The experimental design used was split plot design in 6 replications. The obtained results reveal that both sowing dates and wheat cultivars significantly affected dry weight of blades, tillers (stems and sheaths) and spikes of wheat cultivars at different growth stages. The percentages of blades and stems+sheaths were at the highest values at booting stage and in favor of wheat Gemmiza 9 cultivar followed by Giza 168 and Sakha 93. As the plants advanced towards maturity the percentage distribution of blades and stems+sheaths were markedly reduced. These reductions were accompanied with increase of spikes percentage of total plant dry weight ranging from 44.1 for Giza 168-45.4% for Sakha 93. The percentages distribution of plant organs of wheat cultivars was significantly varied. Under the conditions of this work sowing wheat plants at 1st November exhibited statistically maximum dry weight and percent distribution of blades, tillers and spikes in early. Sowing wheat plants cultivar Gemmiza 9 in 1st November exhibited maximum Nitrogen Use Efficiency (NUE), N Recovery Efficiency (NRE) and Nitrogen Harvest Index (NHI).

Key words: *Triticum aestivum*, wheat, sowing date, cultivars

INTRODUCTION

Wheat is an important food crop grown during the winter season. Variation in weather conditions among and within season is one of the most important factors affecting growth and dry matter accumulation (Aslani and Mehrvar, 2012). Ehdaie *et al.* (2001) tested nine wheat genotypes for nitrogen use efficiency and grain yield in relation to sowing dates. They found that late and early sowing may affect N requirement by changing the potential for root and plant development and the ability of the crop to recover soil N.

Ehdaie and Waines (2001) observed that the early planted crop removed more nitrogen from the soil, but less partitioning of nitrogen to grain compared to planted on the optimum date. They reported that, one of the requirements for obtaining optimum growth and yield potential is the choice of the suitable sowing date and high yielding cultivars. Genotypic differences for N concentration in straw were relatively small. Thus, N content in the shoot at anthesis and in grain and in straw at maturity was largely determined by dry matter accumulation rather than by N concentration.

The results of Qingsheng and Zhaosu (2008) showed that the amounts of dry matter accumulation significantly affected the grain weight. The varieties were differed in grain filling rate of each stage regardless its duration.

The aim of the present investigation was to evaluate the accumulation and percentage distribution of aerial plant organs during phynological stages of plant growth as well as the nitrogen physiological parameters at harvest.

MATERIALS AND METHODS

Two field experiments were carried out in Agric. Expt. Farm, Fac. of Agric., Ain Shams University at Shalakan, Kaleobia Governorate, Egypt during 2010/2011 and 2011/2012 growing seasons to study the response of some bread wheat cultivars to sowing date. Each experiment included 15 treatments which were the combination between three wheat cultivars namely (Sakha 93, Giza1 68 and Gemmiza 9), which were obtained from Wheat Dept., Agric. Res. Center (ARC), Ministry of Agric. at Giza and five sowing dates, which were: October 1, October 16, November 1, November 16 and December 1.

The mineral nitrogen fertilizer was applied as form of ammonium nitrate (33.5% N) at a rate of 80 kg N fad^{-1}. The N fertilizer was added in two equal portions. The first portion was added just before the first irrigation and the second portion was added just before the second irrigation. Phosphorus fertilizer was applied as calcium super-phosphate (15.5% P_2O_5) at a rate of 31 kg P_2O_5 fad^{-1} before sowing during the land preparation of the experimental soil.

The experimental design was split plot design in 6 replications. The sowing dates were arranged in the main plots. Varieties were allocated in the sub plots. The experimental unit area was 14 m^2 consisting of 20 rows each of 3.5 m along and 20 cm apart, grains were drilled in a single row. The recommended normal practical applications of growing wheat cultivar were applied during wheat growth. At harvest a sample of plants from 1 m^2 of each treatment in three replications was chosen at random, dried at 105°C. The following data were recorded.

Dry matter partitioning: At the different stages of growth, sample of 0.06 m^2 was chosen at random from every treatment in three replications at booting, heading and physiological maturity to determine dry weight of stems+sheaths, blades and spikes by drying the samples in an oven at 105°C to constant weight to estimate dry matter partitioned to stems+sheaths, blades and spikes (% of total plant biomass).

Nitrogen physiological parameters: The total accumulated nitrogen in grains and straw yields were estimated according to AOAC (1995) to calculate nitrogen physiological parameters including N recovery efficiency (NRE, kg N absorbed×100 kg^{-1} N applied fad^{-1}), N use efficiency (NUE, grain yield in kg fad^{-1} kg^{-1} N applied fad^{-1}), Nitrogen Harvest Index (NHI%, total N in grains×100/total N uptake) and nitrogen physiological efficiency (NPE, grain yield in kg/fad/N applied/fad) were calculated according to Timsina *et al.* (2001).

Statistical analysis: The obtained data in four replications were computed for proper statistical analysis according to SAS (2003). The LSD at 5% level of significance was used to differentiate between means. Data of 2009/2010 and 2010/2011 growing seasons were subjected to homogeneity variance test for running the combined analysis of the data.

RESULTS AND DISCUSSION

Cultivar differences

Dry matter accumulation and partitioning: The dry weight of the aerial parts of wheat cultivars including stems+sheaths and blades at booting stage as well as stems+sheaths, blades and spikes at heading and physiological maturity stages were evaluated during phenological stages of growth.

The data in Table 1 cleared that dry weight of plant organs varied significantly versus studied cultivars and growth stages. The dry weight of blades, tillers and spikes of wheat cultivars were in descending order with Gemmiza 9, Giza 168 and Sakha 93. Gemmiza 9 cultivar produced the highest and significant values of dry matter weighs at all studied stages. The weight of blades was in highest values at heading stage followed by marked decreases by advancing the plants towards maturity stage. These decreases were corresponded with substantial increases in reproductive organs, spikes dry weight, up to physiological maturity. It could be mainly attributed the decreases in blades weight to translocation of photosynthetic assimilates from vegetative to reproductive organs. These findings are in good agreement with those of Timsina *et al.* (2001), Tahir *et al.* (2005), El-Habbal *et al.* (2008) and Noureldin *et al.* (2007).

The data in Table 2 indicate that the percentage distribution of blades, tillers and spikes of wheat cultivars were significantly varied versus phynological stages and cultivars. The percentages of blades and stems+sheaths were at the highest values at booting stage and in favor of wheat Gemmiza 9 cultivar followed by Giza 168 and Sakha 93. As the plants advanced towards maturity the percentage distribution of blades and stems+sheaths were markedly reduced. These reductions were accompanied with increase of spikes percentage of total plant dry weight ranging from 44.1 for Giza 168-45.4% for Sakha 93.

Nitrogen physiological efficiency: The grain and straw nitrogen content were estimated to evaluate nitrogen physiological parameters as affected by studied cultivars. The data of NUE, NRE,

Table 1: Varietal differences in blades, stems+sheaths and spikes dry weight (g m^{-2}) of wheat plants at booting (B), heading (H) and physiological maturity (Phm) stages, combined analysis of the two growing seasons

	Blades			Stems+sheaths			Spikes	
Cultivars	B	H	Phm	B	H	Phm	H	Phm
Giza 168	273.5	303.8	242.5	375.2	549.6	776.2	232.4	821.0
Sakha 93	246.2	274.8	222.1	350.9	568.1	718.7	226.3	795.0
Gemmiza 9	289.0	319.1	272.2	401.7	616.1	877.5	245.5	942.8
LSD at 5%	3.1	5.4	8.8	3.9	3.3	5.9	2.9	8.7

Table 2: Varietal differences in dry matter partitioning (% of total plant dry weight) of stems+sheaths (T), blades (B) and spikes (S) of wheat plants during phynological stages of growth, combined analysis of the two growing seasons

	Booting		Heading			Physiological maturity		
Cultivars	B	T	B	T	S	B	T	S
Giza 168	42.1	57.9	27.7	51.2	21.1	13.5	42.4	44.1
Sakha 93	41.1	58.9	26.3	51.9	21.8	13.2	41.4	45.4
Gemmiza 9	41.9	58.1	27.9	51.1	21.0	13.3	41.9	44.8
LSD at 5%	0.4	0.4	0.4	0.4	0.2	NS	0.2	0.3

NS: Non significance

Table 3: Varietal differences in nitrogen use efficiency (NUE), nitrogen physiological efficiency (NPE%), nitrogen recovery efficiency (NRE) and nitrogen harvest index (NHI%) of wheat plant, data of 2010/2011 growing season

	N yield (kg fad^{-1})						
Cultivars	G	S	Total	NUE	NRE (%)	NPE	NHI (%)
Gizal 68	54.4	9.7	64.1	31.9	80.0	39.7	84.9
Sakha 93	51.8	10.6	62.4	30.7	78.0	39.3	83.2
Gemmiza 9	59.6	11.1	70.7	33.8	88.3	38.2	84.4
LSD at 5%	1.3	NS	2.0	1.0	2.5	NS	NS

NS: Non significance

Table 4: Blades, tillers and spikes dry weight (g m^{-2}) of wheat plant at booting (B), heading (H) and physiological maturity (Phm) stages as affected by sowing dates during phenological stages of growth, combined analysis of the two growing seasous

	Blades			Tillers			Spikes	
Sowing dates	B	H	Phm	B	H	Phm	H	Phm
1/10	174.4	215.3	205.0	248.7	321.9	529.5	171.4	551.4
16/10	239.8	275.7	217.2	336.2	420.6	692.2	198.3	690.2
1/11	314.4	347.9	268.5	454.1	866.5	986.1	298.2	1092.1
16/11	311.6	320.2	273.5	425.3	667.0	848.7	235.8	887.2
1/12	307.6	337.1	263.7	415.3	680.3	897.5	269.9	1027.1
LSD at 5%	2.1	5.8	7.3	5.4	2.2	7.1	3.5	10.2

NPE and NHI traits were varied considerably depending on wheat genetic make-up. Table 3 shows that wheat cultivar Gemmiza 9 had maximal values of NUE and NRE exhibiting 33.8 kg grains kg^{-1} nitrogen applied and 88.3%, respectively followed by Giza 168 and Sakha 93.

On the other hand, NPE and NHI of studied cultivars were insignificantly differed to be range between 38.2-39.7 kg grains kg^{-1} N absorbed and between 83.2-84.9% for the above respective cultivars. It was also found a positive relationship between NUE and NRE. These findings are true and in good agreement with those obtained by Tahir *et al*. (2005) and El-Habbal *et al*. (2008).

Effect of sowing dates

Dry matter accumulation and partitioning: The dry weight of above ground vegetative organs versus sowing dates of wheat plant was evaluated at booting, heading and physiological maturity stages. As shown in Table 4, there were significant differences in dry weight of vegetative organs. Sowing wheat plants at 1st November exhibited statistically maximum dry weight of blades, tillers and spikes in comparable to early and late sowing in the season.

On the other hand, the dry matter partitioning expressed as percentage of total plant dry weight showed different trend. The lowest significant percentage of blades at booting, heading and physiological maturity obtained at the three studied growing stages was obtained by sowing wheat plants on 1st November (Table 5). It was generally noticed a remarkable reduction in percentage of blades and tillers by advancing the plants towards maturity stage. On the contrary, the highest spikes yield either absolute amount (Table 4) or percentage of total plant biomass (Table 5) was found when the plants were sown on 1st November. It is worthy to note that, maximum growth of plants was obtained by sowing on 1st November being the optimum sowing date under Kaluobia Gvernorate conditions.

Table 5: Dry matter partitioning (% of total plant dry weight) of stems+sheaths (T), blades (B) and spikes (S) of wheat plant as affected by sowing dates during phenological stages of growth, combined analysis of the two growing seasons

	Booting		Heading			Physiological maturity		
Sowing dates	B	T	B	T	S	B	T	S
1/10	41.2	58.8	30.3	45.5	24.3	15.9	41.2	42.8
16/10	41.5	58.5	30.8	47.1	22.2	13.5	43.2	43.3
1/11	40.9	59.1	23.0	57.3	19.7	11.4	42.0	46.6
16/11	42.3	57.7	26.2	54.5	19.3	13.7	42.2	44.2
1/12	42.5	57.5	26.2	52.8	21.0	12.1	41.7	46.9
LSD at 5%	0.4	4.0	0.3	0.4	0.3	0.3	0.2	0.5

Table 6: Nitrogen nse efficiency (NUE), nitrogen physiological efficiency (NPE), nitrogen recovery efficiency (NRE%) and nitrogen harvest index (NHI%) of wheat plant as affected by sowing dates, combined analysis of the two growing seasons

	N yield (kg fad^{-1})						
Sowing dates	GN	SN	Total	NUE	NRE (%)	NPE	NHI (%)
1/10	46.1	8.9	54.9	25.1	68.7	36.7	83.9
16/10	49.0	9.1	58.1	28.3	72.6	39.1	84.4
1/11	65.6	12.3	78.0	38.9	97.4	39.9	84.2
16/11	60.0	12.3	72.4	36.0	90.4	39.9	83.0
1/12	55.4	9.7	65.1	32.3	81.4	39.8	85.2
LSD at 5%	0.9	0.9	1.2	1.2	1.5	0.8	NS

NS: Non significance

At harvest the total nitrogen yield in straw and grains was recorded to calculate NUE, NRE, NPF and NHI. Data in Table 6 cleared that sowing wheat plants on 1st November exhibited maximum NUE, NRE and NPE being 38.9 kg grains kg^{-1} applied N, 97.4% and 39.9 kg grains kg^{-1} absorbed N, respectively.

Delaying sowing date from 1st November up to 16th November or 1st December reduced NUE to 36.0 and 32.3 kg grains kg^{-1} applied N, whereas NPE was statistically at the same level. As sowing early in the season the significant lowest values was monitored in the above studied traits. Concerning NHI, the data in Table 6 showed slight differences versus studying sowing dates to be range between 83.0-85.2%.

Effect of the interaction between wheat cultivars and sowing dates

Dry matter partitioning: The interaction between sowing dates and studied wheat cultivars on dry matter accumulation were evaluated at booting, heading and physiological maturity stages. As shown in Table 7 it was cleared that the dry weight of vegetative organs of wheat cultivar Gemmiza 9 exhibited significant maximum dry weight of blades, stems+sheaths and spikes under different growth stages. The dry matter accumulated in plant organs were markedly and significantly decreased versus early sowing date and reached their significant minimal values by sowing on 1st October. On the other hand, the decrease in the above traits was monitored at late sowing but by less extent as compared to early sowing. It is worthy to note that the dry weight of stems+sheaths was substantially increased by advancing the plants towards maturity and beginning the differentiation of reproductive organs. The dry weight of spikes was markedly increased reaching their maximum values at physiological maturity stage.

Table 7: Effect of the interaction between wheat cultivars and sowing dates on blades, stems+sheaths and spikes dry weight (g m^{-2}) at booting (B), heading (H) and physiological maturity (Phm) during phenological stages of growth, combined analysis of the two growing seasons

		Blades			Tillers			Spikes	
Sowing dates	Cultivars	B	H	Phm	B	H	Phm	H	Phm
1/10	Giza 168	172.7	222.3	205.1	242.3	322.7	551.2	167.9	487.8
	Sakha 93	163.0	177.6	167.8	234.9	293.7	434.5	168.5	485.8
	Gemmiza 9	187.6	246.2	242.3	268.8	349.1	602.6	177.8	680.6
16/10	Giza 168	244.5	274.8	206.6	337.7	416.2	701.7	197.3	687.4
	Sakha 93	205.8	253.7	186.1	315.7	414.7	576.2	190.9	631.4
	Gemmiza 9	269.0	298.5	258.9	355.2	430.9	798.7	206.5	751.8
1/11	Giza 168	325.1	356.2	253.8	453.7	858.1	916.7	284.4	1047.8
	Sakha 93	282.4	320.3	250.9	426.4	861.1	953.2	284.7	1034.6
	Gemmiza 9	335.8	367.2	300.8	482.3	880.2	1088.4	325.5	1193.9
16/11	Giza 168	312.3	323.2	276.9	419.1	690.3	818.3	254.1	877.8
	Sakha 93	296.2	306.9	263.3	390.1	642.9	775.7	231.0	838.0
	Gemmiza 9	326.4	330.4	280.4	466.5	667.7	952.0	222.3	945.8
1/12	Giza 168	312.8	342.5	270.0	423.1	660.4	893.2	258.1	1004.2
	Sakha 93	283.6	315.6	242.4	387.2	627.9	853.8	256.5	935.1
	Gemmiza 9	326.4	353.1	278.9	435.7	752.5	945.6	295.0	1142.1
LSD at 5%		6.8	12.1	19.6	8.6	7.3	13.2	6.4	19.5

From the above-mentioned data, it may be concluded that the daytime air and soil temperatures play an important role on dry matter accumulation. The relatively high temperatures in the season negatively affected all the above studied parameters. These findings agree with (Fowler *et al.*, 1990). They found that yield and its attributes are influenced by both environmental and genotypic factors that are difficult to separate. In this respect, Tahir *et al.* (2005) indicated that high daytime temperatures of air and soil significantly decreased the chlorophyll content of flag leaves, grain filling duration and increased carbohydrate remobi-lization or loss from the tillers and roots but with varying degrees among genotypes.

On the other hand, the dry matter partitioning expressed as percentage of dry weight of plant organs to total plant dry weight showed different trend (Table 8). The percentages of blades and stems+sheaths were markedly decreased by advancing the plants from booting towards maturity stage. These decreases were corresponded with substantial increase in spikes percentage reaching their maximal values at physiological maturity stage. The maximum percentage of blades showed when sowing Sakha 93 on 16th November, sowing Gemmiza 9 on 16th October and sowing Giza 168 sown on 1st October during booting, heading and physiological maturity stages, respectively.

Meanwhile, the maximum percentage of spikes observed when Sakha 93 was sown on 1st October and Gemmiza 9 sown on 1st December during heading and physiological maturity stages, respectively.

Nitrogen physiological parameters: The interaction between sowing dates and studied wheat cultivars affected significantly nitrogen physiological parameters. The data in Table 9 cleared that all the three studied cultivars gave maximum values of NUE, NRE and NPE by sowing on 1st November. Gemmiza 9 exhibited maximum value of NUE (41.6 kg grains kg^{-1} N applied) and NRE (105.7%) in comparison to the other two cultivars grown under the same date. The exceeded of NRE over 100% could be attributed to more absorption and utilization of available soil N by roots of

Table 8: Effect of the interaction between wheat cultivars and sowing dates on dry matter partitioning (% of total plant dry weight) of blades (B), stems+sheaths (T) and spikes (S) during phenological stages growth, combined analysis of the two growing seasons

		Booting		Heading			Physiological maturity		
Sowing dates	Cultivars	B	T	B	T	S	B	T	S
1/10	Giza 168	41.6	58.4	31.2	45.3	23.5	16.5	44.3	39.2
	Sakha 93	41.0	59.0	27.8	45.9	26.3	15.4	39.9	44.7
	Gezmiza 9	41.1	58.9	31.8	45.2	23.0	15.9	39.5	44.6
16/10	Giza 168	42.0	58.0	30.9	46.9	22.2	13.0	44.0	43.0
	Sakha 93	39.5	60.5	29.5	48.3	22.2	13.4	41.3	45.3
	Gemmiza 9	43.1	56.9	31.9	46.0	22.1	14.3	44.1	41.6
1/11	Giza 168	41.7	58.3	23.8	57.2	19.0	11.4	41.3	47.3
	Sakha 93	39.8	60.2	21.9	58.7	19.4	11.2	42.6	46.2
	Gemmiza 9	41.0	59.0	23.3	56.0	20.7	11.7	42.1	46.2
16/11	Giza 168	42.7	57.3	25.5	54.5	20.0	14.0	41.5	44.5
	Sakha 93	43.2	56.8	26.0	54.5	19.5	14.0	41.3	44.7
	Gemmiza 9	41.2	58.8	27.1	54.7	18.2	13.0	43.7	43.3
1/12	Giza 168	42.5	57.5	27.1	52.4	20.5	12.5	41.2	46.3
	Sakha 93	42.3	57.7	26.3	52.3	21.4	11.9	42.0	46.1
	Gemmiza 9	42.8	57.2	25.2	53.7	21.1	11.8	40.0	48.2
LSD at 5%		0.9	0.8	0.9	0.9	0.5	0.8	0.5	0.7

Table 9: Effect of the interaction between wheat cultivars and sowing dates on nitrogen use efficiency (NUE), nitrogen physiological efficiency (NPE), nitrogen recovery efficiency (NRE) and nitrogen harvest index (NHI) of wheat plant as affected by sowing dates, combined analysis of the two growing seasons

		N yield						
Sowing dates	Cultivars	G	S	Total	NUE	NRE (%)	NPE	NHI (%)
1/10	Giza 168	45.5	9.8	55.3	25.0	69.2	36.1	82.3
	Sakha 93	43.0	8.1	51.1	24.0	63.9	37.7	84.2
	Gemmiza 9	49.8	8.7	58.4	26.4	73.0	36.2	85.3
16/10	Giza 168	48.8	8.7	57.4	28.4	71.8	39.7	85.0
	Sakha 93	46.7	9.9	56.6	27.2	70.8	38.5	82.6
	Gemmiza 9	51.6	8.8	60.4	29.4	75.4	39.1	85.5
1/11	Giza 168	64.1	11.0	75.1	38.4	93.8	41.0	85.4
	Sakha 93	61.1	13.2	74.3	36.6	92.8	39.4	82.3
	Gemmiza 9	71.8	12.7	84.6	41.6	105.0	93.3	85.0
16/11	Giza 168	59.1	10.6	69.7	35.6	87.1	41.0	84.8
	Sakha 93	56.0	12.7	68.8	34.6	85.9	40.2	81.5
	Gemmiza 9	65.1	13.7	78.7	37.9	98.4	38.6	82.7
1/12	Giza 168	54.5	8.3	62.8	32.0	78.4	40.8	86.9
	Sakha 93	52.2	9.0	61.2	31.0	76.5	40.7	85.3
	Gemmiza 9	59.6	11.9	71.4	33.8	89.3	37.8	83.4
LSD at 5%		2.8	3.5	4.4	2.3	5.5	2.9	NS

NS: Non significance

studied cultivar. Concerning NHI, The results showed slight differences versus studying the interaction between sowing dates and wheat cultivars with an average of 84.3%. This finding indicates how difficult to improve N partitioning efficiency to any great extent. Therefore, it is necessary to enhance the N assimilation in order to concentrate more N in the grains and prolonging the duration of N uptake.

CONCLUSION

It could be concluded that sowing wheat plants at 1st November exhibited statistically maximum dry weight and percent distribution of blades, tillers and spikes in early and late sowing in the season. Sowing wheat plants cultivar Gemmiza 9 in 1st November exhibited maximum NUE, NRE and NPE. Nitrogen Harvest Index (NHI) was slightly differed versus sowing dates and genotypic differences.

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