Egypt. J. Plant Breed. 24(2):319– 343(2020)

EFFECT OF SOWING DATE, CULTIVAR, AND SEEDING RATE ON BARLEY UNDER SANDY SOIL CONDITIONS IN EYGPT

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ABSTRACT

A field trial was carried out at Ismailia Agric. Res. Sta. through 2017/2018 and 2018/2019 winter seasons. The study aimed to find out the effect of three sowing dates (5th November, 25th November and 15th December) and four seeding rate (30, 40, 50 and 60 kg seeds fad^{-1}) on three barley cultivars (Giza 2000, Giza 134 and Giza 131) under sandy soil conditions for phenological stages, growth parameters, yield and yield components of barley. The early sowing on 5th Nov. produced the longest phenological duration and growing degree days at booting, heading and maturity, the highest growth parameters, i.e. total chlorophyll, crop growth rate, leaf relative water content, the highest yield, yield components and attributes i.e. plant height, number of grains spike^{-1}, 1000-grain weight, number of spikes m^{-2} grain and harvest index compared with other sowing dates. Cultivars significantly affected phenological stages, growth parameters, yield and yield components. Giza134 cultivar had the highest values of all mentioned traits, except for 1000-grain weight, which was increased by Giza 131cultivar. Increasing seeding rate up to 60 kg seeds fad^{-1} decreased number of days and growing degree days at all phenological stages, total chlorophyll, leaf relative water content, spike length, number of grains spike^{-1}, 1000-grain weight and harvest index, however it increased plant height, number of spikes m^{-2} and biological yield fad^{-1}. Crop growth rate, net assimilation rate and grain yield fad^{-1} responded to increasing seeding rate up to 50 kg seeds fad^{-1}.

Key words: ***Barley, Sowing date, Seeding rate, Phenological stages, Growth parameters, Grain yield.***

INTRODUCTION

Barley (*Hordeum vulgare,* L.) is the world's fourth most important cereal crop and the fourth ranking cereal in Egypt after wheat, maize and rice (Noaman 2008). Barley is grown over a border that is produced in regions with climates unfavorable for production of other major cereals. Total harvested area by barley in Egypt from 2016/2017 season amounted to 175270 feddan with an annual production of approximately 239667 ton (Economic Affairs Sector- Bulletin of Agriculture Statistics). Yield and quality of barley are known to be influenced by several factors such as cultivar, sowing time, sowing depth, seeding rate, water and nutrient management, harvesting time and other agronomic practices. On the other hand, late sowing of barley might expose the plants to higher temperature after and during heading, resulting in reduced number of spikes m^{-2} and grains number spike^{-1} (Randhawa *et al* 1977). Late sowing is always accompanied with late emergence due to low day and night temperatures. Many workers reported that early sowing of barley significantly increased yield and its attributes compared with late sowing. Chaudhary *et al* (2017) studied five dates of sowing on barley growth under sandy loam conditions at 30th October, 10th, 20th, 30th November and 10th December. They revealed that sowing at 30th October recorded higher number of productive tillers, grains number per spike, spike length, whereas, the lowest number previous traits were recorded in sowing at 10th Dec. and they added selection of optimum sowing time may be the best option to escape heat stress at anthesis and grain filling stage and to avoid losses and sustain yield levels. On the other hand, Amarjeet *et al* (2020) found that sowing barley in last week of October and 1st week of November produced the highest grain yield compared with sowing in 3rd week of November. This might be because of the higher temperature during the reproductive phase, particularly at the grain filling stage. Abiotic stresses (heat and drought) affect grain filling and reproductive processes (Sehgal *et al* 2018). In the same trend Mahanta *et al* (2018) sowed barley at 25th October, 10th, 25th Nov., and 10th and 25th December and pointed out that sowing at 10th Nov. was superior to others in effective tillers m^{-2} grains $head^{-1}$, thousand-grain weight, plant height, head length and grain yield. While, the previous traits recorded the worst values with sowing date at 25th Dec. Suleiman *et al* (2014) reported that late sowing not only shortened the vegetative phases but also reduced yield of wheat. The highest yield was obtained when cultivars were sown between 1st Nov. to 15th Nov. Singh *et al* (2018) sowed barley at 20th Oct., 16th Nov. and 10th Dec. and found that sowing date at 20th Oct. achieved maximum values of no. spike m^{-2} and biological yield, while sowing date at 16th Nov. resulted in better grain yield, spike length and number of grains $spike^{-1}$.

Several investigators reported that barley cultivars showed significant differences in yield and yield attributes due to differences in their genetic background (El-Bawab *et al*, 2011, El-Bawab *et al*, 2014, El-Banna *et al*, 2011, Omar 2013 Ramadhan., 2013, Ashmawy *et al* 2016 and Abu-Grab *et al* 2017), who recorded that the two new barley cultivars Giza 133 and Giza 134 surpassed Giza 123 and Giza 2000 under newly reclaimed lands.

An appropriate seed rate is the most important agronomic management factor in barley. Delaying sowing date in dry area with sufficient soil moisture is not adequate, reduced individual plant growth and tiller production. So late sowing date and dry area normally require higher seed rate. Seed rate also differ by cultivar and sowing method.

Generally, broadcast sowing method requires higher seed than any sowing method. So proper amount of seed is necessary for good plant stand and establishment. Donavon *et al* (2011) found that increasing seeding rate from 200 to 400 seeds m^{-2} had no significant effect on grain yield of malting barley cultivars grown under Canadian conditions. Ramadhan (2013) indicated that increasing seeding rate from 100 to 140 kg/ha caused a significant increase in number of tillers/m^2, plant height, number of spikes m^{-2}, grain and biological yields. Increase in number of tillers/m^2 may be attributed to the fact that more plants emerged as the seeding rate was increased which is reflected on the total number of tillers per unit area. Kiliç and Gürsoy (2010) found a negative correlation between seeding rate and harvest index, no. of grains, 1000 grain and chlorophyll content. Increasing seeding rate from 50 to 550 seeds m^{-2} resulted significant reduction in the above mentioned traits. On the other hand, increasing seeding rate increased in plant height and no. of spike m^{-2} in barley crop (Omar 2013). Therefore, the present study aimed to investigate the effect of sowing date, barley cultivar and planting density on phenological stages, growth parameters, yield and yield components under newly reclaimed sandy soil using sprinkler irrigation system in Eygpt.

MATERIALS AND METHODS

The current study was conducted at Ismalia Agricultural Research Station farm during 2017/2018 and 2018/2019 winter seasons. This study aimed to investigate the phenological and physiological responses to sowing date and seeding rate of three barley cultivars under sandy soil conditions. The experiment was laid out in a split split plot design with three replicates. The main plots were assigned to three sowing dates at 1st Nov.(early), 25th Nov. (optimum) and 15th Dec. (late) and sub-plots were occupied by three barley cultivars, *i.e.* Giza 134, Giza 2000 and Giza 131 whereas the sub sub- plots were devoted to seeding rate *i.e*. 30, 40, 50 and 60 kg seeds/fad. Sub- sub- plot area was 10.5 m^2 (3.5× 3 m), 15 rows, 20 cm apart and 3.5 long. Sprinkler irrigation system was used in this study. Seeds of the tested genotypes were supplied from the Barley Program, Field Crops Research Institute, Agricultural Research Center and using conventional practices in the area.

Some physical and chemical properties of the experimental site are presented in Table (1)

Table 1. Physical and chemical analysis of soil texture in the experimental site.

Season	Particle size distribution				Soil Tex.	O.M%	$CaCO_3$%	pH (1:2.5)	Available nutrients (ppm)		
	Coarse sand%	Fine sand%	Silt%	Clay%					N	P	K
2017/2018	82.27	10.80	1.60	5.33	sandy	0.59	0.46	7.50	32.09	5.30	80.2
2018/2019	82.80	10.60	1.55	5.05	sandy	0.62	0.48	7.40	34.5	5.20	75.3

Table 2. Monthly maximum and minimum air temperatures and relative humidity% at El-Ismalia Agric. Res. Stat. in 2017/2018 and 2018/2019 seasons.

Month	2017/2018				2018/2019			
	Relative humidity%	Temperature ºC			Relative humidity%	Temperature Cº		
		Min	Max	Mean		Min	Max	Mean
November	54.70	12.07	24.91	18.49	51.92	13.24	25.49	19.37
December	60.10	10.40	21.07	15.72	57.10	9.85	19.24	14.55
January	60.11	8.83	17.58	13.21	55.94	6.38	17.61	12.00
February	50.15	10.35	22.06	16.21	51.25	7.47	19.57	13.52
March	45.03	12.63	26.03	19.33	43.29	10.13	21.00	15.57
April	42.05	14.86	27.79	21.33	44.17	12.83	25.47	19.15

***Source: Water Requirements and field Irrigation Research Dpt., Soil Water and Environment Research Institute (SWERI), Agric. Res. Center. Egypt.**

Data recorded

Phenological stages

-Number of days to germination, booting, heading and maturity.

-Growing degree days (GDD): was calculated according to the following formula: (GDD) $=\sum [(T_{max}+ T_{min})/2-T_b]$, where T_{max} and T_{min} are the maximum and minimum daily temperature and T_b is the base temperature $T_b= 4.5\,^oC$ as recommended by Monteith (1984).

Growth parameters

-Total chlorophyll content (mg dm^{-2}) was measured spectrophotometrecally at booting stage according to **Moran (1982)**. The chlorophyll content was calculated using the following formula:

Chl.a+b =7.04 x A664 +20.27 x A647= (µg. ml^{-1}),

Where: A664 is the absorbance reading at 664 nm, A 647 is the reading at 647nm.

To estimate crop growth rate (CGR), plants of 25 cm long from each row were randomly taken from each plot at boating stage and then after 20 days. Plants were separated into roots and shoots then dried at 70^O C in a ventilated oven to a constant weight. The following formula was used to determine CGR character according to Watson (1952).

-Crop growth rate (CGR) is the rate of dry matter accumulation per unit of occupied ground per day.

$CGR = (W_2 – W_1)/(T_2 – T_1) = g\ m^{-2}\ week^{-1}$

Where, W_1 and W_2 refer to dry weight of barley plant at boating stage and then after 20 days whereas T_1 and T_2 refer to the time between boating stage and then after 20 days.

Net Assimilation rate (NAR)-

Net assimilation rate is the increase rate of plant dry matter per leaf area unit per time unit.

$NAR = (W_2 – W_1) (\log_e A_2 – \log_e A_1) / (A_2 – A_1) (T_2-T_1) = g /m^{-2}/ week$ according to Radford (1967).

Where: W_1, A_1 and W_2, A_2 respectively refer to dry weight and leaf area at time (T_1 and T_2) in weeks.

-Leaf relative water content (RWC%)

RWC = (F_w - D_w) / (T_w - D_w) X 100 according to (Barris and Weatherly 1962), where F_w , T_w and D_w are fresh weight, turgid weight and dry weight, respectively.

-Flag leaf osmotic potential (OP, bar) (Gusev 1960).

Yield and yield components

At harvest time, ten guarded plants were randomly taken from the central row in each plot to determine the following traits:

- Plant height (cm). - Spike length (cm).
- 1000- grain weight (g). - Number of grains per spike.

Numbers of spikes m^{-2} were determined from one m area in each plot. In addition, plants in the central area (2 m^2) of each plot were harvested to determine:

- Biological yield (kg/fed). - Grain yield (ard fed^{-1}). - Harvest index (%).

Data were statistically analyzed according to Gomez and Gomez (1984) by using MSTAT-C (1991) where statistical program Version 2.1 was used for analysis of variance (ANOVA). In table 3, 4 a combined analysis was performed for the data of the two seasons after testing the homogeneity of the experimental error by Bartellets test (Steel *et al* 1997). The collected data were statistically analyzed (Steel and Torrie 1980). Means of the studied traits were compared using LSD at 5% probability level.

RESULTS AND DISCUSSION

Phenological stage

Table (3) showed the effect of sowing date and seeding rate on number of days and growing degree days to germination, booting, heading and maturity stages of the three barley cultivars.

Number of days to germination, booting, heading and maturity

Effect of sowing date

Sowing date significantly affected all traits for combined data across years. Early sowing date resulted in an increase in number of days for studied traits, except number of days to germination stage which was shorter than other dates. Also, number of days to germination decreased by 4.08 days compared with late sowing.

Table 3. Phenological traits of three barley cultivars as affected by sowing date, cultivar and seeding rate in the combined analysis across years.

Treats	No. of days to				Growing degree days			
	Germ.	Booting	Heading	Maturity	Germ.	Booting	Heading	Maturity
Sowing date (A)								
5th Nov. (A_1)	15.14	78.24	87.76	130.4	233.0	905.1	981.8	1434
25th Nov. (A_2)	17.07	73.65	83.69	124.5	199.6	719.2	820.3	1316
15th Dec. (A_3)	19.22	67.85	75.83	119.1	175.1	623.9	719.4	1317
LSD 0.05	0.22	0.80	0.74	2.1	2.1	5.0	5.13	28
Cultivars (B)								
Giza 2000 (B_1)	17.31	73.04	82.76	124.2	204.2	746.3	843.1	1348
Giza 134 (B_2)	16.25	75.47	84.69	127.7	193.4	772.0	863.3	1397
Giza 131 (B_3)	17.88	71.22	79.83	122.1	210.0	730.0	815.0	1321
LSD 0.05	0.34	0.74	0.57	0.9	4.1	5.9	4.4	12
Seeding rate (C)								
30 kg seeds fad^{-1} (C_1)	19.02	75.63	85.46	127.7	223.9	771.7	869.5	1396
40 kg seeds fad^{-1} (C_2)	17.57	74.26	83.52	125.4	207.0	759.6	850.8	1365
50 kg seeds fad^{-1} (C_3)	16.48	72.41	81.50	123.5	195.2	741.8	831.5	1341
60 kg seeds fad^{-1} (C_4)	15.50	70.69	79.24	122.1	184.1	724.5	810.1	1321
LSD 0.05	0.32	0.72	0.63	1.4	3.4	6.2	6.5	18

Treats = Treatments, Germ. = Germination.

Number of days to booting, heading and maturity stages increased by 10.39, 11.93 and 11.30 days, respectively when sowing was at 5th Nov. compared with delaying of sowing. Our results are in agreement with those of Alam *et al* (2006) who stated that delaying sowing crop may be face the unappropriate temperature prevailing at different growth stages, moreover, low temperature at the time of germination delayed growth and development of the crop, resulting in sufficient of the accumulation biomass and shortening of crop duration. In addition, sowing at 10th Nov. increased number of days at booting stage compared with 20th Dec. (Wahid *et al* 2017) and increased number of days at heading and maturity stages compared with 15th Dec. when sowing was at 25th Oct. (Ali *et al* 2017).

Barley cultivars behavior

There were significant differences among studied cultivars for studied attributes. Giza134 was earlier in germination by 1.63 days compared with Giza 131 but showed increased number of days to booting, heading and maturity stages by 4.25, 4.86 and 5.60 days, respectively, compared with Giza 131(Table, 3).

Effect of seeding rate

As shown in Table (3), data indicated that increasing seeding rate to 60 kg seeds fad^{-1} decreased number of days to germination, booting, heading and maturity stage by 3.52, 4.94, 6.22 and 5.58 days, respectively compared with seeding rate at 30 kg seeds fad^{-1}. These results agreed with those of Ejas *et al* (2003), who stated that the low seeds rate increased number of days to reach the stages of flowering, grain filling and full maturity of barley. Turk *et al* (2003) confirmed that high seeding rate stimulated the early evolution of phenological maturity and breadth of flag leaf at about ten days, compared with the low seed rate. Our results are agreed with those of (Dofing and Knight, 1992, Rawashdeh, 2015 and Amarjeet *et al* 2020).

Effect of the interactions

Data in (Table, 4) mentioned that the interaction between sowing date and cultivar had a significant effect on number of days to heading and maturity stages. Early sowing at 5th Nov. of Giza 134 increased number of days to heading and maturity stages. On the other side, late sowing at 15th Dec. of Giza 131 decreased number of days to heading and maturity stages.

Data presented in (Table 4) for sowing date and seeding rate interaction indicated that there are significant effect on number of days to germination and booting stages, while heading and maturity were not significant affected. Sowing 60 kg seeds fad^{-1} at 5th Nov. decreased number of days to germination. On the other side, sowing 30 kg seeds fad^{1} at 15th Dec. increased number of days to germination. In addition, sowing 30 kg seeds fad^{-1} at 5th Nov. significantly increased number of days to booting stage, while sowing 60 kg seeds fad^{-1} at 15th Dec. significantly decreased number of days to booting stage. The interaction between cultivar and seeding rate was not significant in all phenological stages.

Table 4. Phenological traits of three barley cultivars as affected by sowing date x Cultivars (A x B), sowing date x seeding rate (A x C) and Cultivars x seeding rate (B x C) interactions in the combined analysis.

Treats	No. of days to				Growing degree days			
	Germ.	Booting	Heading	Maturity	Germ.	Booting	Heading	Maturity
AB								
A1B1	15.25	78.29	87.54	129.4	234.5	905.4	980.1	1419
A1B2	14.50	81.04	90.29	134.7	223.9	927.2	1002.6	1491
A1B3	15.67	75.38	85.46	127.2	240.5	882.5	962.6	1392
A2B1	17.17	73.13	84.63	124.3	200.6	712.1	828.8	1314
A2B2	16.21	75.63	85.29	127.3	190.4	743.0	835.1	1351
A2B3	17.83	72.21	81.17	121.9	207.7	702.6	796.9	1282
A3B1	19.50	67.71	76.13	118.8	177.4	621.3	720.4	1312
A3B2	18.04	69.75	78.50	121.2	165.9	645.8	752.3	1350
A3B3	20.13	66.08	72.88	117.3	181.9	604.7	685.5	1289
LSD0.05	NS	NS	0.98	1.6	NS	NS	7.7	NS
AC								
A1C1	17.22	81.83	91.06	134.3	262.4	933.4	1009.9	1484
A1C2	15.56	79.56	89.11	130.8	239.0	915.4	992.6	1437
A1C3	14.44	77.00	86.72	128.9	223.4	895.3	973.3	1415
A1C4	13.33	74.56	84.17	127.6	207.1	876.2	951.4	1401
A2C1	19.39	75.28	87.11	127.7	225.1	737.1	851.7	1358
A2C2	17.50	74.94	84.83	125.6	203.7	734.7	830.5	1329
A2C3	16.28	72.89	82.78	123.3	190.7	712.5	811.1	1300
A2C4	15.11	71.50	80.06	121.5	178.8	692.7	787.7	1276
A3C1	20.44	69.78	78.22	120.9	184.3	644.7	746.9	1345
A3C2	19.67	68.28	76.61	119.9	178.3	628.8	729.3	1330
A3C3	18.72	67.33	75.00	118.4	171.5	617.7	710.2	1307
A3C4	18.06	66.00	73.50	117.1	166.3	604.6	691.2	1285
LSD 0.05	0.56	1.25	NS	NS	5.9	NS	NS	NS

Treats = Treatments, Germ. = Germination.
AB = sowing date x Cultivars, AC = sowing date x seeding rate, BC = Cultivars x seeding rate

Growing degree days (GDD)

Effect of sowing date:

At early sowing, growing degree days to germination, booting, heading and maturity stages were increased compared with other sowing dates. Growing degree days to germination, booting, heading and maturity stages were increased by 24.85, 31.06, 26.72 and 8.16%, respectively in response to early sowing compared with late sowing (Table 3). The obtained results are in agreement with those of Ram and Kaur (2018), who noted that early sowing achieved higher GDD than under late sown conditions due to number of days taken to maturity under timely sown conditions on barley. Similar results were reported by Ram and Gupta (2016) in wheat crop.

Barley cultivars behavior

Regarding barley cultivars, results indicated that there were significant effects on GDD during all phonological stages. The high GDD accumulation was recorded by Giza 134 (5.45, 5.60 and 5.44 %) during booting, heading and maturity stages, respectively except for germination stage which was lowered by 7.91 % compared with Giza 131(Table, 3).

Effect of seeding rate

There was negative relation between seeding rate and GDD at all studied stages where, increasing seeding rates up to 60 kg seeds fad^{-1} reduced GDD for phenological stages compared with 30 kg seeds fad^{-1}. A reduction was found in GDD for germination, booting, heading and maturity stages at 60 kg seeds fad^{-1} reaching 17.78, 6.12, 6.83 and 5.37 % respectively compared with 30 kg seeds fad^{-1} (Table, 3) .

Effect of the interactions among studied factors

Data presented in Table (4) for the interaction between sowing date and cultivars showed that a significant effect was observed on GDD to heading. Early sowing of Giza 134 increased GDD heading stage. In contrast, late sowing of Giza 131 decreased GDD to heading stage.

The interaction between sowing date and seeding rate (Table, 4) clearly showed significant effects on GDD to germination only stage. Sowing 30 kg seeds fad^{-1} at 5th Nov. increased GDD to germination stage. On the other side it was decreased when sowing 60 kg seeds fad^{-1} at 15th Dec.

Growth parameters

Results in Tables (5 and 6) show the effect of sowing date and seeding rate on total chlorophyll (total chl.), crop growth rate (CGR), net assimilation rate (NAR), leaf relative water content (RWC) and flag leaf osmotic potential (OP) of the three barley cultivars and their interactions in the analysis combined across years.

Table 5. Growth parameters of three barley cultivars as affected by sowing date, cultivar and seeding rate in the combined analysis.

Treatments	Total Chl (mg dm^{-2})	CGR (g m^{-2} $week^{-1}$)	NAR (g m^{-2} day^{-1})	OP (bar)	RWC (%)
Sowing date (A)					
5th Nov. (A_1)	19.31	177.4	5.08	16.29	75.57
25th Nov. (A_2)	17.51	160.7	4.70	18.26	72.50
15th Dec. (A_3)	14.78	134.0	3.63	21.60	64.64
LSD 0.05	0.73	10.3	0.35	0.39	1.65
Cultivars (B)					
Giza 2000(B_1)	16.96	155.1	4.50	18.62	70.53
Giza 134(B_2)	18.59	168.7	4.83	17.16	74.27
Giza 131(B_3)	16.04	148.3	4.08	20.37	67.91
LSD 0.05	0.35	2.9	0.29	0.43	0.81
Seeding rate(C)					
30 kg seeds fad^{-1}(C_1)	19.04	137.9	3.60	16.82	74.69
40 kg seeds fad^{-1}(C_2)	17.89	153.2	4.21	17.96	72.01
50 kg seeds fad^{-1}(C_3)	16.66	168.5	4.94	19.12	69.74
60 kg seeds fad^{-1}(C_4)	15.20	169.8	5.13	20.95	67.19
LSD 0.05	0.46	6.0	0.22	0.53	0.79

Total Chl. = total chlorophyll, CGR= crop growth rate, NAR= net assimilation rate, OP = flag leaf osmotic potential, RWC = leaf relative water content.

Effect of sowing date

Data presented in Table (5) showed that early sowing date significantly increased all above studied traits except of flag leaf osmotic potential (OP) which decreased compared with other dates. Sowing at 5th Nov. increased total chlorophyll (total chl.), crop growth rate (CGR), net assimilation rate (NAR), leaf relative water content (RWC) by 23.46, 24.46, 28.54 and 14.46%, respectively and improved flag leaf osmotic potential (OP) by 24.58% compared with sowing at 15th Dec. It is interesting to mention that 5th Nov. sowing date experienced more favorable climatic conditions. It could be attributed to high temperature in late sowing date resulting in shortening of growing season and consequently CGR and NAR which reduced as a result of reduction in total dry matter which causes earlier senescence of leaves. This conclusion is in harmony with that reported by Fahad and Samir, (2015), Pankaj *et al*

(2016), Ali *et al* (2017), Priya devi *et al* (2018), Singh *et al* (2018) and (Shah *et al* (2019)

Barley cultivars behavior

As far as, cultivars differences in total Chl., CGR, NAR, RWC and OP, it is quite evident that the response of Giza 134 in all growth parameters was greater than the other two cultivars (Table, 5). The superiority of Giza 134 may be due to it took more number of days from booting to maturity, thus having longer period for photosynthesis and then enhanced Chl., CGR, NAR. These results are in harmony with those reported by El-Bawab *et al* (2014) and Abu-Grab *et al* (2017).

Effect of seeding rate

In the analysis combined across years, increasing of seeding rate from 30 to 60 kg seeds fad^{-1} significantly decreased total Chl., RWC, CGR and NAR while, OP was significantly increased (Table 5). The reduction in total Chl. and RWC by increasing seeding rate up to 60 kg seeds fad^{-1} reaching 20.17 and 10.04 %, respectively but, increasing seeding rate up to 50 kg seeds fad^{-1} resulted in increasing CGR and NAR by 18.17 and 27.13%, respectively. OP was increased at rate of 60 kg seeds fad^{-1} by 19.71%. As in low population, the fewer plants grown so well, inter plant spaces increased more and ability of plants to absorb the light and nutrient elements is improved and increase chlorophyll content Jamaati *et al* (2009). In the same trend, Kiliç and Gürsoy (2010) found a negative correlation between seeding rates and chlorophyll content, whereas increasing seeding rate from 50 to 550 seed/m^2 resulted in significant reduction in Chl. content. On the other hand, Sharifi and Raei (2011) on barley noticed that the increase in CGR resulted in increase in total dry matter as due to increasing seeding rate from 400 to 500 seed m^{-2}. It is perhaps related to accelerating the photosynthesis activity that is caused dry matter accumulation increased.

Effect of the interactions among studied factor

The interaction between sowing date and cultivar had a significant effect on CGR, RWC and OP. Giza 134 recorded the best value at sowing 5th Nov. while Giza 131 gave the worst value at sowing 15th Dec. in all traits (Table 6).

Table 6. Growth parameters of three barley cultivars as affected by sowing date x Cultivars (AxB), sowing date x seeding rate (AxC) and Cultivars x seeding rate (BxC) interactions in the combined analysis.

Treatments	Total Chl (mg dm^{-2})	CGR (g m^{-2} week^{-1})	NAR (g m^{-2} day^{-1})	OP (bar)	RWC (%)
AB					
A1B1	18.85	175.2	5.20	16.46	75.43
A1B2	21.00	196.0	5.41	14.38	79.40
A1B3	18.06	161.1	4.62	18.03	71.89
A2B1	17.37	160.4	4.74	18.19	71.99
A2B2	18.81	166.2	5.07	17.02	76.04
A2B3	16.34	155.6	4.29	19.56	69.47
A3B1	14.66	129.7	3.56	21.21	64.18
A3B2	15.95	143.8	4.00	20.08	67.37
A3B3	13.71	128.3	3.34	23.51	62.37
LSD0.05	NS	5.0	NS	0.91	2.10
AC					
A1C1	21.46	160.2	4.19	14.03	80.21
A1C2	20.28	177.5	4.81	15.52	76.54
A1C3	18.72	187.4	5.57	16.56	74.43
A1C4	16.77	184.6	5.75	19.04	71.11
A2C1	19.76	145.7	3.89	16.45	76.38
A2C2	18.38	158.1	4.50	17.58	73.77
A2C3	16.78	175.1	5.20	18.61	71.05
A2C4	15.11	164.1	5.21	20.38	68.79
A3C1	15.91	107.8	2.72	20.00	67.46
A3C2	15.00	124.1	3.32	20.78	65.70
A3C3	14.48	143.1	4.04	22.19	63.73
A3C4	13.71	160.9	4.44	23.44	61.67
LSD0.05	0.80	10.5	NS	NS	NS
BC					
B1C1	18.75	137.9	3.53	17.10	73.93
B1C2	17.94	151.7	4.19	17.59	71.89
B1C3	16.48	167.8	5.02	19.08	69.40
B1C4	14.68	162.9	5.25	20.71	66.91
B2C1	20.49	150.1	4.06	15.11	77.65
B2C2	19.34	166.6	4.57	16.62	75.23
B2C3	18.04	183.4	5.27	17.66	73.51
B2C4	16.49	174.6	5.41	19.24	70.69
B3C1	17.89	125.7	3.21	18.26	72.48
B3C2	16.39	141.3	3.87	19.67	68.90
B3C3	15.45	154.4	4.52	20.63	66.30
B3C4	14.43	172.0	4.74	22.91	63.97
LSD0.05	NS	10.5	NS	NS	NS

*** Total Chl. = total chlorophyll, CGR= crop growth rate, NAR= net assimilation rate, OP = flag leaf osmotic potential, RWC = leaf relative water content. *AB= sowing date x Cultivars, AC= sowing date x seeding rate, BC= Cultivars x seeding rate.**

The interaction between sowing date and seeding rate showed that there were significant effects on total Chl. and on CGR. Sowing 30 kg seed fad^{-1} at 5th Nov. achieved the best values of Chl. and 50 kg seeds fad^{-1} for CGR. The lowest values were obtained when sowing 60 kg seed fad^{-1} at 15th Dec. for Chl. and by 30 kg seeds fad^{-1} for CGR.

The interaction between cultivar and seeding rate had a significant effect on CGR. Giza134 recorded the highest values at 50 kg seeds and the lowest value was obtained from Giza131 at seeding rate of 30 kg seeds fad^{-1}.

The interaction between sowing date, cultivars and seeding rate had significant effect for CGR where, sowing Giza 134 at 5th Nov. with 60 kg seeds fad^{-1} achieved the highest values while Giza 131 sowing at 15th Dec. with 30 kg seeds fad^{-1} recorded the lowest values.

Yield and yield components

Plant height, spike length, no. of grains spike^{-1} and no. of spikes m^{-2}

Table (7) showed that the effect of sowing date and seeding rate on plant height, spike length, grains spike^{-1} and no. of spikes m^{-2} of the three barley cultivars.

Effect of sowing date

Late sowing significantly decreased plant height, spike length, no. of grains spike^{-1} and no. of spikes m^{-2} compared with early and optimum sowing date. Sowing at 5th Nov. increased plant height, spike length, no. of grains spike^{-1} and no. of spikes m^{-2} by 23.55, 18.54, 15.07 and 23.08 %, respectively compared with sowing at 15th Dec. These results clearly indicate that the climatic conditions did not favor barley plants growth when sowing was delayed to 15th Dec. due to low temperature and the critical day length which affect growth of late sown plants. In Egypt, Dec. 21st is the day of the shortest photoperiod where thereafter days become longer, *i.e.* day hours tend to increase and hence force the long day plants of which barley belong to commit reproduction earlier than those sown on 5th or 25th November. Late sowing at 15th Dec. produced shorter plants with lower number of spikes than sowing at 5 or 20th Nov. Our results are close to those obtained by Chaudhary *et al* (2017) and Mahanta *et al* (2018) who reported that the worst value of number of productive tillers, number of grains per spike, spike length were obtained from late sowing than other sowing dates.

Table 7. Yield and yield component of three barley cultivars as affected by sowing date, cultivar and seeding rate in the combined analysis.

Treatments	plant height (cm)	spike length (cm)	No. of grain spike^{-1}	1000-grain weight (g)	No. of spike m^{-2}	Grain yield (ard/fed)	Biological yield (kg/fed)	Harvest index (%)
Sowing date (A)								
5th Nov. (A_1)	91.22	7.28	61.79	46.14	288.1	11.46	3769	37.34
25th Nov. (A_2)	85.86	6.96	57.43	44.42	269.2	10.06	3543	34.37
15th Dec. (A_3)	69.74	5.93	52.48	42.85	221.6	8.37	3233	30.92
LSD 0.05	1.97	0.16	1.04	1.44	8.6	0.33	222	2.08
Cultivars (B)								
Giza 2000 (B_1)	82.00	6.60	59.02	43.77	257.4	9.92	3633	33.1
Giza 134 (B_2)	86.62	7.57	62.01	42.28	278.6	11.42	3747	36.93
Giza 131(B_3)	78.20	5.99	50.67	47.37	243.0	8.54	3165	32.6
LSD 0.05	1.58	0.23	0.85	1.22	7.4	0.29	175	1.41
Seeding rates (C)								
30 kg seeds fad^{-1}(C_1)	77.32	8.09	61.23	47.54	245.8	8.93	3149	34.49
40 kg seeds fad^{-1}(C_2)	81.33	6.81	58.10	44.88	255.3	9.78	3291	35.52
50 kg seeds fad^{-1}(C_3)	83.48	6.30	56.25	43.49	263.3	10.45	3684	33.89
60 kg seeds fad^{-1}(C_4)	86.96	5.68	53.34	41.96	274.3	10.69	3937	32.93
LSD 0.05	1.02	0.22	0.74	0.73	6.0	0.21	157	0.87

Barley cultivars behavior

The data in the combined analysis showed that there were significant differences among cultivars for plant height, spike length, no. of grain spike^{-1} and no. of spike m^2. It is obviously clear that Giza 134 surpassed other cultivars in these characters (Table 7). The superiority of Giza 134 may be attributed to the duration of vegetative growth stage which encouraged dry matter accumulation and increased plant capacity in building up metabolites and grain development. Similar results were reported by El-Bawab *et al* (2014).

Effect of seeding rate

Respecting seeding rate, the results indicated that plant height, spike length, and no. of grains spike^{-1} no. of spikes m^{-2} were significantly affected in the combined analysis (Table 7). Increasing seeding rate gradually increased plant height and no. of spikes m^{-2}, while spike length and no. grains spike^{-1} were reduced. The increase in plant height and no. of spikes m^{-2} by increasing seeding rate up to 60 kg seeds fad^{-1} reached 11.09 and 10.39 %, respectively, but, spike length, and no. of grains spike^{-1} were decreased at a rate of 60 kg seeds fad^{-1} by 29.79 and 12.89 %, respectively. The present results were confirmed by Amarjeet *et al* (2020) who reported the increasing seeding rate from 87.5 to 96.25 kg seeds/ha augmented plant population, which in turn improved spikes per unit area and finally the grain yield. As in low populations, the fewer plants grown so well, inter plant spaces increased more and ability of plants to absorb the light and nutrient elements is improved and the chlorophyll content was increased (Jamaati *et al* 2009). In addition, the increase in plant height with increasing seeding rate could be attributed to the elongating effect always caused by dense planting where the proportion of invisible radiation is increased among dense sown plants (Pessarakli 2001).

Effect of the interactions among studied factor

The results in Table (8) show that a significant interaction effect was found between sowing date and barley cultivar on plant height, spike length, no. grains spike^{-1} and no. of spikes m^{-2} in the combined analysis. Sowing Giza 134 at 5th Nov. achieved the highest values for the mentioned traits, while Giza 131 gave the lowest values when sown at 15th Dec. The interaction between sowing date and seeding rate had significant effect for each former traits in the combined analysis. Sowing 60 kg seeds fad^{-1} at 5th Nov. recorded the highest values of plant height and no. of spikes, but sowing 30 kg seeds fad^{-1} at 15th Dec. gave the lowest values in these traits. Sowing 30 kg seeds fad^{-1} at 5th Nov. caused an increasing in spike length and no. grains of spike but sowing 60 kg seeds fad^{-1} at 15th Dec. reduced the previous traits.

Table 8. Yield and yield component of three barley cultivars as affected by sowing date x Cultivars (A x B), sowing date x seeding rate (A x C) and Cultivars x seeding rate (B x C) interactions in the combined analysis.

Treatments	plant height (cm)	spike length (cm)	No. of grain spike^{-1}	1000-grain weight (g)	No. of spike m^{-2}	Grain yield (ard/fad)	Biological yield (kg/fad)	Harvest index (%)
AB								
A1B1	89.95	6.98	63.11	45.42	280.3	11.56	4149	34.26
A1B2	98.22	8.67	67.07	43.67	307.2	12.87	3803	41.65
A1B3	85.49	6.18	55.20	49.33	276.8	9.95	3354	36.11
A2B1	86.09	7.09	58.39	42.34	264.4	10.10	3543	34.62
A2B2	88.39	7.70	61.64	42.55	282.4	11.62	3870	36.43
A2B3	83.09	6.08	52.25	48.37	261.0	8.45	3217	32.05
A3B1	69.95	5.72	55.55	43.53	227.4	8.11	3206	30.43
A3B2	73.24	6.34	57.33	40.62	246.1	9.77	3569	32.7
A3B3	66.02	5.72	44.55	44.40	191.3	7.24	2926	29.63
LSD0.05	2.74	0.40	1.48	2.11	12.8	0.64	230	2.45
AC								
A1C1	86.73	9.14	66.93	49.56	271.8	10.89	3794	36.17
A1C2	89.42	7.28	62.78	46.47	280.2	11.40	3446	39.82
A1C3	91.71	6.68	60.55	45.01	290.6	11.85	3853	36.99
A1C4	97.03	6.01	56.91	43.51	309.7	11.69	3982	36.37
A2C1	81.73	8.29	62.26	47.06	262.4	8.95	2870	37.32
A2C2	85.02	7.02	58.68	44.92	266.0	9.93	3259	36.5
A2C3	87.56	6.56	56.35	43.82	271.1	10.54	3794	33.22
A2C4	89.12	5.97	52.42	41.88	277.5	10.80	4250	30.42
A3C1	63.49	6.84	54.50	46.01	203.1	6.96	2783	29.99
A3C2	69.54	6.15	52.85	43.25	219.6	8.00	3166	30.24
A3C3	71.17	5.65	51.86	41.65	228.0	8.96	3405	31.46
A3C4	74.73	5.07	50.70	40.50	235.8	9.58	3580	31.99
LSD0.05	1.76	0.38	1.28	NS	10.3	0.37	199	1.51

Table 8. Yield and yield component of three barley cultivars as affected by sowing date x Cultivars (A x B), sowing date x seeding rate (A x C) and Cultivars x seeding rate (B x C) interactions in the combined analysis.

Treatments	plant height (cm)	spike length (cm)	No. of grain spike^{-1}	1000-grain weight (g)	No. of spike m^{-2}	Grain yield (ard/fad)	Biological yield (kg/fad)	Harvest index (%)
BC								
B1C1	78.10	7.93	63.01	46.07	244.4	8.96	3470	31.88
B1C2	80.82	6.72	60.03	44.33	252.6	9.66	3409	33.86
B1C3	82.97	6.18	58.11	42.98	261.5	10.43	3667	34.14
B1C4	86.11	5.58	54.92	41.69	271.0	10.64	3984	32.52
B2C1	82.73	9.40	67.34	44.03	265.0	10.35	3374	37.17
B2C2	85.33	7.64	62.73	42.55	273.5	11.19	3542	37.99
B2C3	87.90	6.89	60.32	42.06	281.3	12.02	3980	36.22
B2C4	90.51	6.35	57.66	40.48	294.5	12.12	4094	36.31
B3C1	71.13	6.93	53.34	52.54	228.0	7.49	2602	34.43
B3C2	77.83	6.09	51.55	47.78	239.7	8.48	2921	34.71
B3C3	79.57	5.83	50.33	45.44	247.0	8.90	3405	31.3
B3C4	84.26	5.12	47.45	43.72	257.5	9.31	3734	29.95
LSD0.05	1.76	0.38	1.28	1.26	NS	NS	199	1.51

AB = sowing date x Cultivars, AC = sowing date x seeding rates, BC = Cultivars x seeding rates

It could be observed that the interaction barley cultivars and seeding rate had significant effect in combined on plant height, spike length and no grain spike^{-1}.

The interaction between sowing, date cultivars and seeding rate had significant effect where, sowing Giza 134 at 5th Nov. with 60 kg seeds fad^{-1} achieved the highest values for plant height and with 30 kg seeds fad^{-1} for spike length while Giza 131 sowing at 15th Dec. with 30 kg seeds fad^{-1} recorded the lowest values for plant height and with 60 kg seeds fad^{-1} for spike length.

1000-grain weight, grain yield, biological yield and harvest index

Results in Table (7) show the effect of sowing date and seeding rate on 1000-grain weight, grain yield, biological yield and harvest index of the three barley cultivars in the combined analysis.

Effect of sowing date

The data pointed out that early sowing date resulted in significant increases in the above mentioned traits compared with delaying sowing at 15th Dec. Sowing at 5th Nov. increased 1000-grain weight, grain yield, biological yield and harvest index by 7.13, 26.96, 14.22 and 17.19%, respectively compared with sowing at 15th Dec. This is due to the reduction in no. spikes m^{-2}, no. of grains spike-1 and 1000 - grain weight with late sowing compared with early sowing which took more number of days from heading to maturity, thus got longer period for photosynthates translocation to grain (Ding *et al* 2015) .In the same trend, harvest index clearly indicate that late sowing date might built more canopy on the expense of grain yield. These results are in line with those of Mahanta *et al* (2018), Priya devi *et al* (2018) and Singh *et al* (2018).

Barley cultivars behavior

The results showed significant differences among barley cultivars on all studied traits. In general, the cultivar Giza 134 was superior in each of grain yield, biological yield and harvest index compared with other cultivars in combined analysis Table (7) while Giza 131 which attained the highest 1000-grain weight. Giza 134 recorded the highest harvest index indicating its superiority in dry matter partioning towards grain filling and hence grain yield fed^{-1}. High grain yield in these cultivars was found to be due higher yield attributes, i.e. more number of days and GDD from booting to maturity. These results are in harmony with those obtained by El-Banna *et al* (2011), Soleymani *et al* (2011) and Ramadhan (2013).

Effect of seeding rate

The effect of seeding rate on 1000-grain weight, grain yield, biological yield/fad^{-1} and harvest index (Table 7) was significant in combined analysis across years. Increasing seeding rate from 50 to 60 kg fad^{-1} had no significant effect on grain yield. There were negative effects of seeding rate on 1000-grain weight and harvest index. Although the increasing of seeding rate from 50 to 60 kg increased no. of spikes m^{-2}, but grain yield were declined. It may be attributed to more plant competition for growth resources, particularly plant nutrients. Mutual shading among the dense sown barley plants which in turn decrease the proportion of photosynthetically active radiation cannot be neglected in this respect as dense sown plants might have had suffered from shortage in the amount of assimilates available for their development. Many workers revealed the importance of increasing seeding rate to increase the productivity of barley, e. g. Kilic and Gursoy (2010), Noworolnik (2010), Sharifi and Raei (2011) and Ramadhan (2013).

Effect of the interactions among studied factor

The results Table (8) showed a significant interaction between sowing date and barley cultivar on 1000-grain weight, grain yield, biological yield and harvest index in the combined analysis. Sowing all cultivars at 5^{th} Nov. achieved the highest values of 1000-grain weight, grain yield and harvest index. In contrary, late sowing barley at 15^{th} Dec. resulted in the lowest values of 1000-grain weight and grain yield for Giza 134. Giza 131 and Giza 2000 recorded the lowest values of harvest index with the same sowing date.

The interaction between sowing date and seeding rate were significant for grain yield, biological yield fad^{-1} and harvest index. While, it was not significant for 1000-grain weight as shown in Table (8). The highest values of biological, grain yields and harvest index were recorded by sowing 50 kg or 60 kg seeds fad^{-1} at 5^{th} Nov. followed by 30 kg seeds fad^{-1}. However sowing 30 kg seeds fad^{-1} at 15^{th} Dec. gave impair productivity in grain yield and harvest index. In the same trend, biological yield failed to achieve good production when sowing with 30 kg seeds fad^{-1} at 25 Nov. The interaction between barley cultivar and seeding rate had a significant effect on 1000-grain weight. Sowing Giza 131 with 30 kg seeds/fad recorded the highest values, while Giza 134 with 60 kg seeds/fad gave the lowest values. These findings are in close conformity with the results of Dawson and Wardlaw (1989). Also Singh *et al* (2018) reported that sowing at 16^{th} Nov. gave better 1000-grain weight and grain yield than 20^{th} Oct and 10^{th} Dec. sowing at 20^{th} Oct surpassed others in biological yield.

CONCLUSION

In the light of the present results, it is clear that the maximum grain yield of barley was obtained from sowing date is 5^{th} Nov. for Giza 134 cultivar with 50 kg seeds fad^{-1}, while delaying of sowing date required increasing the seeding rate to 60 kg seeds to compensate crop shortage under sandy soil conditions.

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تأثيرميعاد الزراعة والصنف ومعدل التقاوى والصنف على الشعير
تحت ظروف التربة الرملية فى مصر

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أجريت تجربة حقلية في محطة البحوث الزراعية بالإسماعيلية. خلال موسمى الزراعة ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ . تهدف الدراسة إلى معرفة تأثير ثلاثة مواعيد للزراعة (٥ نوفمبر و ٢٥ نوفمبر و ١٥ ديسمبر) وثلاثة أصناف من الشعير (جيزة ٢٠٠٠ و جيزة ١٣٤ و جيزة ١٣١) وأربعة معدلات تقاوى (٣٠ و ٤٠ و ٥٠ و ٦٠ كجم تقاوى/فدان) تحت ظروف الأراضى الرملية على المراحل الفينولوجية والصفات الفسيولوجية والمحصول ومكوناته ويمكن تلخيص النتائج فيما يلى: ١- أدت الزراعة في ٥ نوفمبر الى زيادة عدد الايام ودرجات الحرارة المتجمعة فى المراحل الفينولوجية (انتفاخ غمد ورقة العلم و الطرد و النضج) كما حققت أعلى مقاييس النمو أي محتوى الكلوروفيل الكلي، معدل النمو النسبى، صافي التمثيل الضوئى، المحتوى المائي النسبي للأوراق، الجهد الأسموزى لورقة العلم كما ادى الى زيادة المحصول ومكوناته (ارتفاع النبات، طول السنبلة، عدد حبوب السنبلة، وزن حبوب السنبلة، وزن الـ ١٠٠٠ حبة، محصول الحبوب والمحصول البيولوجي للفدان ودليل الحصاد) مقارنة بمواعيد الزراعة الأخرى. ٢- وجدت اختلافات معنوية للأصناف المستخدمة حيث سجل الصنف جيزة ١٣٤ اعلى القيم لعدد الايام ودرجات الحرارة المتجمعة فى المراحل الفينولوجية (انتفاخ غمد ورقة العلم و طرد السنابل و

النضج) كما حقق أعلى مقاييس النمو أي محتوى الكلوروفيل الكلي، معدل النمو النسبى، صافي التمثيل الضوئى، المحتوى المائي النسبي للأوراق، الجهد الأسموزى لورقة العلم المحصول ومكوناته، وتفوق فى صفت المحصول ومكوناته باستثناء وزن الـ ١٠٠٠ حبة، حيث تفوق جيزة ١٣١. ٣- أدت زيادة معدل التقاوى حتى ٦٠ كجم للفدان الى انخفاض معنوى في عدد الأيام ودرجات الحرارة المتجمعة في جميع المراحل الفينولوجية، الكلوروفيل الكلي، المحتوى المائي النسبي للأوراق، طول السنبلة، عدد حبوب السنبلة، وزن ١٠٠٠ حبة ودليل الحصاد وزيادة ارتفاع النبات، عدد سنابل/م٢ والمحصول البيولوجي للفدان. كما زاد معدل النمو النسبى, صافي التمثيل الضوئى و محصول الحبوب للفدان لزيادة معدل التقاوى حتى ٥٠ كجم/للفدان. وينصح بزراعة صنف الشعير جيزة ١٣٤ فى ٥ نوفمبر بمعدل تقاوى ٥٠ كجم للفدان لتعظيم محصول الحبوب تحت ظروف الاراضى الرملية.

المجلة المصرية لتربية النبات ٢٤(٢): ٣١٩- ٣٤٣ (٢٠٢٠)