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The Response of High Performance Spring Wheat (*Triticum astivam* L.) Yield and Its Components to Wide Range of Sowing Dates and Plant Densities

Shwana Ahmad Hussain, Shang Haseeb Abdulqader & Kamil Mahmood Mustafa

College of Agricultural Science-Sulaimani University, Bakrajo Street, Sulaimaniya
E-mail: ***shwana.hussain@univsul.edu.iq; shang.abdalqadr@univsul.edu.****iq;* ***kamil.mustafa@univsul.edu.iq***

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Abstract

A field experiment was conducted to determine the influence of six various seed rates: R1 (120 kg ha^{-1}), R2 (140 kg ha^{-1}), R3 (160 kg ha^{-1}), R4 (180 kg ha^{-1}), R5 (200 kg $^{ha-1}$), and R6 (220 kg ha^{-1}) and six sowing dates: T1 (Nov-15th), T2 (Dec-5th), T3 (Dec-25th), T4(Jan-15th), T5(Feb -5th), T6(Feb-25th) on yield contributing traits of wheat cultivar Adana-99. Results showed that the effects of date of sowing, seeding rates and its interaction on the all studied yield parameters were significant (P≤0.01). Maximum mean values were recorded for the plant height (cm) in T_1 (Nov-15th) with R_6 (220 kg ha$^{-1)}$, spike length (cm) in T_1 (Nov-15th) with R_1(120 kg ha$^{-1)}$, number of spike m^{-2} T_2 (Dec-5th) with R_6 (220 kg ha$^{-1)}$, number of grain spike^{-1} T_1 (Nov-15th) with R_1 (120 kg ha$^{-1)}$, 1000 grain weight (g) T_1 (Nov-15th) with R_2 (140 kg ha$^{-1)}$, and grain yield (ton ha^{-1}) T_2 (Dec-5th) with R_5 (200 kg ha^{-1}). On the basis of our results, it is concluded that wheat Adana-99 cultivar should be sown between November-15 to Desember-5 with seed rate of 200 kg ha^{-1} under the guaranteed rainfed areas in Kurdistan- Iraq Region.

Introduction

In general, Kurdistan-Iraq region has an appropriate climate for many cereal crops. This is not fully true of rainfed area with low input like varieties, managements and variable rainfall in timing and or quantities, where the cereal crops including bread wheat (*Triticum aestivum* L.) commonly perform poorly. Macholdt & Honermeier (2017) ***[1]*** concluded that yield stability is affected by many agronomic, environmental and genetic factors, which thereafter makes it a complex matter. In common wheat, plant or seed density vary frequently worldwide, relying on the production system, environment, and variety ***[2]***. Previous studies have pointed that plant population density is a significant factor affecting wheat yield related traits. Plant density in wheat either bread or durum governs the components of grain yield, and therefore improving the yield quantity of individual plants. A regular allocation of plants per unit area is a precondition for yield stability ***[3]***. Slafer & Satorre (1999) ***[4]*** proposed that Optimum plant density is considered a credible significant management factor for perfecting to improve grain yield of wheat. It is of special significance in production of wheat for it is under the producer's control in most cropping systems. Zhen–Wen *et al*. (1988) ***[5]*** confirmed that a close relation occurs between wheat population and the components of yield. Previous studies offered that plant densities rates significantly affected plant height and 1000 grain weight ***[6]***, grains spike^{-1} and days to heading ***[7]***, spike m^{-2} ***[8]***, and spike plant^{-1} and grain yield area^{-1} ***[3]***.

Optimum planting date is one of the influential factors that impact the grain yield of wheat appreciably. Drastic reduction may occur in wheat yield when planting done at unsuitable time. In Kurdistan-Iraq region,

generally, wheat crop sown during mid November. Ansari *et al*. (1989) ***[9]*** indicated that appropriate sowing time results in preferable yield and so any postponement in sowing reduced spikes, grain weight and yield quantity. Other researchers also adduced linear reduction in grain yield of wheat crop with delayed sowing ***[10 and 11]***. Based on ***[12]*** early sowing reinforce wheat traits *via,* plant height, grains spike^{-1} and grain weight over late sowing.

The planting density and sowing time are considerable importance which effectively determine the appropriate stand establishment of the crop plants through balancing between plants competition and finally impact the yield, Nakano & Morita (2009) ***[13]*** observed that early sowing confers higher yield than delayed sowing time due to vigorous growth and more growing period connected with fast and uniform emergence of seedling ***[14]*** and preferable combination of spike number and leaf size ***[15]***. Kristo *et al*. (2006) ***[16]*** pointed that winter wheat grown under good favorable environments (Oct. sowing with 600 seeds m^{-2}) had more response than which grown under unfavorable environments (Nov. sowing with 300 seeds m^{-2}). Baloch *et al*. (2010) ***[17]*** supported that a reasonable increase of the plant density with that of sowing time is an efficacious mean to rise the wheat yield. Farooq *et al*. (2016) ***[18]*** suggested, that early wheat sowing (Oct-25th to Nov-10th) with seed rate100-120 kg ha^{-1} whereas in late sowing, use the higher level (150 kg ha^{-1}) for gaining the rational wheat grain yield. The present paper is conducted to optimize the best sowing date and proper seed rate for wheat cultivar Adana-99 under the guaranteed rainfed areas in Kurdistan- Iraq Region.

Materials and Methods

The study was conducted to look the impact of sowing time and seeding density on yield attributes and yield of bread wheat cultivar Adana-99 at Qilyasan Agricultural Research Station, University of Sulaimani (35° 34′ 307″ N, 45° 21′ 992″ E and elevation 765 m above sea level) during the 2015/2016 cropping seasons. The soil of the experimental location is silty clay, with pH, available CaCO, phosphate, and organic matter contents of 7.94, 21%, 4.51 ppm, and 2.24%, respectively. Meteorological data on the experimental site was explained in Table 1. The experiment was laid out with a factorial arrangement in RCBD-design having 3-replications. Six sowing date T1 (Nov-15th), T2 (Dec-5th), T3 (Dec-25th), T4(Jan-15th), T5(Feb -5th), T6 (Feb-25th) with six seeding rates R1 (120 kg ha^{-1}), R2 (140 kg ha^{-1}), R3 (160 kg ha^{-1}), R4 (180 kg ha^{-1}), R5 (200 kg ha^{-1}), and R6 (220 kg ha^{-1}). Each plot comprised five rows of 2.0 m length with row-row distance of 0.2m and the net plot size was kept 2m^2. The land was well prepared by plowing 2 times in order to make a convenient seedbed for better germination and emergence. All the recommended phosphate (80 kg h^{-1} P_2O_5) was applied with nitrogen (120 kg h^{-1} N) in split dozes i.e., half at cultivation and remaining at tillering stage. The data were recorded on plant height (cm), spike length (cm), number of spike m^{-2}, number of grain spike^{-1}, 1000 grain weight (g), and grain yield (ton ha^{-1}) and analyzed statistically using MSTATC computer software.

Table- 1: Average monthly and seasonal meteorological data during 2015-2016.

Month	*Qilyasan site*			
	Min. Temp.(^{o}C)	*Max. Temp. (^{o}C)*	*Avg. Temp. (^{o}C)*	*Rainfall (mm)*
October	*22.7*	*25.32*	*20.29*	*96.7*
November	*12*	*17.6*	*14.8*	*152*
December	*7.4*	*12.45*	*9.9*	*52.7*
January	*5.7*	*10.6*	*8.15*	*72.5*
February	*9.88*	*15.7*	*12.79*	*64.8*
March	*12.4*	*18.4*	*15.4*	*122.6*
April	*17.1*	*23.9*	*20.5*	*55.2*

May	*22.4*	*29.8*	*26.1*	*6*
June	*30.6*	*37.6*	*34.1*	*0*
Total rainfall				*622.5*

Source: Agro-meteorological station at Bakrajo

Results and Discussion

The final results of wheat plants traits appeared that sowing dates and seeding rates had a highly significant effect on all plant traits ($P \leq 0.01$). Therefore, our outcomes denoted a expressive improved grain yield, plant height, spike length, number of spike m^{-2}, number of grain $spike^{-1}$ and1000 grain weight performance. In addition, there were a highly significant interactions between seeding rate and dates of sowing on all plant traits (($P \leq 0.01$) too. This means that not all seeding rates responded the same to the six sowing dates of wheat (*Table: 2*).

Table- 2 : **Mean square of ANOVA's** of plant height, spike length, number of spike m^{-2}, number of grain $spike^{-1}$, 1000-grain weight and grain yield in wheat.

S.O.V	***d.f***	***PH***	***SL***	***SN***	***SS***	***GW***	***GY***
Replicates	*2*	*6.8*	*0.6*	*50.2*	*8.1*	*11.0*	*0.1*
Sowing Dates (A)	*5*	*4635.2***	*12.9***	*79982.0***	*942.7***	*323.1***	*41.7***
Seed Rates (B)	*5*	*331.4***	*4.0***	*161796.5***	*216.7***	*147.6***	*3.5***
(A x B)	*25*	*65.9***	*0.4***	*5646.8***	*12.8***	*4.5***	*0.112***
Exp. Error	*70*	*0.149*	*0.149*	*194.517*	*0.565*	*0.674*	*0.006*

*PH: plant height (cm), SL: spike length (cm), SN; no. of spike m^{-2}, SS: no. of grain $spike^{-1}$, GW: 1000 grain weight (g), and GY: grain yield (ton ha^{-1}), *and **: Significant at 5 and 1% levels respectively.*

Plant height (cm)*:** Height of the crop is principally governed by the genetic structure of a genotype and it can also be influenced by the factors of environment ***[19]. The data offered that plant height differed significantly by sowing time and seeding rates. Sowing on November-15th and December- 5th gave the tallest plants at par plant height of 104.3cm. While in seeding rates, the maximum plant height (87.3 cm) was occurring with a seed rate of 200 kg ha^{-1}. Maximum plant height (108.3 cm) was on T_1 (Nov-15th) with the higher seed rate R_6 (220 kg ha^{-1}) followed by (106.3 cm) (Nov-15th) R_5 (200 kg ha^{-1}) seed rate. The lowest height (50.3 cm) was observed on T_6 (Feb-25th) with R_1 (120 kg ha^{-1}) seed rate accompanying with similar values (50.3 cm) in seeding rates R_1-120 (kg ha^{-1}) on the same date (*Table: 3*). Minimum height of wheat plants in late sowing may be due to short growing period as monitored previously that wheat planted in suitable date produces the longest plant height ***[17]***.

Table- 3 : Plant height (cm) as affected by seed rate and sowing date in wheat.

Seed Rate :R (kg ha^{-1})	***Date of Sowing: T***						***Mean***
	T_1 (Nov-15)	***T_2 (Dec-5)***	***T_3 (Dec-25)***	***T_4 (Jan-15)***	***T_5 (Feb -5)***	***T_6 (Feb-25)***	
R_1 (120)	*100.3 e*	*85.3 l*	*95.3 e*	*65.0 t*	*70.3 r*	*50.3 x*	*77.8 e*
R_2 (140)	*102.3 d*	*87.3 k*	*80.0 o*	*68.3 s*	*75.3 q*	*50.3 x*	*77.3 f*
R_3 (160)	*104.3 c*	*93.3 g*	*84.3 m*	*75.3 q*	*76.3 p*	*55.3 w*	*81.5 d*
R_4 (180)	*104.3 c*	*95.0 e*	*75.3 q*	*80.3 o*	*80.3 o*	*58.3 v*	*82.3 c*
R_5 (200)	*106.3 b*	*94.3 f*	*90.3 i*	*88.0 j*	*82.3 n*	*62.3 u*	*87.3 a*
R_6 (220)	*108.3 a*	*90.0 i*	*92.3 h*	*84.0 m*	*84.3 m*	*62.3 u*	*86.9 b*

Mean	*104.3 a*	*104.3 a*	*86.3 b*	*76.8 d*	*78.2 c*	*56.5 e*

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 0.257, . LSD0.05 (Date of sowing) =0.257, LSD0.05 (Interaction) = 0.629

Spikes number(m^{-2}): In most of the cereal, economic yield is dependent on the number of spikes area^{-1} or productive tillers. Spikes numbers relied on a genotype and the environments during crop growth. Results showed that the effect of date of sowing, seeding rates and its interaction on the spikes m^{-2} were highly significant ($P \leq 0.01$) (*Table: 2*). The comparison of the mean values of the spikes m^{-2} for wheat plant time of Nov-15 showed that had the highest (545.6)) followed by (543.9) spike was on T_2 (Dec-5), while the Feb-25 had the lowest spikes m^{-2} (396.9). The comparison of the mean values of the spikes m^{-2} for seeding rates showed that 220 kg ha^{-1} of seed had the highest (596.1) and the 120 kg ha^{-1} of seed had the lowest number spikes m^{-2} (361.1) (*Table: 4*). These results are in consistent with those of ***[20]***. The highest spikes number (726.7) was produced on T_2 (Dec-5th) for the seed rate R_6(220 kg ha^{-1}) followed by statistically insignificant with 713.3 spike m^{-2} with seeding rate R_5-200 (kg ha^{-1}) on same sowing time. While the minimum spikes number (251.7) was obtained on T_6 (Feb-25th) for the seed rate R_1 (120 kg ha^{-1}) (*Table: 4*). Shahzad *et al*. (2007) ***[19]*** also declared that wheat sowing on 15th December gave significantly more spikes than the crop sown on 15th and 30th November. Maximum spikes (m^{-2}) in suitable sowing date might due to favorable temperature for germination while in delay wheat sowing the numbers of spikes (m^{-2}) reduced due to less temperature ***[21]***.

Table- 4 : Number of spike m^{-2} as affected by seed rate and planting time in wheat.

Seed Rate :R (kg ha^{-1})	***Date of Sowing: T***						***Mean***
	T_1 (Nov-15)	***T_2 (Dec-5)***	***T_3 (Dec-25)***	***T_4 (Jan-15)***	***T_5 (Feb -5)***	***T_6 (Feb-25)***	
R_1 (120)	*435.0 ij*	*365.0 no*	*405.0 kl*	*386.7 mn*	*323.3 p*	*251.7 r*	*361.1 f*
R_2 (140)	*480.0 gh*	*388.3 lm*	*440.0 i*	*415.0 jk*	*351.7 o*	*298.3 q*	*395.6 e*
R_3 (160)	*541.7 ef*	*441.7 i*	*478.3 gh*	*463.3 gh*	*390.0 lm*	*366.7 no*	*446.9 d*
R_4 (180)	*576.7 d*	*628.3 c*	*610.0 c*	*521.7 f*	*386.7 mn*	*456.7 hi*	*530.0 c*
R_5 (200)	*578.3 d*	*713.3 a*	*581.7 d*	*545.0 e*	*460.0 hi*	*490.0 g*	*561.4 b*
R_6 (220)	*661.7 b*	*726.7 a*	*583.3 d*	*568.3 d*	*518.3 f*	*518.3 f*	*596.1 a*
Mean	*545.6 a*	*543.9 a*	*516.4 b*	*483.3 c*	*405.0 d*	*396.9 e*	

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 9.272, . LSD0.05 (Date of sowing) =9.272, LSD0.05 (Interaction) = 22.712

Spike length (cm): Spike length trait in wheat plays a pivotal action towards the grains spike^{-1} and eventually the yield ***[19]***.In so far as the date of sowing is concerned, high significant observations were observed for the this trait. Date of sowing on Novvember-15th -Nov gave the longest and statistically spike length of 7.8 cm (*Table:5*). More delay the time of sowing resulted in shorter wheat spike. These results agree with those pointed by Laghari *et al*. (2011) ***[6]***. Seed rate appeared high significant effect on spike length (*Table: 2*), however, the longest spike length of 7.2 cm was appeared with R_1 (120 kg) seed ha^{-1}. The earlier sowing resulted in more spike development due to extended growing period (Baloch et al., 2010). The tallest spike length (9.4 cm) was produced on T^1 (Nov-15th) for the seed rate R^1 (120 kg ha^{-1}) while minimum spike length (4.9cm) was obtained on T_6 (Feb-25th) (*Table: 5*).

Table-5 : Spike length (cm) as affected by seed rate and sowing date in wheat.

Seed Rate :R (kg ha^{-1})	***Date of Sowing: T***						***Mean***
	T_1 (Nov-15)	***T_2 (Dec-5)***	***T_3 (Dec-25)***	***T_4 (Jan-15)***	***T_5 (Feb -5)***	***T_6 (Feb-25)***	
R_1 (120)	*9.4 a*	*7.2 c-f*	*7.3 c-e*	*6.3 h-l*	*7.0 d-g*	*5.8 m-p*	*7.2 a*
R_2 (140)	*7.7 bc*	*6.8 e-g*	*6.6 g-j*	*6.1 i-o*	*5.5 o-s*	*5.9 l-p*	*6.4 b*
R_3 (160)	*8.2 b*	*6.7 f-i*	*6.3 h-m*	*6.1 i-n*	*5.6 n-r*	*5.3 q-s*	*6.4 b*

R_4 (180)	7.4 c-e	6.2 i-m	6.5 g-k	5.8 m-q	5.5 o-s	5.2 rs	6.1 c
R_5 (200)	7.5 cd	6.0 j-p	6.1 i-n	5.6 n-r	5.4 p-s	5.2 rs	6.0 c
R_6 (220)	6.6 g-j	5.9 k-p	6.5 g-l	6.1 i-n	5.2 q-s	4.9 s	5.9 c
Mean	7.8 a	6.5 b	6.5 b	6.0 c	5.7d	5.4 e	

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 0.257, . LSD0.05 (Date of sowing) =0.257, LSD0.05 (Interaction) = 0.628

Number of seed spike^{-1}*:** Number of grains spike^{-1} is very great component sharing toward grain yield. It relies on the spike length and it is controlled by genetic and environmental factors prevailing during the period of growth. Number of seed spike^{-1} has a direct effect on the final wheat grain yield ***[22]. Results showed that the effect of date of sowing, seeding rates and its interaction on the Number of seed spike^{-1}were highly significant ($P \leq 0.01$) (*Table: 2*). The comparison of the mean values of the seeds spike^{-1} for wheat plant time of Nov-15 showed that had the highest (39.4) while, the Feb-25 had the lowest seeds spike^{-1} (21.1). Waraich *et al*. (1981) ***[23]*** pointed that earlier sowing outputted better spike development due to longer growing period. The comparison of the mean values of the seeds spike^{-1} for seeding rates showed that 120 kg ha^{-1} of seed had the highest (34.8) and the 220 kg ha^{-1} of seed had the lowest number seeds spike^{-1} (25.6) (*Table: 6*). These results are in consistent with those of Eslami *et al.*(2014) ***[20]***. The highest seeds number (44.3) was produced on T_1 (Nov-15th) for the seed rate R_1(120 kg ha^{-1}) followed by statistically insignificant with 43.8 seed spike^{-1} with sowing time T_2(Nov-15th) on same seeding rate. While minimum seeds number (19.4) was obtained on T_5 (Feb -5th) for the seed rate R_6 (220 kg ha^{-1}) (*Table: 6*). Farooq *et al*. (2016) ***[18]*** also depicted that early sowing date gave the highest number seed spike^{-1} at all the seeding rates of 100, 120 and 150 kg ha-^{1}.

Table- 6 : Number of seed spike^{-1} as affected by seed rate and sowing date in wheat.

Seed Rate :R (kg ha^{-1})	***Date of Sowing: T***						***Mean***
	T_1 (Nov-15)	***T_2 (Dec-5)***	***T_3 (Dec-25)***	***T_4 (Jan-15)***	***T_5 (Feb -5)***	***T_6 (Feb-25)***	
R_1 (120)	44.3 a	43.8 ab	38.6 d	29.2 f	30.2 ef	22.7 m	34.8 a
R_2 (140)	42.9 b	40.7 c	36.1 e	26.2 i	25.6 ij	21.8 no	32.2 b
R_3 (160)	41.3 c	36.0 e	33.7 f	23.6 kl	23.2 lm	20.9 opq	29.8 c
R_4 (180)	38.5 d	32.6 f	29.5 ef	24.0 kl	21.8 no	20.7 opq	27.9 d
R_5 (200)	35.7 e	30.6 e	29.0 fg	24.4 jk	22.2 mn	20.4 pqr	27.1 e
R_6 (220)	33.8 f	27.7 h	27.9 gh	24.7 jk	19.4 r	19.8 qr	25.6 f
Mean	39.4 a	35.2 b	32.5 c	25.4 d	23.7 e	21.1 f	

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 0.500, . LSD0.05 (Date of sowing) = 0.500 , LSD0.05 (Interaction) = 1.224

Thousand-grain weight (g): Results showed that the effect of date of sowing, seeding rates and its interaction on the thousand grain weight were highly significant ($P \leq 0.01$) (*Table: 2*). The comparison of the mean values of the thousand grain weight for wheat plant time of Nov-15 showed that had the heaviest (42.0) while, the Feb-25 had The lightest thousand grain weight (33.3). The comparison of the mean values of the thousand grain weight for seeding rates showed that 140 kg ha^{-1} of seed had the highest (39.8) and the 220 kg ha^{-1} of seed had the lowest thousand grain weight (33.5) (*Table: 7*). Our results are in accordance with the findings of Laghari *et al.* (2011). However Shahazad *et al*. (2002) ***[22]*** reported that 1000-grain weight reduced with delay in sowing. The heaviest grain weight (50.1 g) was produced on T^1 (Nov-15th) for the seed rate R^2(140 kg ha^{-1}) followed by statistically insignificant with 49.4 g with seeding rate R^1-120 (kg ha^{-1}) on same sowing time. While the lightest grain weight (30.0 g) was obtained on T_6 (Feb-25th) for the seed rate R^6 (220 kg ha^{-1}) (*Table: 7*). The reason may be due to the production of more grains spike^{-1} number associated with lighter weight.

Table- 7 : 1000-grain weight (g) as affected by seed rate and sowing date in wheat.

Seed Rate :R (kg ha^{-1})	Date of Sowing: T						Mean
	T_1 (Nov-15)	T_2 (Dec-5)	T_3 (Dec-25)	T_4 (Jan-15)	T_5 (Feb -5)	T_6 (Feb-25)	
R_1 (120)	49.4a	43.0 c	41.4 de	40.0 e	36.5 ij	35.9 i-l	38.2 b
R_2 (140)	50.1a	39.5 ef	40.5 e	38.4 fg	33.9 mno	36.3 ijk	39.8 a
R_3 (160)	45.6 b	36.6 hi	39.4 ef	35.560i-l	34.0 mn	33.7 mno	37.5 c
R_4 (180)	43.4 c	36.8 hi	38.0 gh	34.9 lm	32.7 nop	33.0 nop	36.5 d
R_5 (200)	42.1 cd	35.1 j-m	35.0 klm	33.1 no	32.5 op	31.1 qr	34.8 e
R_6 (220)	38.3 fg	34.9 lm	33.9 mno	32.4 nop	31.6 pq	30.0 r	33.5 f
Mean	42.0 a	37.7 b	38.0 b	35.7 c	33.5 d	33.3 d	

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 0.546 , . LSD0.05 (Date of sowing) =0.546, LSD0.05 (Interaction) = 1.337

Grain yield (t ha^{-1}) : Results showed that the effect of dates of sowing, seeding rates and its interaction on the Grain yield (t ha^{-1}) were highly significant (P≤0.01) (*Table: 2*). The same highest grain yield was obtained from Nov-15th and Dec-5th sowing date (6.32) t ha^{-1} than the rest sowing dates used while Feb-25 gave the lowest grain yield of 2.59 t ha^{-1} (*Table: 8*). Darwinkel *et al.* (1977) ***[2]*** stated that decreasing in grain yield was closely related to lower thousand grain weight with late sown crops. Our results also confirmed the finding of ***[24, 17, 25]***. The highest wheat grain yield was obtained from R_5 (200 kg h^{-1}) and R_6 (220 kg h^{-1}) optimal seeding rate (5.32 and 5.28 t ha^{-1} respectively) than other seeding rates used, while R_1 (120 kg h^{-1}) produced the lowest wheat grain yield of 4.20 t ha^{-1} (*Table: 8*). Higher grain yield of 6.89 (t ha^{-1}) on T_2 (Dec-5th) optimal sowing date with seeding rate R_5 (200 kg ha^{-1}) was statistically at par with that on T_1 (Nov-15th) on same seeding rate producing 6.80 (t ha^{-1}) (*Table: 8*). The lowest of 1.96 (t ha^{-1}) was obtained on T_6 (Feb-25th) with recommended seeding rate R_1= 120 (kg ha^{-1}) followed by T_6 (Feb-25th) with R_2 140 (kg ha^{-1}) gave 2.19 (t ha^{-1}) grain yield. Early planted bread wheat on T_1(Nov-15th) and T_2 (Dec-5th) allowed to give the highest quantity of grain yield may be due to more growth period which resulted longer spikes packed with heavier grain weight and higher number of spikes area^{-1}. While in state of late sowing, the higher seed rate gave rise to the grain yield as compared to lowest rate of seed might be attributed to highest spike m^{-2} in highest seed rate. The trend of decreasing in economic yield with delayed date of sowing due to shorter growing period which reduced spike m^{-2}, long of spike, 1000 grain weight and seed spike^{-1} (*Table: 8*). Our results also confirmed the finding of ***[6, 7, 13, 17, 26, 27]***. Our results amply showed, that the densest rate R_5 produced (1.12, 0.72, 0.41.0.170, 0.04 t/ha) more and (26.7, 15.7, 8.4, 3.3, 0.8%) extra grain yield than the rest seeding rates R^1, R^2, R^3, R^4, and R^6, respectively. Therefore the economically bread wheat production for Adana cultivar should be with R^5 (180 kg ha^{-1})rate of seeding. However , the earliest sowing T_1 and T_2 yielded (3.73, 2.68, 1.44, 0.62 t/ha) more and (144.0, 73.6, 29.5, 10.9%) extra than the rest sowing dates T_6, T_5, T_3 and T_4, respectively. Therefore the best bread wheat production for Adana-99 cultivar should be with T_1 or and T_2 (Nov-15th, Dec-5th)sowing dates due to managements and precipitations date. The sowing from middle November to inception December with more favorable conditions higher seeding rate 200 kg ha^{-1} resulted in higher grain yield, than the sparser treatments.

Table- 8 : Grain yield (t ha^{-1}) as affected by seed rate and sowing date in wheat

Seed Rate :R (kg ha^{-1})	Date of Sowing: T						Mean
	T_1 (Nov-15)	T_2 (Dec-5)	T_3 (Dec-25)	T_4 (Jan-15)	T_5 (Feb -5)	T_6 (Feb-25)	
R_1 (120)	5.56 j	5.43 j	4.99 l	4.22 o	3.02 t	1.96 w	4.20 e
R_2 (140)	6.12 fg	6.09 g	5.44 j	4.54 n	3.21 s	2.19 v	4.60 d
R_3 (160)	6.52 cd	6.47 d	5.80 i	4.75 m	3.49 r	2.45 u	4.91 c
R_4 (180)	6.69 bc	6.74 bc	5.93 h	5.07 l	3.78 q	2.70 r	5.15 b
R_5 (200)	6.80 ab	6.89 a	5.90 h	5.29 k	4.07 p	2.96 t	5.32 a
R_6 (220)	6.23 ef	6.34 e	6.10 fg	5.43 j	4.29 o	3.28 s	5.28 a
Mean	6.32 a	6.32 a	5.70 c	4.88 d	3.64 e	2.59 f	

Means followed by different letter(s) in a column and rows are significant at 5% level of probability, LSD0.05 (Seed rate) = 0.052, LSD0.05 (Date of sowing) =0.052, LSD0.05 (Interaction) = 0.129

Conclusion

From the fulfillments investigated by various researchers, it can be concluded that the adoption of some agronomic practices like timely sowing and Seed rating. Wheat sown at optimum seed rate of 200 kg ha^{-1} had better number of spike m^{-2} and economically grain yield compared to lower seed rates (120-180 kg ha^{-1}) while, early sowing from middle November to inception December is optimum . The interactive effect of T_1 or T_2 sowing date × 200 kg ha^{-1} seed rate was found superior for obtaining a higher quantity of grain yield under the guaranteed rainfed areas in Kurdistan- Iraq Region.

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