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Effect of Sowing Dates and Seed Rates on Growth and Yield of Different Wheat Varieties: A Review

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Abstract: Sowing time, seeding rate and variety are the key responsible among many other factors enhancing the growth and yield of wheat. Wheat is one of the most important leading crops of Afghanistan and the world. Despite higher yield potential the average yield of wheat in Afghanistan is very less than most of countries of the world. Besides other responsible factors for lower yield introduction of new high yielding potential varieties, optimum seeding rates and their adaptability with new environment are the most important factors which decide the growth, yield and quality of wheat. Changes of optimum temperature during vegetative or reproductive growth of wheat adversely affect the initiation and duration of crop in different pheno-phases and finally yield of wheat. Wheat as winter crop requires definite temperature and light for optimum growth. Too early sowing when temperature is above the optimum produce poor plants and even higher seeding rate cannot compensate low yield. Under late sown conditions, wheat faces low temperature in the earlier stage and high temperature in the later stages of the growing season and requires favorable moisture for better growth and development which causes yield reduction. At optimum temperature, early sowing with optimum plant population enhances the growth and nutrient uptake of wheat resulting in higher crop production. The optimum seeding rate depends on temperature, sowing date and type of varieties. The seed rate increases with delay in sowing due to poor plant stand, where higher seeding rate produces more plants in unit area resulting in higher intra-crop competition hereby affecting the yield and production cost. Similarly lower plant population produces lower grain yield due to higher vegetative growth and space wastages. Therefore to minimize the effect of temperature variation, proper sowing date, optimum plant population and varietal selection according to environmental conditions are the best noncash options to increase the growth, yield traits and yield of the wheat.

Keywords: Sowing date, Seed rate, Wheat variety, growth, yield.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most widely cultivated cereal crops and stable food of many countries in the world. Wheat crop with is remarkable adaptability in many agro-climates stands second in respect to area of production in the world and provides about 20 per cent of total food calories

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for human being. Despite higher yield potential, the average yield of wheat in Afghanistan is very less than most countries of the world. There are many factors responsible for low yield such as cultivation of old varieties, sowing date, low seed rate, low fertilizer rates etc. The environment under which crop is grown creates a tremendous impact on growth, development and yielding ability of wheat crop. Wheat crop requires optimum conditions during its growth and development to attain good yield. High temperature is one of the most important abiotic environmental factors during grain filling and may influence both the quantity and quality of the yield. High temperature after anthesis causes a reduction in grain filling (Wardlaw and Moncur, 1995; Veisz *et al*., 2008), more rapid apoptosis and the earlier attainment of harvest maturity (Altenbach *et al*., 2003). Under late sown conditions, wheat faces low temperature in the earlier part and high temperature in the later part of the growing season and requires favorable moisture for better growth and development. Therefore, efforts ought to be made to minimize the effect of temperature variation caused due to changed sowing date by choosing appropriate wheat varieties which can synchronize its temperature requirement. The introduction of new varieties with high yield potential and wide range of adaptability is an important factor responsible for enhancing wheat production. Different varieties respond differently to applied nutrient fertilizer and hence differ in their yield potential. Similarly cultivars differ significantly regarding fertile tillers, spike length, number of grains per spike, grain and straw yield (Naeem, 2001; *Ali et al*., 2010).

Optimum seed rate is one of the most important production factors for higher grain yield as well as for quality crop. Indiscriminate use of seeding rate not only increases production costs but usually decrease wheat grain yield. Optimum seeding rate is particularly important in wheat production because it is under the farmer's control in most cropping systems (Slafer and Satorre, 1999). Optimum plant densities are greatly affected by areas, climatic conditions, soil, sowing time, and varieties (Darwinkel *et al*. 1977). If optimal seeding rates exceed, yield reductions often occur (Beuerlein and Lafever, 1989; Harrison and Beuerlein, 1989). Previous researches indicated that seeding rates significantly affected biological yield (Ayaz *et al*. 1997. Higher seeding rates compensate for reduced tiller development and promote more main stem spikes which can be favorable, especially for cultivars that tend to produce fewer tillers (Coventry *et al*. 1993; Staggenborg *et al*. 2003). A close relationship exists between wheat stands and yield components (Zhen–Wen *et al*. 1988). Keeping in view of above facts, this review was carried out to explain effect of sowing dates and seed rate on growth and yield of different wheat varieties.

Effect of sowing dates and variety on growth and yield of wheat

Osmani *et al*. (2020) conducted field experiments for two consecutive spring seasons of 2017 and 2018 at experimental farm of Kabul University, to find out the adoptability of four local spring wheat varieties *i.e*., V1-Zardana Baghlan, V2- Sorkha-Andarab, V3-Safida-Kunduz and V4-Safida-Andarab varieties under Agro-climate conditions of Kabul. They observed that during both the seasons Safida-Andarab (V4) produced shorter plant height but significantly higher number of tillers, spikes, grains per spike, spike length, test weight and grain yield (4.17 and 4.43 t/ha) of wheat, which all these parameters were on par with variety of Safida-Kunduz during both the consecutive years. Fazily *et al*. (2019) conducted a field experiment during winter season of 2015-16 on sandy loam soils of Poz-e-Ishan Research Farm of Agricultural Faculty of Baghlan University, to find out the performance of four wheat varieties (Milad 013, Bakhtar 013, Chonta 01, Kabul 013) on different dates of sowing (25th November, 11th December, 26th December and 11th January 2016) under irrigated condition of Baghlan province.

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They found that all varieties sown in 25th November-15 significantly produced higher plant height, number of effective tillers, took more number of days to heading and physiological maturity, higher test weight and grain yield than varieties sown on 26th December and 11th January 2016. Among the varieties Chonta 01, produced significantly higher grain yield but on par with Kabul 013 at all dates of sowing. Habibi *et al.* (2019) conducted a field experiment on sandy loam soils of Poz-e-Ishan Research Farm of Agricultural Faculty of Baghlan University, to study the response of 11 different wheat varieties to water stress condition of Baghlan province. They observed that among all varieties SHARORA//INQALAB 91*2/TUKURU has taken more number of days to 70% heading (135 days), longer days for 70% anthesis (141.33) and longer period (165 days) to maturity. Similarly, SHARORA/INQALAB 91*2/TUKURU produced significantly taller plant height (111.33), more number of effective tillers (4.97/ plant) at maturity, longer spike length (10.50 cm), heavier test weight (40.24 g) and grain (4080 kg/ha) and straw yield (6587 kg/ha) over all other treatments. Bachhoa *et al.* (2018) conducted a field experiment to find the effect of four sowing dates (S1: 3rd week of November, S2: 1st week of December , S3 : 3rd week of December, S4 : 1st week of January) for three wheat varieties of V1 :Trimbak (NIAW 301), V2 : Tapowan (NIAW 917) and V3 : Godavari (NIDW 295). Among sowing dates S2 (1st week of December) was found superior for growth, yield attributes and yield of wheat. Among the wheat varieties Tapowan was found better to sowing date of 1st week of December with regards to growth and yield attributes. Economically Tapowan wheat variety in S2 (1st week of December) sowing date attained higher gross, net monetary returns and B:C 2.02. Lodo *et al.* (2018) concluded that variety Imdad-2005 was superior in all the growth and yield contributing characters, followed by W.R.I-11 and SKD-2; while among sowing dates, 15th November remained appropriately best sowing time for producing highest grain yield in all varieties respectively.

Yadav *et al.* (2017) found a significant increase of 5.9 per cent in grain yield of wheat sown at normal date (15th November) than sowing date on 25th November. Hossain *et al.* (2017) conducted a research experiment to evaluate the performance of three wheat varieties ('Shatabdi', 'BARI Gom 27' and 'BARI Gom 28') at three sowing dates *viz.*, early sowing (1st November), optimum sowing (15th November) and late sowing (30th December). They concluded that 'BARI Gom 28' was the best variety, followed by 'Shatabdi' and 'BARI Gom 27' for producing higher grain yield and November 15th was the best time for sowing of wheat, whereas December 30th was the worst sowing condition that negatively affected on grain yield of wheat. Verma *et al.* (2016) concluded that the timely sowing (15th November) produced significantly higher grain yield than delayed sowing (25th November). A decreased of 6.3% in grain yield was recorded by advancing the sowing of wheat crop by 10 days. Kamrozzaman *et al.* (2016) conducted a field experiment to study the growth and yield performance of cv. BARI Gom-24 as affected by different dates of sowing (November 5, November 15, November 25, December 5 and December 15). The overall results indicated that November 25 sown crop showed better performance in respect of growth and yield of wheat under Charland ecosystem of Bangladesh. Krupnik *et al.* (2015) reported that early sowing caused wheat to escape heat stress, as the late sowing takes wheat growth into a period during which higher temperatures are experienced, resulting in terminal heat stress and yield loss.

Mumtaz *et al.* (2015) conducted two years field experiments to find the effect of six different sowing dates (D1-1 November, D2-11 November, D3-21 November, D4-1 December, D5-11 December, D6-21 December) on growth, yield and yield components of six different wheat genotypes (V1-Aari-11, V2-Aas-11, V3-Meraj-08, V4-Millat-11, V5-Punjab-11, V6-Seher-06). Two years results revealed that wheat sown on 11th November performed better with respect to days taken to booting, heading, anthesis, maturity, germination count, number of tillers, plant height, number of grains per spike, test weight and

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grain yield. It was also revealed that late sowing of wheat caused reduction in these attributes. Zia ul Hassan *et al.* (2014) reported that yield of wheat was reduced by 17.4, 17.2 and 26.2 per cent in the crop planted on 15th November, 30th November and 15th October, respectively, as compared with crop planted on 30th October sowing. Tomar *et al.* (2014) reported that early sowing (14th November) resulted 12.8 per cent higher grain yield than to that of 21st November sowing. The delayed sowing on 8th December reduced the grain yield by 19.3 per cent than that of 14th November sowing. Suleiman *et al.* (2014) evaluated four sowing dates of wheat (November 1, November 15, December 1 and December 15) on five wheat varieties at Bahri (Sudan). They observed highest number of tillers, extended phenological parameters and highest grain yield with cultivars which were sown on 1st November followed by 15th November. On overall basis, it was concluded that wheat should be sown from 11th November to 21st November to get high crop yield. Nagarjuna *et al*. (2014) concluded that date of sowing and variety significantly influenced the yield attributes, yield and economics of wheat. Amrawat *et al.* (2013) observed that delay in sowing beyond 20th November significantly reduced the grain yield of timely sown wheat varieties. Pal and Murty (2013) reported that higher grain yield of wheat sown on November 20 was due to lower mean minimum and maximum temperature than late planting in Pantnagar of India.

Chourasiya *et al*. (2013) reported that early sowing (11th November) of HI 8498 wheat variety produced 6.37% lower grain yield compared to normal date (18th November). Similarly, the grain protein content of early sown varieties was higher compared to normal and delayed sown crop. The highest gross return, net return and benefit:cost of all wheat varieties sown on 18th November was higher than varieties sown on 11th and 25th November. Alam *et al.* (2013) concluded that November 20 sown crop resulted in significantly higher plant height, dry matter, leaf area index, days taken to maturity and number of tillers than December 20 sown crop. Similarly the crop sown 20th November produced 14.7 per cent higher number of spikes, 26.4%, 15.1% and 45.2 percent higher spike length, number of grains per spike and grain yield as compared to 20th December sowing respectively. Sufyan *et al.* (2013) conducted a field research at Adaptive Research Farm, Sheikhupura, Punjab, Pakistan to investigate the growth and yield response of three wheat varieties (Inqalab-91, Uqaab-2000 and AS-2002) at two different sowing dates (24.11.03 and S2 = 14.12.03). They found that increase in all yield attributes such as number of effective tillers, spikelets per spike, grains per spike and test weight of wheat was recorded with early November sown crop. The cultivar AS-2002 with the highest grain yield of 3647 kg ha^{-1} at early (November) sowing were considered suitable than the rest of two other cultivars. Kumar (2012) recorded highest yield attributes, grain and straw yield of wheat sown on 10th November followed by 17th and 24th November sown crops. Ram *et al.* (2012) reported that sowing of six varieties of wheat at seven dates of sowing (October 25, November 5, November 15, November 25, December 5, December 15 and December 25) indicated that October 25 took maximum number of days, growing degree days, photo-thermal units and helio-thermal units for earing and maturity resulting to higher grain yield. All these characters were reduced significantly with subsequent delay in sowing time and recorded lowest value in December 25 sown crop. They also stated that early sowing was considered as optimum and timely sown calendar which resulted to better grain development due to longer growing period which had more time for the dry matter accumulation to produce the higher grain yield. Mohsen and Yamada (1991) concluded that low temperature in the growing season reduces germination and retards vegetative growth by inducing metabolic unbalances and can delay or prevent reproductive devolvement of wheat crop. Seleiman *et al.* (2011) revealed that among different dates of sowing the highest values for all growth, yield and its components as well as grain quality characters was obtained from wheat sown on 15th November. Pal *et al*. (2010) evaluated the effect of three wheat genotypes (HUW-234, PBW-373 and UP-2338) on three

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dates of sowing (15 December 2005, 25 December 2005 and 4 January 2006). They found that however HUW-234 produced better test weight and more no. of grains/m2 but PBW-373 produced higher grain yield in all dates of sowing. Shirpurkar *et al.* (2008) observed that early sowing (8th November) of wheat crop produced significantly higher grain yield than late sowing (20th December). Sattar *et al.* (2010) observed that delayed sowing reduced crop emergence due to poor crop establishment and reduced the number of productive tillers and ultimately the final yield. Dry matter accumulation was reduced with delay in sowing due to high temperature at reproductive stage of the crop which further decreased the final yield.

Jalota *et al.* (2010) concluded that early sown wheat in November produced the highest grain yield. Tahir *et al.* (2009) reported that delayed sowing affected germination, growth, grain development and producesd poor tillering due to winter injury in low temperature and suppressed the yield. Normal sowing prolongs the duration of tillering and produces more number of tillers, number of spikes, grains per spike and grain weight that ultimately boosts up grain and straw yields (Qasim *et al.*, 2008). Singh *et al.* (2008) revealed that delay in sowing beyond 15 November significantly reduced ear length and number of grains per ear during both years. Among the cultivars, the length of spike was highest with PBW-502 which was closely followed by PBW-343. Qasim *et al.* (2008) evaluated the response of three wheat cultivars (Suliman-96, Chakwal-97 and Inqalab-91) on three sowing dates of sowing (15 November, 30 November and 15 December). They reported that maximum, yield attributes, grain and straw yield of wheat was obtained from early sowing date (15 November). Among varieties Suliman-96 produced higher grain yield at all sowing dates. Tripathi and Verma (2007) observed that delay in sowing from 28 November to 28 December reduced the LAI to 15.02% at 60 DAS and this reduction increased to 29.39% at 75 DAS. The significantly lower chlorophyll content at 20 days after anthesis was observed in late-sown crop and in general a decline in leaf greenness was observed from optimum to late sown wheat. Shirpurkar *et al.* (2007) obtained maximum grain yield of wheat with normal sowing crop (11th November) than late sowing (27th November). Dhaka *et al.* (2006) found that the delay in wheat sowing time from 20th Nov. to 25th Dec. caused adverse effect on plant growth. The final plant height recorded at maturity was about 10 cm, lower under late sowing than timely sowing. The reduction in plant height under delayed sowing was primarily because of shortening of vegetative phase. During both the consecutive years the final dry weight at maturity was 30.0% and 26.0% lower under delayed sowing respectively. Marked reduction in grain yield (49.8 and 48.4 per cent) and straw yield (19.1 and 21.4 per cent) was observed under late sowing during both the consecutive years respectively. Significant reduction in harvest index was also observed apparently because the reductions in grain yield.

Zende *et al.* (2005) evaluated the effects of sowing time (15th November, 1st December and 15th December) on the growth and yield of durum wheat cultivars AKDW 4146 and MACS 2846 in Akola, Maharashtra, India. They concluded that both varieties had significantly higher growth and yield components on 15th November compared with those sown on 1st December and 15th December. Mishra *et al.* (2003) investigated the effect of 2 sowing dates, i.e. 22 November (normal) and 22 December (late), on yield component and yield of 12 wheat genotypes (CPAN-3004, NIAW-34, PBW-343, PBW-373, RAJ-3077, RAJ-3765, UP-2003, UP-2338, UP-2382, UP-2425, WH-542 and WH-896). The normal-sown condition produced significantly higher yield over late-sown condition. Among the varieties PBW-343 produced significantly higher yield components and yield during 2000-01, while the significantly higher yield of wheat among the cultivars during 2000-02 was recorded from UP-2425. The higher yield of early sowing over late sowing wheat can be the result of longer growing period, vigorous growth with rapid

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and uniform seedling emergence resulting higher number of tillers which ultimately contributed to final yield (Munir *et al*., 2002; Tanveer *et al*., 2003).

Sardana *et al.* (2002) reported wheat grain yield reduced to 32.6 per cent with mean reduction of 45 kg grain/ha/day with delay in sowing from 15th November to 15th December. Singh *et al.* (2002) observed that the germination percentage, shoot and root length, total seedling length, seedling dry weight, yield components, biological yield, harvest index and seed vigour of wheat decreased with delay in sowing from 1st December to 10th January. Jadhav and Karanjikar (2001) found that the grain yield of late sown wheat was higher than normal sown crops. Among different cultivars Bread wheat genotype DWR 225 produced higher yield. Patil *et al.* (2001) observed that among six cultivars, AKW-381, produced the highest average number of tillers per plant and total biomass at maturity, suggesting that these cultivars were most beat-resistant, as it exhibited stable biomass production under varying environmental conditions associated with various sowing periods. Donaldson *et al.* (2001) revealed that early sowing increased the grain and straw yield of wheat of wheat over mid to late sowing date. Ghosh *et al.* (2000) concluded that delayed sowing decreased the LAI and dry matter accumulation at all of the growth stages. The highest yield attributes and grain yield of wheat were achieved from 16th November sown crop but were on par with those of the crop raised on 26th November which further the grain yield gradually decreased with delay in sowing. Kumar *et al.* (2000) observed that wheat sown on 20th November indicated better growth than 1st November or 10th December. The variety cv. WH-542 produced higher yield than HD-2329 and WH-533. Tripathi *et al.* (2000) tested the effect of sowing dates (30 September, 15 October and 31 October) on wheat cultivars (GW-1034, HI-1277, Sujata and A-9-30-1) in Madhya Pradesh, India. They found that A-9-30-1 and Sujata produced higher grain and straw yield of wheat. Sowing on 15 October produced higher yield and yield components compared to other sowing dates. Mishra *et al.* (2000) recommended the DL 788-2 and GW 190 varieties of wheat for normal and late sowing conditions due to their higher adaptability and stability. They found that cultivar WH 147 was responsive on normal sowing dates. Nainwal and Singh (2000) revealed that one month delay in sowing of wheat during winter season of 1995-96 and 1996-97 at GBPUA & T, Pantnagar with two dates of sowing (27th November and 27th December) significantly reduced the growth characters, growth phenology, yield attributes, grain growth duration, grain and yield of wheat during both the years.

Lathwal *et al.* (1999) conducted a research experiment to know the response of different wheat cultivars on different dates started from 5-November with 10 days interval to 5-December. They observed that the plant height, grain and straw yield and harvest index of wheat decreased with the every 10 days delay in sowing date. Patel *et al*. (1999) concluded that the nutrient uptake of wheat varieties was higher on 1st week of December (5th December) as compared to other dates of sowing (25th November,15th and 25th December and 5th January) Tiwari *et al.* (1999) observed that the wheat crop was sown in the fourth week of November produced significantly highest grain and straw yields than those of other sowing dates. The increased yield at this sowing date may be owing to significantly higher number of tillers/meter row length as well as higher values of other yield attributes. Sowing in fourth week of November also recorded maximum harvest index and significantly highest net return than rest of sowing dates. Early sowing always produces higher yield than late sowing. Each day delay in sowing from 20th November decreased grain yield at 39 kg ha^{-1} per day (Singh and Uttam, 1999). Rajput and Verma (1994) revealed that normal sowing produced higher grain yield than late sowing. Jain *et al.* (1992) studied the impact of 5 sowing dates on six wheat varieties and found that all varieties sown on December 20 produced significantly higher grain yield as compared to other late sowing dates. Too early sowing produces weak plants with poor root systems. Temperature above optimum leads to irregular germination and the embryo

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frequently dies and the endosperm may undergo decomposition due to activities of bacteria or fungi. In late planting, the wheat variety should be short duration that may escape from high temperature at the grain filling stage (Phadnawis and Saini, 1992). Randhawa *et al.* (1981) reported that when the crop is sown late, its flowering period is shortened because by the time it comes to flowering, the atmospheric temperature starts rising, therefore, the late sown crop is forced to flower and mature early. Ansary *et al.* (1989) concluded that delay sowing suppressed the yield, caused by reduction in the yield contributing traits like number of tillers, number of grains per spike and grain yield. Ahmed (1986) observed 1.3% reductions in one day of December. He concluded that adverse effect of temperature could be minimized by adjusting sowing time to an optimum date and to find out heat tolerant genotypes, which are suitable for late and very early sown conditions to ensure high grain yield. Razzaq *et al.* (1986) concluded that the emergence and number of days to earing wheat was higher in 15th November and decreased with delay in planting to 15 December. Wiegard and Cellular (1981) reported that increase of each 1.0 oC in mean daily air temperature during grain filling of wheat resulted in decrease of 3 days in grain filling period.

Effect of seed rate and variety on growth and yield of wheat

Bhatta *et al.* (2017) evaluated the effects of three seeding rates (0.5, 1, and 2 times of the normal seeding rate), six genotypes and top dressed nitrogen (0 and 34 kg N ha−1 at the flag leaf stage) on yield and agronomic characteristics of winter wheat at two sites (ARF and HPAL sites) for two years. They found that twice, seeding rate increased grain yield, by 5% in 2014 and 13% in 2015 at ARF and the yield increase was 9% in 2014 and 5% in 2015 at the HPAL site. Instar (2017) evaluated the effect of six seeding rates (80, 100, 120, 140, 160 and 180 kg ha^{-1}) on growth and yield of three wheat cultivars (Bohooth 22, Bohooth 158, and Rasheed). They reported that plant height increased with increasing seeding rate and 180 kg ha^{-1} seed rate produced highest grain yield, where the highest number of tillers, biological yield and straw yield were recorded at 140 kg ha^{-1} seeding rate. Increase in seed rate decreased the stem diameter and maximum stem diameter was noted with seeding rate of 80 kg ha^{-1} (4.14 cm). Among the cultivars Rasheed produced highest plant height, stem diameter, more number of tillers and highest biological and straw yield. Yadav and Dhani (2017) concluded that among different doses of nitrogen (100, 120 and 140 kg/ha) and 100, 125 and 150 kg/ha seed rate , application of 140 kg N/ha and 150 kg seed rate/ha was the best combination for getting higher seed yield with better quality. Akhtar *et al.* (2017) conducted a research with three seeding rates (100, 120 and 140 Kg ha^{-1}) and five wheat varieties (BARI Gom 24, BARI Gom 25, BARI Gom 26, BARI Gom 27 and BARI Gom 28) in Bangladesh Agricultural Research Institute, Dinajpur, Bangladesh to determine the optimum seed rate for newly released varieties. They found that performance of yield traits and yield of the wheat varieties varied with seeding rates. They concluded that optimum seed rate for varieties BARI Gom 24, BARI Gom 26 and BARI Gom 28 were 140 kg seed ha^{-1}. Whereas 120 kg seed ha^{-1} was found to be the optimum seed rate for varieties of BARI Gom 25 and BARI Gom 27.

Anwar *et al.* (2015) evaluated the effect of seed rates (120,150,180 kg ha^{-1}) and sowing dates (29th October, 10th November, 24th November, 10th December, 26th December and 10th January) on agro-physiological traits of wheat. They concluded that wheat should preferably be sown between 29th October and 24th November at 150 kg ha^{-1} seed rate to get higher grain yield in Peshawar valley. Nizamani *et al.* (2014) conducted a field experiment to determine the influence of different seed rates (100, 125 and 150 kg ha^{-1}) on yield contributing traits of promising wheat varieties viz. Sarsabz, Kiran-95 and TD-1. They concluded that the Kiran-95 at seed rate of 125 kg ha^{-1} performed best, followed by TD-1 and Sarsabz which also produced more yield at seed rate of 125 kg ha^{-1}. Costa *et al.* (2013) conducted

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an experiment to determine the effect of sowing date and seeding rate (200 and 350 seeds m^{-2}) on test weight and grain yield of fifteen bread wheat varieties and five advanced lines from Portuguese Wheat Breeding Program under irrigated Mediterranean systems. They found that sowing date and seeding rate affected test weight and yield under irrigated field conditions. Higher yield of wheat was obtained with the 2nd sowing date (21 December) for most of the varieties. Laghari *et al.* (2011) evaluated the effect of different seed rates (125, 150, 175 and 200 kg ha^{-1}) on growth, yield and nutrient uptake of wheat varieties (TD-1, TJ-83 and Mehran-89). They observed that wheat crop sown at low seed rate of 125 kg ha^{-1} had better growth, yield, nutrient uptake and low lodging tendency. The variety TD-1 sown at 125 kg ha^{-1} produced maximum tillers, spike length, grains per spike, grain weight per spike, dry matter, crop growth rate, seed index, biological yield, grain yield, harvest index and low lodging. However, higher seed rates (200 kg ha^{-1}) resulted in delayed maturity, greater internodes length and higher lodging in Mehran-89. They also concluded that optimum seeding rate is one of the important management factors for achieving higher yield of wheat since it is under the control of farmers in many cropping systems. Ram *et al.* (2013) investigated influence of varieties (PBW 550, PBW 343 and DBW 17) and seeding rates (87.5, 100, 112.5 and 125) on growth, productivity, disease reaction and economics of wheat at Ludhiana, India in 2007-08 to 2008-09. They found that there was no trend for different diseases with respect to seed rate. The highest productivity was recorded in 112.5 kg seed rate/ha which was significantly higher than all the other seed rates. The highest grain yield of PBW 550 at seed rate of 112.5 kg/ha was statistically on par with only PBW 550 at 125 kg seed rate ha^{-1} but significantly higher than all the other varieties at all the seed rates. The highest gross, net returns and B:C recorded in PBW 550 at 112.5 kg seed rate ha^{-1}.

Ram *et al.* (2012) reported that among six varieties of wheat sown at seven dates of sowing (October 25, November 5, November 15, November 25, December 5, December 15 and December 25) October 25 took maximum number of days, growing degree days, photo-thermal units and helio-thermal units for earing and maturity which resulted to highest grain yield. Further all these parameters significantly decreased with subsequent delay in sowing time and the lowest values recorded with December 25 sown crop. They also stated that early sowing was considered as optimum and timely sown calendar which resulted to better grain development due to longer growing period which had more time for the dry matter accumulation to produce higher grain yield. Iqbal *et al.* (2012) conducted an experiment with three seeding rates of 125, 150 and 175 kg/ha with five nitrogen levels of 0, 75, 100, 125 and 150 kg N/ha. They found significant interaction for number of grain/ spike, grain yield, biological yield and harvest index and were maximum at seeding rate of 150 kg/ha with nitrogen level of 125 kg/ha. McKenzie *et al.* (2011) reported that increase in seed rate results to higher plant population thus suppress weeds and will give maximum yield and economic returns. Akmal *et al.* (2011) reported that each week delay in date of wheat sowing reduces the yield through shortening of vegetative and reproductive stages and overall the crop duration. Ali *et al*. (2010) evaluated the impact of four levels of seeding rates (125, 150, 175 and 200 kg ha^{-1}) for three consecutive seasons. They found that increase in seeding rate up to 200 kg ha^{-1} increased the straw yield of wheat while the lowest straw yield of wheat was obtained with seeding rate of 125kg ha^{-1} during entire three consecutive seasons.

Malik *et al*. (2009) concluded that the germination, yield attributes and yield of wheat was decreased with delayed in date of sowing whereas the increase in seeding rate did not affect grain yield. Kabir (2009) concluded that that the seed rate of 140 kg ha^{-1} with one irrigation given at CRI stage may be practiced for better performance of wheat cv. Early crop establishment is a key factor for higher wheat production (Soomro *et al*., 2009). Dubey *et al.* (2008) reported that date of sowing significantly

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influenced the yield of wheat. The highest grain yield of wheat was produced on 30 November sowing date. One month delay in sowing (30 November-30 December) reduced the grain yield by 20%. Bakht *et al*. (2007) studied the response of four wheat varieties (Fakhr-e-Sarhad, Suleman 96, Haider 2000, Saleem 2000 and Khyber 87) to four rows spacing (30, 40, 50 and 60 cm). They recorded maximum grain yield (3528 kg ha^{-1}), number of grains per spike (68) and test weight (45 g) of all varieties with row spacing of 30 cm. while the minimum grain yield (1891 kg ha^{-1}) was recorded in 60 cm row spacing. Hiltbrunner *et al*. (2007) stated that increase in seeding density and sowing time is an effective mean to increase the grain yield. Ozturk *et al.* (2006) stated the decrease in seed rate from 625 to 325 seeds m^{-2} increased the number of kernels per spike. They concluded that stated that seeding rate directly influences the number of spikes per unit area, which further increase other yield components such as the number of grains per spike and individual grain weight. Kristo *et al*. (2006) reported that the growth and yield of winter wheat was higher under more favorable conditions (October sowing) with seeding rate of 600 seeds m^{-2} than those grown under unfavourable conditions (November sowing) with seeding rate of 300 seeds m^{-2}. Khan *et al*. (2005) concluded that among seeding rate of (100, 120, 140 and 160 kg/ha) of wheat sowing rates of 100 and 120 kg/ha produced significantly higher spike length, number of grains per spike, number of spikelets per spike and ultimately higher grain and straw yield. Whereas lowest yield traits and yield was obtained from sowing rates of 140 and 160 kg ha^{-1}.

Wajid *et al.* (2004) conducted a research experiment to investigate the effect of sowing date (10 November, 25 November and 10 December) and plant population (200-, 300- and 400 plants m^{-2}) on biomass, yield components and grain yield of wheat. The early sowing (10 Nov.) produced 60.6% higher grain yield over late sowing (10 Dec.). While the grain yield of 10 Nov. sowing was 45% higher than 25 Dec. sowing. Increasing plant population from 200 plant m^{-2} to 300- and 400 plant m^{-2} also enhanced grain yield but the response was quadratic. Lloveras *et al.* (2004) reported that due to differences in environmental factors, soil type, sowing date and wheat genotypes the appropriate seeding rate significantly differs from region to region. Staggenborg *et al.* (2003) reported that reduced tiller formation of wheat can be compensated by higher seeding rate through production of more main stem spikes particularly for the crop genotypes which produces less number of tillers. Kumar *et al.* (2002) reported that net return increased with increasing seed rates and the benefit cost ratio was highest with 100 kg/ha sowing rate. High or low seeding rates reduce the chances of obtaining full yield potential of specific genotype. Grain yield followed a positive linear response (Geleta *et al*., 2002). Spink *et al.* (2000) stated that lower seeding rate may increase the risks for reducing yield, whereas higher seeding rate may increase overall cost of production. Khan *et al.* (2002) reported that seeding rate of 150 kg /ha had higher emergence, plant height, number of effective tillers and grain yield. Seeding rate of 100 kg/ha took maximum number of days to maturity, while 50 kg seeded rate produced more number of grains/spike and test weight.

Conclusion

Optimum seed rates date of sowing and suitable cultivars play an important role in achieving potential yield of wheat. Plant density is a major factor determining the ability of the crop to capture resources and generate yield. It can be developed by using a suitable seeding rate to produce higher grain yield of wheat. The seed rate increases with delay in sowing due to poor plant stand, where higher seed rate produces more plants in unit area resulting in higher intra-crop competition hereby affecting the yield and production cost. Similarly lower plant population produces lower grain yield due to higher vegetative growth and space wastages. Growth and yield of wheat are affected by environmental conditions which

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can be regulated by sowing time, seeding rate and variety which are under the control of farmers in most cropping systems especially in wheat cultivation. However high yielding wheat varieties have maximum genetic potential to produce high yield but they cannot explore their genetic potential without ensuring proper time of sowing and seeding rate. Consequently, there is a relationship between cultivar, plant density and sowing date. As the plant density increases, the competition for resources especially for water, nutrient and space also increases that badly affect the final yield. Similarly different high yielding cultivars have varied optimum seed rate to maintain the optimum plant population for higher yield. Too early sowing when temperature is above the optimum produce poor plants and even higher seeding rate cannot compensate low yield. Under late sown conditions, wheat faces low temperature in the earlier stage and high temperature in the later stages of the growing season which due to lack of favorable moisture for its better growth and development at this stage causes yield reduction. At optimum temperature, early sowing with optimum plant population enhances the growth and nutrient uptake and causes higher crop production. Therefore to minimize the effect of temperature variation caused due to changed sowing date by choosing appropriate wheat varieties with the optimum seed rate which can synchronize its temperature requirement and to produce optimum yield, proper sowing date, optimum plant population and varietal selection according to environmental conditions are the best noncash options to increase growth, yield and quality traits of the wheat.

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Co-curricular activities: Attended 10 National and two International conference, seven training programmes and two workshops abroad of my country.

List of Publications

1. Fazily Tamim (2011). Response of late sown wheat (Triticum aestivum L.) to organic under irrigation. MSc thesis.
2. Fazily Tamim (2011). Effect of different doses of nitrogen and phosphorus on growth, yield and economics of potato (*Solanum tuberosom*) . Thesis for Academic promotion.
3. Fazily Tamim (2014). Effect of integrated nutrient management on growth, yield and quality of wheat. PhD thesis.
4. Fazily Tamim (2020). Effect of integrated nutrient management on growth, yield and quality of wheat. PhD thesis, Translated in Persian.
5. Fazily Tamim,. Thakral S.K., Dhaka A.K and Sharma M.K. (2021). Effect of Integrated Nutrient Management on Growth, Yield Attributes and Yield of Wheat. *International Journal of Advances in Agricultural Science and Technology*. *8(1)*: 106-118.
6. Fazily Tamim. Thakral S.K., Dhaka, A.K and Sharma M.K (2020). Effect of Integrated use of organic and inorganic sources of nitrogen on nutrient uptake by wheat and soil fertility. *International Journal of Current Advanced Research*. 9 (2): 21201-21204.
7. Fazily Tamim,. Thakral S.K., Dhaka A.K and Sharma M.K. (2020). Evaluation of yield and economics of wheat under integrated nutrient management. *International Journal of Research and Development in Technology*. 13(1): 49-53.

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8. Fazily Tamim,. Thakral S.K., Dhaka A.K and Sharma M.K. (2020). Impact of Organic and Inorganic Sources of Nitrogen on Growth Phenology, Yield and Quality of Wheat (*Triticum aestivum* L.). *International Journal of Advances in Agricultural Science and Technology. 7(*2): 31-38.
9. Fazily Tamim and Hunshal C.S. (2019). Response of late sown wheat (*Triticum aestivum* L.) to organics. *International Journal of Advanced Research and Development.* 55-57.
10. Fazily Tamim (2020). Impact of integrated nutrient management on wheat productivity and sustainable soil fertility: A review. *EPRA International Journal of Multidisciplinary Research*. *6* (1): 236-241.
11. Fazily Tamim. Thakral S.K., Dhaka, A.K and Sharma M.K (2020). Effect of Integrated Nutrient Management on Fertilizer Use Efficiency in Wheat (*Triticum aestivum* L.) under Irrigated Condition. *International Journal of Advances in Agricultural Science and Technology.* 7 (2): 1-9.
12. Fazily Tamim, Thakral S.K and Dhaka A.K. Effects of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.) under irrigated condition" published in Golden Jubilee International Conference. Organized by Directorate of Research CCS Haryana Agricultural University on Nov-6-2019.
13. Fazily Tamim, Hunshal C.S., Chimmad V.P, Hebbar Manjunath and Potdar M.P. Response of late sown wheat (*Triticum aestivum* L.) to organics" published in International Symposium: A need for sustainable Agriculture. Organized by Directorate of Research CCS Haryana Agricultural University on Feb-2-2019.
14. Fazily Tamim and Hunshal C.S. (2019). Effect of Organic Manures on Yield and Economics of Late Sown Wheat (*Triticum aestivum* L.*). International Journal of Research & Review. 6(1)* 168-171.
15. Fazily Tamim (2014). Effect of different doses of nitrogen and phosphorus fertilizers on yield and economics of potato. *Pozuhesh Seasonal Magazine Academic and cultural*. 6(2):75-82.
16. Fazily Tamim (2019). Integrated Nitrogen Management through Different Sources on Growth and Yield of Wheat (*Triticum aestivum* L.). *Pozuhesh Scientific Journal*. 16:45-56.
17. Fazily Tamim and Alemi Muhammad Alem (2019). Effect of different doses of nitrogen and phosphorus on growth and yield potato (Solanum tuberosum L.). *International Journal of Advance Research, Ideas and Innovations in Technology*. *5(1):* 105-107.
18. Fazily Tamim and Habibi Ainullah (2019). Performance of wheat varieties under different dates of sowing under irrigated condition of Baghlan province, Afghanistan. *International Journal of Emerging Technologies and Innovative Research*. 6:50-53.
19. Habibi Ainullah and Fazily Tamim (2020). Effect of sowing dates on growth, yield attributes and yield of four wheat varieties. *International Journal of Research and Development*. 5(1): 57-59.
20. Habibi Ainullah, Fazily Tamim and Halimi Abdul Hasib (2019). Varietal response of wheat to water stress condition of Baghlan province, Afghanistan. *SSRG International Journal of Agriculture and Environmental Science*. 6(3): 43-46.
21. Osmani Mohammad Hakim, Fazily Tamim, Koshani Beheshtah and Mirzaee Mujtaba (2020). Comparison of adaptation assessment of four local spring varieties in Kabul climatic condition. *EPRA International Journal of Research and Development.* 5 (1):21-23.
22. Wasim Mohammad, Mor V.S., Singh Vikram, Fazily Tamim and Hemender (2020). Morphological Quantitative Characterization of Wheat (*Triticum aestivum* L.) Genotypes under Normal and Late Sown Conditions. *International Journal of Advances in Agricultural Science and Technology*. 7 (1): 1-8.

