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Effects of Seed density on Grain yield and Agronomic traits of Wheat (*Triticum aestivum* L.) under Kabul and Khost Agro-Ecological conditions, Afghanistan

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***Abstract*—**Optimum seed density is an important factor for high yield as well as wheat grain quality. Apt seed density not only increases yield but reduces the total cost of wheat production. The purpose of this research was to investigate the most optimum density for three wheat varieties under two different environments to produce high yield of wheat. The experiment was conducted in two different agro-ecological zones (Kabul and Khost provinces, Afghanistan) during the 2018 - 2019 growing season. The research was arranged in Randomized Complete Block Design with the combinations of densities (100, 110 and 120 kg ha^{-1}) and three wheat varieties (Baghlan09, Kabul013 and Moqawim09). Densities and varieties revealed significant differences for different traits under study. Results indicated that Kabul013 and Baghlan09 at 110 kg seeds ha^{-1} in zone 1 had better fertile tillers, spike length and grain yield while the same varieties in zone 2 performed better at 120 kg ha^{-1} for these traits. Interestingly Moawwim09 produced better of these traits on120 kg ha^{-1}in both zones. Interaction effects among the locations, densities x variety were also significant. From the analysis results, it's concluded that 110 kg seeds ha^{-1} for Kabul013 and Baghlan09 varieties and 120 kg seeds ha^{-1} for Moqawim09 variety in zone 1 while 120 kg seeds ha^{-1} for all three varieties in zone 2 are the suitable seed rate and should be sown

***Keywords*—** Densities, environment, wheat varieties, yield and .yield components

I. INTRODUCTION

Wheat (*Triticum aestivum* L.) belonging to the gramineae family and is one of the main cereal crop of the world [1]. The origin of wheat crop is southwestern Asia and has been distributed to other parts of the world such as Asia, Europe, Africa and America [2]. Wheat crop in Afghanistan has been cultivated since prehistoric times. It plays a very important role in providing of carbohydrates, protein, high content of Vitamin B - complex and minerals [3]. Wheat crop in Afghanistan is not only use for human consumption but its straw is the major fodder for cattle's. Wheat is a global crop with an area of about 215.24 million hectares and a production of 730.50 million tons during 2018 - 2019 years. It is grown in Afghanistan at more than 2.00 million hectares with an average yield 3.60 million tons [4]. Wheat crop in Afghanistan occupies an important position among cereals, not only in cultivated area and production but also in its abilities in adaptation to a varied range of agro-climatic conditions. Wheat crop in Afghanistan during the 2005 – 2010 years had 78.5% an average yield of all cereals and the major production of wheat in Afghanistan comes from the Northern provinces (Takhar, Kunduz, Balkh, Jawzjan and Faryab) of the country [5].

The yield of wheat is approved by high yielding varieties (genotypic ability), ideal agronomic practices, and soil fertility. From the agronomic practices, seed density can play a vital role for both economic yield and higher quality [6].

Most farmers in Afghanistan used sowing seeds from their last season production and the amount of wheat seeds sometime can reach two or three equal of the ideal amount, that may damage the resources and not economically.

II. RELATED WORK

Appropriate sowing densities of seed is most important for the wheat crop, when more amount of seed is used, the population of the crop will be more and there will be competition among the crops for resources (water, nutrients, and sunlight) finely the low quality and low yield will be produced. However, if we use a small amount of seed, the yield will be less due to the less amount of plants per unite area [7]. Investigations indicated that increased in seed density can cause the released of different diseases [8,

9, 10]. On the other hand, using of inappropriate seeding density can lead to weeds problem in wheat fields [11].

In most cropping systems seeding rate is an important controlling factor which farmers can control it [12].
The effects of seed densities are differ to various varieties according to sowing time between areas to produced high yield [13]. Different environments with differ climatic conditions like amount of rainfall and temperature can influence the grain yield of wheat [14, 15, 16].

From the above aspects, the objectives of this study was to identify the most optimum amount of seed density and its effect on total yield and yield component of three wheat varieties under two different agro- ecological zones in Afghanistan.

III. MATERIALS AND METHODS

Study area
The research was conducted in two different agro – ecological zones {Experimental farm of the Agriculture faculty, Kabul University, Kabul Province (zone 1) and in Almara Village Khost Province (zone 2)} during the growing season of 2018 – 2019. Soil type, soil analysis, latitude, longitude, altitude, monthly rainfall (mm) and temperature (^{0}C) are presented in Table 1.

Treatments and experimental design
The treatments for this research were three seed densities (100, 110 and 120 kg seeds ha^{-1}) and three facultative wheat (*Triticum aestivum* L.) varieties (Baghlan09, Kabul013 and Moqawim09). The experiment was laid out in Randomize Complete Block Design (RCBD) with split plot design arrangement, seed density was the main plot and variety was sub plot with three replications.

Sowing
All three facultative wheat varieties were sown on 24th October in zone1 but one month later (24th November) in zone 2 according to its local cultivation time, respectively. Used hand drill method for sowing. The preceding crops were pea and corn in these sites, respectively. Nitrogen fertilizer, @ 120 kg ha^{-1} and Phosphorus@ 80 kg ha^{-1} were used. All Phosphorus fertilizer and 1/3 amount of Nitrogen were applied at the sowing time and the leftovers quantity of Nitrogen was used at jointing and flowering stages of wheat.

Data collection and measurements
The data was recorded for the following parameters.
Number of days to heading: The heading days were noted by using visual observation from sowing to 100% of produced spikes in each plot.

Number of days to maturity: Maturity days were counted from sowing to harvest time for all observations.

Plant height (cm): Five plants were randomly selected and tagged in each plot. The plant height was measured at the maturity stage from the surface of soil to the top of the spike.

Fertile tillers (no): Randomly from each plots one meter square area was selected then the number of fertile tillers were counted.

Spike length (cm): Five spikes from each plot were taken and the length of spike was measured from the bottom to the top of the spikelets then the mean was noted as spike length.

Kernel spike^{-1}(no): The above taken spikes were threshed, the total number of kernels were divided on the number of spikes. Finely the mean was recorded as number of kernel spike^{-1}.

1000 Kernel weight (gr): Sample for 1000 kernel weight was taken in each plot from the harvested area then weighted and recorded for 1000 kernel weight.

Grain yield (kg ha^{-1}): The yield of above one meter square was weighted, then converted to hectare, separately for each plot.

Statistical analysis.
Using R (version i386 4.0.2) statistical software for the data analyzing and for the comparing of mean value the Duncan's multiple range test is used ($\alpha = 0.05$).

Table 1. Soil (soil type and classification), metrological data, and monthly maximum and minimum temperature for the two environments Zones (Kabul and Khost Provinces) on the period when the wheat was grown (2018 – 2019).

Environment		Kabul	Khost
Soil type	Property		
	Clay (%)	59.76	50.56
	Silt (%)	21	27
	Sand (%)	19.24	22.44
	Textural class	Sandy loam	Sandy Clay loam
Latitude	N	$34^0 54' 44''$	$33^0 18' 0''$
Longitude	E	$70^0 10' 09''$	$69^0 .39' 24''$
Altitude	(m)	1791	1386

Soil analysis	pH(in water)		8.3			7.9	
	N (%)		2.2			3	
	P(mg kg^{-1})		6.9			7.5	
	K(mg kg^{-1})		190			171	
	OM (%)		0.91			0.93	
Monthly Rainfall(mm) and Temperature(^{0}C)	Month	Rainfall	Temp		Rainfall	Temp	
			Min	Max		Min	Max
	Oct	23.5	4	23	-	-	-
	Nov	45.5	-1	15	5.5	3.8	6.1
	Dec	2	-5	8	17	-0.3	14.9
	Jan	106	-7	5	38	-1	13.1
	Feb	146	-5	7	6	1.9	14.7
	Mar	130	1	13	109	6.6	19.4
	Apr	80	5	18	111	10.5	23.8
	May	43	9	24	88	14.8	30
	Jun	1	12	30	54.5	20	35.1

IV. RESULTS AND DISCUSSION

Densities

Analysis of variance for the studied traits is summarized in Table 2. There were significant differences (p<0.05) for days to heading in zone 2 and at (p<0.01) probability level for fertile tillers, spike length and grain yield in both zones while the effects of densities were non – significant for days to heading in zone 1, plant height, kernel spike^{-1} and 1000 kernel weight for both zones.

Varieties

Data concerning days to heading, days to maturity, plant height, fertile tillers, spike length, kernel spike^{-1}, 1000 kernel weight and grain yield have significant difference (p<0.01) in both zones (Table 2).

Interactions

Data presented in Table 2 indicated that interaction among densities x verities in zone2 but fertile tillers and grain yield for both zones are significant (p<0.01) in simple analysis while the combined analysis also showed significant difference among the locations at (p<0.01) probability level, such as interaction among the locations x varieties for days to heading, days to maturity, fertile tillers and grain yield, interaction among verities x densities for spike length, kernel spike^{-1} and grain yield, interaction among locations x densities for fertile tillers, spike length and grain yield and interaction among the locations x varieties x densities for fertile tillers an grain yield are significant.

Table 2. Analysis of variance for the agronomic traits of (days to heading, days to maturity, plant height, fertile tillers, spike length, kernel spike $^{-1}$, 1000 kernel weight and grain yield.

Source of Variance	df	Days to heading MS	Days to maturity MS	Plant height MS	Fertile Tillers MS	Spike length MS	Kernel spike^{-1} MS	1000 Kernel weight MS	Grain yield MS
					Kabul				
Replication	2	0.111	0.037	0.102	843.44	0.704	5.760	2.660	13337.03
Density (D)	2	0.777	0.703*	1.538	1420.33*	0.763**	2.507	0.626	155114.81**
Variety (V)	2	124.33**	258.925**	398.79**	6627.11**	3.301**	238.63**	21.96**	1092803.70**
D x V	4	0.111	0.259	0.007	1156.61	0.808**	10.793	0.088	50259.25**
Error	16	0.2361	0.120	0.525	387.02	0.094	5.033	0.813	116.20
					Khost				
Replication	2	0.671	0.259	2.269	67.44	0.314	9.867	1.750	46304.00
Density (D)	2	0.703**	0.148	1.538	3444.77**	0.839**	12.893	0.626	639664.33**
Variety (V)	2	156.592**	49.370**	398.793**	1864.77**	5.537**	238.632**	21.96**	797209.03**
D x V	4	0.148	0.092	0.007	609.22**	0.206	5.599	0.088	12436.67**
Error	16	0.106	0.143	0.525	43.361	0.049	5.033	0.813	3480.83
					Combined Analysis				
Location(L)	1	48360.29**	36244.46**	294.00**	1093.50	19.80**	141.13*	14.41	923840.40**
Rep within location	4	0.29	0.14	1.68*	455.44	0.40**	7.81	2.20*	29820.52**
Density(D)	2	1.40**	0.72**	3.07**	2718.05**	0.84**	6.99	1.25	634815.79**
Variety (V)	2	277.01**	267.16**	797.58**	6493.16**	8.67**	477.26**	43.99**	1876854.86**

D x V	4	0.07	0.05	0.01	480.80	0.78**	14.28*	0.17	10394.99**
L x V	2	3.90**	41.12**	0.00	1998.72**	0.16	0.00	0.00	13157.86**
L x D	2	0.07	0.12	0.00	2147.05**	0.75**	8.40	0.00	159963.35**
L x V x S	4	0.18	0.29	0.00	1285.07**	0.23	2.11	0.00	52300.93**
Error	32	0.17	0.12	0.52	215.19	0.09	5.03	0.81	1798.51

Note: *: $p< 0.05$, **: $p<0.01$, df: Degree of Freedom, MS: Mean Square,

Discussion

Means for days to heading in Table 3 indicate that Kabul013 variety had more days (195.56 days) for heading followed by Moqawim09 variety but Baghlan09 variety took minimum days to heading in zone 1 while in zone 2 Moqawim09 had more number of days to heading (135.44 days) closely followed by Kabul013 (135.22 days) and Baghlan09 had the minimum number of days for heading (128.11 days). This variation among the varieties for days to heading may be associated to the heredity makeup of the wheat which is alike with [17].

The data indicated that maximum days to maturity (242.89 days) were noted at 120 kg ha^{-1} in zone 1 and minimum were (242.33 days) at 100 kg ha^{-1}. This is in line with [18] who founded that increasing in seed density can enhance the competition among the crops and the crop will be influenced by deprivation due to the storage of food prepared in the leaf by the process of photosynthesis which leads to late maturity of the crop. In case of varieties, Kabul013 had maximum days to maturity(246.00 and 192.22) in zone 1 and in zone 2, respectively while the Baghlan09 toke minimum days to maturity (236.44 and 188.11 days), respectively Table 3.

The maximum plant height (95.81 cm) was observed on Kabul013 variety in zone 1, likewise in zone 2 (91.04 cm) among the varieties while Moqawim09 produce the minimum plant height (82.58 and 77.91 cm) in both zones, respectively (Table 3). This is because plant height is affected by plant heredity face which is in line with [19]. However, the effects of densities were non-significant but wheat's that were cultivated on 120 kg seeds ha^{-1} produced maximum plant height against 110 and 100 kg seeds ha^{-1}. This is may be the less distance in 120 kg seeds ha^{-1} among the wheat and they competed to each other and drive upward growth for light interception. This result is agreement with [20, 21] who observed maximum plant heights when the densities were increasing.

Mean value in Table 3 indicated that maximum number of fertile tillers noted on 110 kg ha^{-1}(443.33 m^{-2}) in zone1 but inversely in zone 2 the maximum number of fertile tillers were noted on 120 kg ha^{-1} (390.11 m^{-2}) while in both zones the minimum number of fertile tillers were recorded at 100 kg ha^{-1}(418.33 and 376.44 m^{-2}), respectively. The amount of 110 kg ha^{-1} seeds for zone 1 and 120 kg ha^{-1} for zone 2 may be the ideal amount of seed density. This result is confirm with [22, 23] who founded maximum number of fertile tillers on more seed densities and contrast with [24] who observed maximum number of fertile tillers on less seed densities. In case of varieties, Baghlan09 produced the maximum number of fertile tillers (456.56 and 424.22 m^{-2}) in both zones respectively while Kabul013 variety produced the minimum number of fertile tillers (402.33 and 361 m^{-2}), respectively. This is due to the genetic makeup which is also confirmed by [25].

Table 3. Means of days to heading, days to maturity, plant height and fertile tillers affected by seed densities, varieties and their interaction in two environments (Kabul and Khost Provinces).

Treatment	**Days to heading 100% (no)**		**Days to maturity 100 % (no)**		**Plant height (cm)**		**Fertile tillers (m^{-2})**	
	Kabul	**Khost**	**Kabul**	**Khost**	**Kabul**	**Khost**	**Kabul**	**Khost**
Seed density(Kg ha^{-1}) S:-								
100 (S1)	192.44	132.67b	242.33b	190.66	88.15	83.48	418.33b	376.44c
110(S2)	192.88	132.89b	242.67ab	190.88	88.42	83.75	443.33a	390.11b
120(S3)	193.00	133.22a	242.89a	190.88	88.96	84.30	428.67ab	418.22a
LSD 5%	NS	0.32	0.34	NS	NS	NS	19.65	11.39
Variety (V):-								
Baghlan09(V1)	188.56c	128.11b	236.44c	188.11b	87.26b	82.59b	456.56a	424.22a
Kabul 013 (V2)	195.56a	135.22a	246.00a	192.22a	95.81a	91.04a	402.33c	361.00c
Moqawim09 (V3)	194.22b	135.44a	245.44b	192.11a	82.58 c	77.91c	431.44b	399.55b
LSD 5%	0.48	0.32	0.43	0.36	0.72	0.72	19.65	11.39
Interaction:-								
S1 * V1	188.00	128.00	236.00	188.00	86.86	82.20	434.66	411.00ba
S2 * V1	188.66	128.00	236.66	188.00	87.16	82.50	482.66	425.66a

S3 * V1	189.00	128.33	236.66	188.33	87.73	83.06	452.33	433.00a
S1 * V2	195.33	135.00	246.00	192.00	95.33	90.66	408.66	381.00b
S2 * V2	195.66	135.00	246.00	192.33	95.66	91.00	415.00	390.33b
S3 * V2	195.66	135.66	246.00	192.33	96.13	91.46	383.33	446.00a
S1 * V3	194.00	135.00	245.00	192.00	82.26	77.60	411.66	425.00b
S2 * V3	194.33	135.66	245.33	192.33	82.43	77.76	432.33	427.66ab
S3 * V3	194.33	135.66	246.00	192.00	83.03	78.36	450.33	450.33a
LSD 5%	NS	NS	NS	NS	NS	NS	NS	11.39

Means for the Treatments with different letters are significantly different (P=0.05); LSD = least significant difference.

The longest spike length (8.44 cm) in zone1 was noted on 110 kg ha^{-1} closely followed by 120 kg ha^{-1} while the shortest spike length was noted on 100 kg ha$^{-1,}$ conversely in zone2 the longest spike length (7.30 cm) was recorded on 120 kg ha^{-1} but the shortest were recorded (6.76 cm) on 100 kg ha^{-1}. In case of varieties, Kabul013 produced the longest spikes (8.73 and 7.63 cm) in both zones, respectively while Baghlan09 produced the shortest (7.52 and 6.09 cm) Table 4. The interaction among the densities and varieties showed that Baghlan09 and Kabul 013 produced longest spikes on 110 kg seed ha^{-1} and Moqawim09 produced at 120 kg seeds ha^{-1} in zone 1 while in zone 2 all three varieties produce the longest spike on 120 kg seeds ha^{-1}. These amounts of seeds can be referred to as ideal and appropriate seed densities for the mentioned varieties which resulted in optimum crop plant competition.

Maximum kernel spike^{-1} (41.22 and 37.99) for Kabul013 variety were recorded in both zones, respectively (Table 4) while the minimum kernel spike^{-1} were recorded for Baghlan09 variety (31.64 and 28.41), respectively.

Heavier kernels in both zones were noted on Kabul013 variety (48.69 and 49.72), respectively while the lighted were recorded on Baghlan09 (46.67 and 46.15). These finding were in harmony with [26] who observed that 1000 kernel weight the characteristic of a variety and there is more difference among the varieties even though if they sow in optimum conditions.

Analysis of the data in Table 4 indicated that maximum grain yield (5541.11 kg ha^{-1}) was recorded at 110 kg ha^{-1} in zone1 and the minimum was (5301.11 kg ha^{-1}) at 100 kg ha^{-1} while in zone2 the maximum grain yield was noted at 120 kg ha^{-1} (5469.27 kg ha^{-1}) and the minimum was (4938.12 kg ha^{-1}) at 100 kg ha^{-1}. It is in line with [23] who founded that optimum sowing density produced high yield against less and more. In case of varieties, Kabul013 (5818.88 and 5511.28 kg ha^{-1}) produced the maximum grain yield in both Zones, respectively while the minimum were recorded on Baghlan09 (5125.55 and 492352 kg ha^{-1}), respectively. This could be due to differences in the genetic makeup of the three varieties [27]. The interaction between the densities x variety indicated that Baghlan09 and Kabul013 varieties in zone1 produced high grain yield (5206.66 and 6043.33 kg ha^{-1}) at 110 kg seeds ha^{-1} and Mowqim09 (5603.33 kg ha^{-1}) produced on 120 kg seeds ha^{-1} while in zone 2 all three varieties produced maximum grain yield (5248.10, 5815 and 5344.73 kg ha^{-1}) at 120 kg seeds ha^{-1} but minimum grain yield for all three varieties were recorded at 100 kg seeds ha^{-1} in both zones.

Table 4. Means of spike length, kernel spike^{-1}, 1000 kernel weight and grain yield affected by seed densities, Varieties and their interaction in two environments (Kabul and Khost Provinces).

Treatment	Spike length (cm)		Kernel spike^{-1} (no)		1000 kernel weight (gr)		Grain yield (kg ha^{-1})	
	Kabul	Khost	Kabul	Khost	Kabul	Khost	Kabul	Khost
Seed density(Kg ha^{-1}) S:-								
100 (S1)	7.86b	6.76b	34.81	31.57	46.75	47.78	5301.11c	4938.12c
110(S2)	8.44a	6.78b	35.86	31.15	46.88	47.92	5541.11a	5163.36b
120(S3)	8.16a	7.30a	35.44	33.25	47.26	48.29	5513.33b	5469.27a
LSD 5%	0.53	0.30	NS	NS	NS	NS	77.82	144.95
Variety (V):-								
Baghlan09(V1)	7.52b	6.09c	31.64b	28.41b	46.59b	47.62b	5125.55c	4923.52c
Kabul 013 (V2)	8.73a	7.63a	41.22a	37.99a	48.69a	49.72a	5818.88a	5511.28a
Moqawim09 (V3)	8.22a	7.12b	33.16b	29.92b	45.63c	46.67c	5411.11b	5135.95b
LSD 5%	0.53	0.30	2.49	2.21	0.90	0.90	10.36	68,59
Interaction:-								

S1 * V1	7.11a	6.01	29.33	26.10	46.36	47.40	5033.33h	4609.66f
S2 * V1	8.23a	6.12	33.86	28.50	46.56	47.60	5206.66f	4912.80e
S3 * V1	7.22b	6.13	31.73	30.63	46.82	47.86	5136.66g	5248.10cd
S1 * V2	8.61ab	7.51	41.30	38.06	48.36	49.40	5613.33c	5278.56c
S2 * V2	9.13a	7.34	42.16	36.96	48.50	49.53	6043.33a	5440.30b
S3 * V2	8.44b	8.03	40.20	38.93	49.20	50.23	5800.00b	5815.00a
S1 * V3	7.86b	6.76	33.80	30.56	45.53	46.56	5256.66e	4926.13e
S2 * V3	7.96b	6.86	31.56	28.33	45.60	46.63	5373.33d	5137.00d
S3 * V3	8.83a	7.73	34.10	30.86	45.76	46.80	5603.33a	5344.73bc
LSD 5%	0.53	NS	NS	NS	NS	NS	17.95	118

V. CONCLUSION

The experiment revealed that the seed densities significantly affected the growth, yield and yield components of wheat but the effects were varied according to the variety and among the environments. The amount of 110 kg seeds ha^{-1} had maximum means of fertile tillers m^{-2}, spike length, grain yield followed by the 100 kg seeds ha^{-1} in zone 1 (Kabul) but the maximum means of the mentioned traits were highly in zone 2 (Khost) at 120 kg seeds ha^{-1}. In the case of varieties, Kabul013 variety produced the longest spikes, more number of kernel $spike^{-1}$, weighty 1000 kernel weight and highest grain yield in both zones, respectively while the Baghaln09 had lest means of these traits. Among the environment, there were also significant differences. The days to heading and maturity and grain yield were high in zone 1 than zone 2. So, from the research results, it can be recommended that in Kabul province for Kabul013 and Baghan09 varieties estimated seed densities are 110 kg seeds ha^{-1} but 120 kg seeds ha^{-1} is optimum for Moqawim09 variety while 120 kg seeds ha^{-1} is optimum amount of densities for the all three varieties in zone 2 for producing of higher yield.

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