Journal of Agricultural Science; Vol. 9, No. 1; 2017
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Employing Phenology to Delineate Wheat Agro-Climatic Zones in Afghanistan

M. Q. Obaidi[1], Elias Mohmand[2], M. H. Azmatyar[1] & Rajiv Sharma[2]

[1] Agricultural Research Institute of Afghanistan, Kabul, Afghanistan

[2] International Maize & Wheat Improvement Centre (CIMMYT), Kabul, Afghanistan

Correspondence: Rajiv Sharma, International Maize & Wheat Improvement Centre (CIMMYT), Kabul, Afghanistan. E-mail: rk.sharma@cgiar.org

Received: October 11, 2016 Accepted: November 7, 2016 Online Published: December 15, 2016

doi:10.5539/jas.v9n1p218 URL: http://dx.doi.org/10.5539/jas.v9n1p218

Abstract

Afghanistan grows wheat on about 2.5 million hectares with an average annual production of about five million tonnes. The local research and development efforts make use of country wide research results to recommend varieties and other technologies. Afghanistan has wide ranging climatic variability and its wheat acreage therefore needs to be delineated into wheat climatic zones. A set of 10 different types of wheat varieties were scored for average number of days to 50% flowering (ADF) at 10 locations to delineate Afghan wheat acreage into homogeneous wheat climatic zones based on ADF values. The results obtained hinted at creating eastern, northern, south western and a highland zone for conducting research and recommending wheat technologies.

Keywords: Afghanistan, wheat, agro-climatic, zone, flowering

1. Introduction

Afghanistan is a wheat eating country where per capita wheat consumption stands at over 200 kg/annum. Wheat is a staple food as it provides over 60% of daily caloric requirement of an average Afghan (Persaud, 2012). Decades of war have inhibited growth of both research and development in all fields and more so in agriculture sector as intervention involves moving physically into insecure country side. However, this has not prevented work of CG canters including CIMMYT, and its germplasm introductions led to development and release of several wheat varieties in the country in recent past (Obaidi et al., 2011, 2014, 2015). Afghanistan grows wheat at over 2.5 million hectares with an average annual production of around five million tonnes (Obaidi et al., 2015). Though adequate number of wheat varieties are available, however their dissemination to farmer fields is severely hampered on account of inefficient seed production providing for a less than five per cent seed replacement rate for wheat. The Afghan agricultural research is spearheaded by Agricultural Research Institute of Afghanistan (ARIA) which constitutes Afghanistan's national agricultural research system (NARS). ARIA has over ten functional wheat research stations spread across length and breadth of the country. Current practice of releasing new wheat varieties makes use of yield evaluation trials conducted throughout the country. Afghanistan has wide range of agro-ecologies characterized by cold winters and hot summers. Though eastern Afghanistan does receive monsoon rains, most of the Afghanistan is semi-arid or arid (Saidajan, 2012). It is therefore imperative that country is categorized into all possible wheat climatic zones to not only fine-tune production management but also identify best adapted varieties for each zone. Phenological traits mainly days to flowering is a reflection of agro climatic features of any location and can be aptly employed to characterize different agro climatic zones (Diaz et al., 2012; Pearce et al., 2016).

2. Material & Methods

A total of ten wheat varieties released in Afghanistan and representing different growth habits viz., winter and spring wheat were used to constitute a phenological nursery. The nursery was grown at several locations viz., Balkh, Baghlan, Bamyan, Nangarhar, Kabul, Takhar, Kunduz, Herat, Badakhshan and Kandhar during 2010-11 to 2015-16 crop seasons. Various geological attributes of these locations viz., longitude, latitude and altitude etc., are presented in Table 1 and their geographical locations are shown in Figure 1. The nursery was sown in an unreplicated experiment and each genotype was sown in two rows of two meters each. Standard recommended

agronomic practices were adopted to raise a successful crop. Days to 50% flowering was recorded on each genotype at all the locations in each year.

Table 1. Agricultural Research Institute of Afghanistan (ARIA) research stations in Afghanistan

No	Site	Acronym	Institution	Latitude(N)	Longitude(E)	Altitude (m)
1	Badakhshan	BDS	Baharak	36°50′ N	70°9′ E	1733
2	Kunduz	KDZ	Central Farm	36°43′ N	68°51′ E	373
3	Takhar	TKR	Taloqan	36°44′ N	49°30′ E	804
4	Balkh	BLK	Dehdadi	36°65′ N	66°96′ E	387
5	Baghlan	BGL	Posi-e-shan	36°42′ N	67°13′ E	510
6	Bamyan	BMN	Mullah Ghulam	34°43′ N	67°49′ E	2550
7	Kabul	KBL	Darulaman	34°28′ N	69°09′ E	1841
8	Nangarhar	NGR	Shishambagh	34°49′ N	70°74′ E	541
9	Herat	HRT	Urdu Khan	34°18′ N	62°16′ E	927
10	Kandahar	KND	Kokaran	31°35′ N	65°40′ E	630

Figure 1. Locations of various ARIA research stations in Afghanistan

3. Results

Varieties on an average took longest to attain 50% flowering at Badakhshan (161 days) followed by Bamyan (159 days) whereas earliest 50% flowering at an average of 95 days (Table 2) was recorded at Nangarhar in the east of Afghanistan. Such a variation was missing among varieties. The earliest ones took an average of 123 days (PBW 154, Muqawim 09, Ghori 96, Rana 96) to attain 50% flowering across locations whereas Bezostaya and Gul 96 were last to attain this stage after 128 days. When presented graphically (Figure 2), locations clearly differed among themselves more or less maintaining the relative ranking of varieties across locations. Figure 2 also indicates similarities among locations that could come together to form wheat climatic zones. Nangarhar in East is distinct with just 95 average number of days (ADF) to attain 50% of flowering (Table 3) and therefore claims to be a distinct zone (Eastern Zone: EZ) in itself, however it suffers from want of any other location in the zone. Northern region has three locations within the interval of 100 to 120 ADF and therefore along with Balkh (ADF of 124) constitute Northern zone. Southern region has just one location of Kandhar (ADF: 101) and West has one location of Herat (ADF: 111). Owing to similarities in ADF, for the time being a single zone of South West (SW zone) is proposed. Central highlands in Afghanistan are a high altitude region with two regional research stations at Kabul and Bamyan with an average ADF of 153 days. However, Badakhshan in North East is

a high altitude region also with an ADF of 161. Though Badakhshan is not geographical contiguous region, however because of similar ADF, a zone comprising of CH and Badakhshan is proposed with the name of Highlands.

Table 2. Average number of days to 50% of flowering of different varieties at several locations over 2010-11 to 2015-16

Locations/Varieties	Balkh	Baghlan	Bamyan	Nangarhar	Kabul	Takhar	Kunduz	Herat	Badakhshan	Kandhar	Average
Bezostaya	130	115	160	97	150	123	114	114	163	103	128
Rana 96	122	107	155	93	144	115	107	111	155	98	123
Mazar 99	125	109	157	94	146	116	110	111	159	100	124
Herat 99	124	109	159	94	146	116	109	110	161	102	124
Solh 02	124	110	159	96	146	114	110	112	164	103	125
Gul 96	127	114	162	97	149	118	115	112	169	104	128
PBW 154	122	108	160	92	147	117	107	110	159	99	123
Ghori 96	122	109	158	95	144	119	108	108	159	98	123
Muqawim 09	122	109	156	95	146	117	109	111	157	99	123
DA 07	126	113	162	96	150	117	111	112	161	103	126
Average	**124**	**110**	**159**	**95**	**147**	**117**	**110**	**111**	**161**	**101**	**124**

Table 3. Regions falling under different categories based on average number of days to 50% flowering (ADF)

ADF Range	E	N	S	W	NE	CH
< 100	NGR (95)	-	-	-	-	
100-120	-	BGL, TKR, KDZ (112)	KND (101)	HRT (111)	-	
120-140		BLK (124)				
> 140					BDK (161)	BMN, KBL (153)
ADF mean for proposed zone	95	118	101	111	161	153

Note. ADF: Average number of days to 50% flowering; E: East; N: North; S: South; W: West; NE: North East; CH: Central Highland.

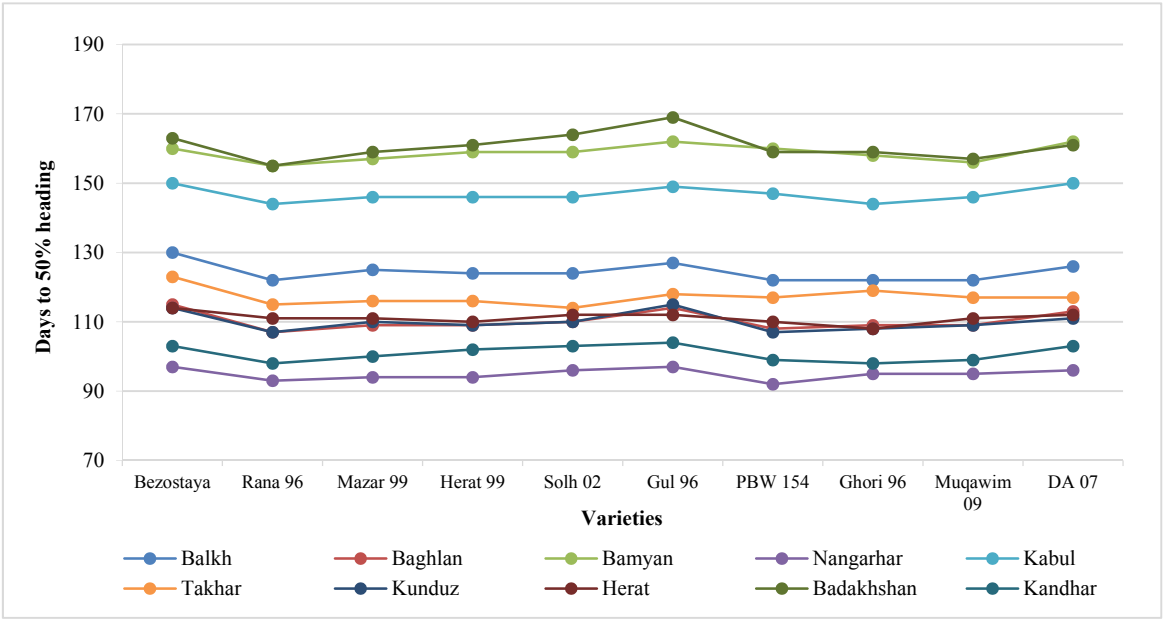

Figure 2. Days to 50% of heading of several wheat varieties across Afghan locations

4. Discussion

Flowering is the development stage signalling transition from vegetative to reproductive stage. Climatic factors like temperature and day length are integrated to regulate flowering time (Nitcher et al., 2014) and are thus critical parameters determining climatic homogeneity in respect of the species in question. Since optimal time of development transition is necessary for reproductive success (Diaz et al., 2012) and to maximize grain yield (Pearce et al., 2016), climatic zonation on the basis of this transition would aid identification of best adapted varieties for a zone. Though, Himani et al. (2013) reported agro climatic zonation of Uttarakhand using remote sensing and GIS, and Jatzold and Kutsch (1982) employed temperature, water supply and length of growing period for zonation of Kenya, Rezaei et al. (2016) distinguished various regions of Iran on the basis of several weather parameters. Additionally, range of weather parameters have been made use of for computing evapotranspiration (Valipour, 2015; Valipour, 2014a, 2014b). However, it will take some time before adequate information on these aspects of Afghanistan is generated to attempt such a zonation. Moreover, we are attempting delineation of Afghan wheat acreage only with respect to a single species. Flowering time (FT) is such an adaptive trait and is the net result of interaction of environmental factors with the species concerned. Therefore, FT can be used to determine climatic homogeneity and thus create zones for the purpose of maximising species performance within the zone. The ADF varied from 95 for Nangarhar in East to a high of 161 in Badakhshan in North East. Interestingly the across location variation is echoed equally by all the genotypes studied. For example, the ADF value ranged between 155 and 169 at Badakhshan, and between 93 and 97 at Nangarhar indicating a much greater role of location in determining ADF. The wheat climatic zones proposed herein *viz*., East, North, South, West, North-East and Central Highlands are only a tentative working solution based on flowering stage observed among a set of wheat varieties adapted to Afghanistan. However, owing to similar ADF and lack of adequate number of testing sites South-West will be only one zone for the time being. Similarly, North-East is clubbed with Central highlands for same reasons. Wart et al. (2013) suggested an effective balance between zone size and number of zones required to adequately cover the harvested area of major food crop. Afghanistan on the other hand suffers from lack of adequate number of regional research stations to serve as testing sites for new varieties and is therefore constrained to manage only with the available functioning research sites. The regions especially in East, South, West and North East should have more number of research stations to better judge varietal adaptability and to optimize factors of production. The currently proposed wheat climatic zones should be changed to better delineate Afghan wheat area as and when more number of research stations are added in South, West, East and North East.

References

Diaz, A., Zikhali, M., Turner, A. S., Isaac, P., & Laurie, D. A. (2012). Copy number variation affecting the *Photoperiod-b1* and *Vernalization-A1* genes is associated with altered flowering time in wheat (*Triticum aestivum*). *PLoS ONE, 7*, e33234. http://dx.doi.org/10.1371/journal.pone.0033234

Himani, B., Nain, A. S., Shweta, G., & Puranik, H. V. (2013). Agro-climatic zonation of Uttarakhand using remote sensing and GIS. *J. Agrometerology, 15*, 30-35.

Jatzold, R., & Kutsch, H. (1982). Agro-ecological zones of the tropics, with a sample from Kenya. *Tropenlandwirt, 83*, 15-34.

Nitcher, R., Pearce, S., Tranquilli, G., Zhang, X. Q., & Dubcovsky, J. (2014). Effect of the Hope *FT-B1* allele on wheat heading time and yield components. *J. Heredity, 105*, 666-675.

Obaidi, M. Q., Azmatyar, M. H., Elias, M., Habibi, A., Qayum, A., & Sharma, R. (2015). Lalmi 04—A new rainfed wheat variety for Afghanistan. *Triticeae Genomics and Genetics, 6*, 1-3. http://dx.doi.org/10.5376/tgg.2015.06.0001

Obaidi, M. Q., Habibi, A., Ghanizada, A. G., Mashook, M., Azmatyar, M. H., Jan, A., … Sharma, R. (2014). A new high yielding, disease resistant winter wheat variety for Afghanistan. *WIS, 117*, 9-12.

Obaidi, M. Q., Osmanzai, M., Singh, R. P., Pena, J., Braun, H. J., & Sharma, R. (2011). Development of four new Ug99 resistant wheat varieties for Afghanistan. *WIS, 112*, 4-10.

Pearce, S., Kippes, N., Chen, A., Debernardi, J. M., & Dubcovsky, J. (2016). RNA-seq studies using wheat *PHYTOCHROME B* and *PHYTOCHROME C* mutants reveal shared and specific functions in the regulation of flowering and shade-avoidance pathways. *BMC Plant Biology, 16*, 141. http://dx.doi.org/10.1186/s12870-016-0831-3

Persaud, S. (2012). *Long term growth Prospects for Wheat Production in Afghanistan*. Retrieved from http://www.ers.usda.gov/media/193523/whs11101_1_.pdf

Rezaei, M., Valipour, M., & Valipour, M. (2016). Modelling evapotranspiration to increase the accuracy of the estimates based on the climatic parameters. *Water Conserv. Sci. Eng., 1*, 197. http://dx.doi.org/10.1007/s41101-016-0013-z

Saidajan, A. (2012). Effects of war on biodiversity and sustainable agricultural development in Afghanistan. *J. of Developments in Sustainable Agriculture, 7*, 9-13. http://dx.doi.org/10.11178/jdsa.7.9

Valipour, M. (2014a). Analysis of potential evapotranspiration using limited weather data. *Applied Water Sci.* (pp. 1-11). http://dx.doi.org/10.1007/s13201-014-0234-2

Valipour, M. (2014b). Application of new mass transfer formulae for computation of evapotranspiration. *J. Applied Water Engineering and Research, 2*, 33-46. http://dx.doi.org/10.1080123249676.2014.923790

Valipour, M. (2015). Caliberation of mass transfer-based models to predict reference crop evapotranspiration. *Applied Water Sci*. (pp. 1-11). http://dx.doi.org/10.1007/s13201-015-0274-2

Wart, J. van, Bussel, L. G. J. van, Wolf, J., Licker, R., et al. (2013). Use of agro-climatic zones to upscale crop yield potential. *Field Crops Res., 143,* 44-55. http://dx.doi.org/10.1016/j.fcr.2012.11.023