EFFECT OF CLIMATIC CHANGE SCENERIO ON REPRODUCTIVE BEHAVIOUR OF SOME FODDER GRASSES GROWING WILD IN PAKISTAN

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Abstract

The main objective of this study was to see the behavior of some fodder grass in global warming situation. In this regard the estimation of florets formation, sex distribution, anthesis, pollen fertility, pollen germination, seed set and seed germination of *Apluda mutica* L., *Bothriocloa ischaemum* (L) Keng, *Chrysopogon aucheri* (Boiss.) Stapf., *C. serrulatus* Trin., *Cymbopogon caesius* (Nees ex Hook. & Arn.) Stapf., *C. jwarancusa* (Jones,) Schult, *C. martinii* (Roxb.) Wat., *C. commutatus (Steud.)* Stapf., *Dichanthium annulatum* (Forssk.) Stapf., *Hyparrhenia hirta* (L.) Stapf., *Sorghum halepense* (L.) Pers. and *Themeda anathera* (Nees) Hack. were investigated. These plants were collected from various climatic areas of Pakistan. The results demonstrated that the highest number (348) of florets per inflorescence were found in *Cymbopogon jwarancusa* (Jones) Schult. from Nathiagally while lowest (135 ± 50) were seen in *Apluda mutica* from Kallar Kahar Hill. Former species and *Bothriochloa* produced largest amount of barren florets. It is shown that from November to February the anthesis started early at 6:00AM in *Cymbopogon* spp. and *Sorghum halepense*, while *Chrysopogon aucheri* at 8:00AM. In *Cymbopogon* spp. and *Sorghum halepense* (L.) Pers. it started ½ hour early during March to May and terminated at 7:00AM, however in *Cymbopogon aucheri* the anthesis time was from 7:30AM to 8:30AM in the same months. To summarize the anthesis behavior in these grasses, generally it started from 6:00AM morning and continued up to 8:30AM, generally. Except *Hyperrhenia, Dicanthium* and *Cymbopogon jwarancusa,* all grasses produced 85% viable pollen grains. Pollen germination significantly increases with increase temperature in some cases. Seed set is poor with higher percentage of seed germination. It is evident that even in considerably higher temperature these grasses show normal behavior. Therefore it is suggested that there should be no negative impact of climate change on these grasses.

Introduction

The importance of grasses and their contribution to productivity of ecosystem and country's economics has been recognized since long time. Grasses provide food to domestic/wild animals and shelter to millions of insects, and birds. They also support complex food web by virtue of their physical structure and primary production, including marine ecosystem and are well recognized for their role as controlling soil erosion and increasing land, marine and freshwater fertility.

Pakistan is an arid country with an average rainfall of 230mm/year and its population has tremendously increased with the passage of time, having population of 65.3 millions in 1980 and 180 millions in 2010. Due to this reason the area of agriculture and forested lands is also reducing with alarming stage. There are a few natural grasslands in Pakistan beside grasses are abundantly distributed in patches along the rivers, canal, dry stream beds, around the agricultural fields and places where ample amount of water is available. Most of our domestic animals depend on these grasses, however due to increased number of domestic animals and reduced area of grasses, these areas are being overgrazed. Peer et al (2001) described impact of over grazing in steppe vegetation of Hindukush while Ahmed et al., (1990-1991) showed the harmful effects of deforestation and overgrazing in Baluchistan.

Most of the grass species are highly colonel, relying an asexual reproduction producing rhizome that may be physiological independent but genetically identical to the mother plant. Besides these grasses are capable of sexual production, producing low quantity seeds. In Pakistan only little work was under taken. On grasses i.e. Ahmed *et al*., (1978); Hussain *et al*., (1980) ; Ahmed (1994) ; Ayaz (1992) ; Hussain and Ilahi (1997) ; Bano *et al*., (2009). Germination, morphology and defoliation response of *Cymbopogon jawarnensa* and *Cymbopogon aucheri* were described by Saleem and Call (1993 a,b) while Khan and Parveen (2009) presented pollen germination capacity of *Curcumas* species.

In Pakistan there is a need to establish artificial grassland. However it is anticipated that global climatic change or global warming will be affected each and every aspect of our life, including our biological resources (Agriculture, forestry and marine ecosystem). Short *et al*., (2003) described the possible impact of global warming on sea grass. Hussain et *al*., (2009) investigated vegetative behaviour of some fodder grasses under climatic change scenario. Therefore, planting fodder grasses on large scale or introduced in different environmental regime, experimental trails should be conducted on small scale, under possible impact of climatic change scenario. In addition, how different crop, weed, forest and horticulture plant species will respond to the changing climate? It is great challenge, important question and worldwide scientific problem. Present paper presents the reproductive behaviour of a few fodder grasses under higher temperature to predict their possible response in future climatic change.

Materials and Methods

An extensive survey was conducted to collect these pasture grasses from twenty different locations of Pakistan. Some of these areas show contrast and diverse climatic conditions. These species were planted in a nursery with five replicates each. Plants were watered regularly and allowed to grow and established, normally. Ten inflorescences per plant were obtained and total number of florets, sex and morphological abnormal floretes were determined. Time of anthesis was recorded for two years; pollen fertility was tested using Cook and Walden (1976) procedure. One way analysis of variance was used to see difference among various staining reagent. Pollen germination at room temperature (20-25°C) and incubator (30-32°C) were observed. After pollination seeds were recorded in several hundreds of florets and germination test was conducted to see seed viability.

Results and Discussion

Fig.1 postulated the sampling locations while the species, place of collection, difference of elevation and environmental conditions of various sampling areas are given in Table 1.

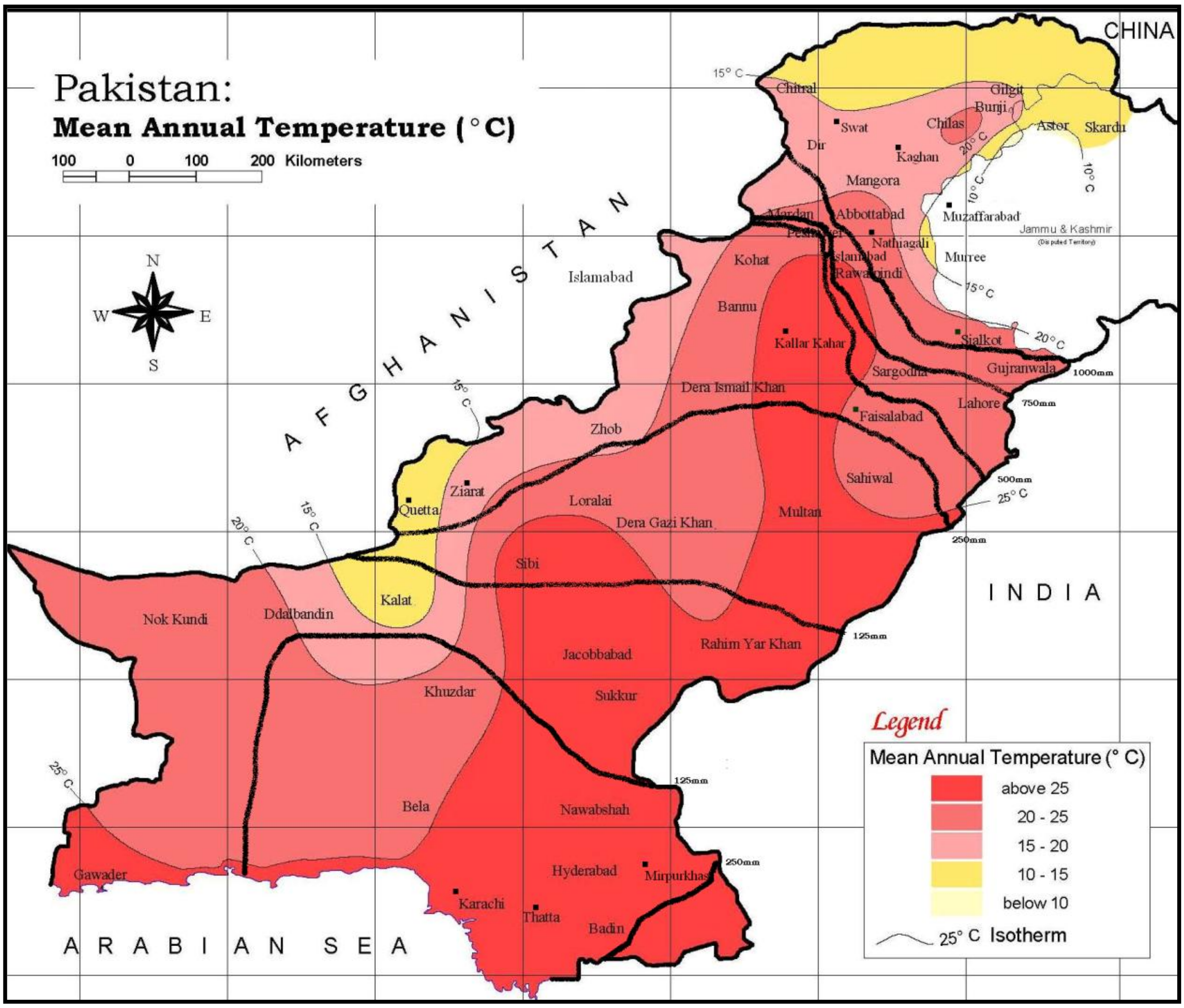

Fig. 1. Map of Pakistan showing sites, different rainfall and temperature areas. Solid lines = rainfall, light lines= temperature

Table 1. Summary of species and characteristics of sampling areas.

S.No.	Species	Place of collection	Elevation (m)	Latitude N°	Longitude E°	Temp. °C	
						Min	Max
1	*Apluda mutica* L.	Kallar Kahar Hills	792	32°44	72° 40	21	30
2	*Bothriochloa ischaemum*(L.) Keng	Mirpur Khas	18	25° 30	69° 00	14	42
3	*Chrysopogon aucheri* (Bioss.) Stapf	Muzaffarabad	878	34° 22	73° 28	2	36
4	*C. serrulatus Trin*	Thatta	05	24° 43	67° 43	6.35	40.55
5	*Cymbopogon caesius* (Nees ex Hook & Arn.) Stapf	Faisalabad	182	31° 24	73° 04	−1	50
6	*C.commutatus* (Steud.) Stapf	Ziarat	2468	30° 22	67° 43	-2	48
7	*C.jwarancusa* (Jones) Schult.	Urak- Quetta	2083	30° 16	67° 09	- 18.3	-42
8	*C. jwarancusa* (Jones) Schult	Ayub Park-Islamabad	450	33° 34	73° 04	-4	52
9	*C.martinii* (Roxb.) Wats.	Karachi University Campus	40	24° 56	67° 06	25	42
10	*Dichanthium annulatum* (Forssk.) Stapf	Sialkot	246	32° 32	74° 28	0	40
11	*Hyparrhenia hirta* (L.) Stapf	Swat	965	34° 46	72° 21	1	38
12	*Sorghum halepense* (L.) Pers.	Faisalabad	180	31° 23	73° 01	−1	39
13	*Themeda anathera* (Nees) Hack.	Kaghan	2140	34° 46	73° 31	3	11
14	*T.anathera* (Nees) Hack.	Nathiagully	2239	34° 04	73° 22	-3	25

Table 2 described that the number of florets/ inflorescence are highly variable with in same species and between the species. Lowest number (135±50) of floret/inflorescence were recorded in *Apluda mutica* while highest (348±98) florete/inflorescences were found in *Cymbopogon jwarancusa*. The species were collected from Kallar Kahar Hills and Nathiagully respectively. *Apluda mutica, Bothriochloa sp.* and *Sorghum* bear no male florets with considerably higher number of barren florets (not suitable for seeds). Hussain *et al* (1980) also reported high number of barren florates in these grasses. Ahmed *et al* (1978) found more than 50% sterile, barren or abnormal florets in three species of *Cymbopogon.*

Anthesis is one of the important phenomenon of sexual reproduction which is responsible for seed formation. Normally anthesis occurs in early morning, different species take different duration to complete this phenomenon. Time of anthesis is also given in Table 2. It is evident that in general anthesis started at 6:00AM and lasted until 8:30AM in all grasses. According to Husain *et al* (1983) in *Bothriochloa, Chrysopogon, Dicanthium, Hyperrhenia* and *Themeda,* anthesis completed between 6:15 to 8:30 AM. In winter (from Nov. to Feb.) anthesis initiated 30-90 minutes late compared to summer months (June-Oct.). It is also recorded that in spring (March-May) and summer (June-Oct.), many grasses completed anthesis with in one hour time *i.e. Apluda mutica* (Kallar Kahar Hill), *Chrysopogon aucheri* (Muzaffarabad), *Cymbopogon caesius* (Faisalabad). A few grasses take shorter time (30 min.) to complete anthesis *Cymbopogon martinii* (Karachi), *Cymbopogon parkeri* (Ziarat) and *Hyperrhenia hirta* (Swat). *Sorghum halepense* shed pollen upto 90 minutes, while *Themeda anathera* took 110 minutes in summer time. It is concluded that due to low temperature in winter anthesis started late while due to higher temperature in summer anthesis initiated earlier. It is also recorded that all species regardless of their original place of growing shed higher amount of pollens.

Table 2. Sex distribution, florets formation and anthesis behavior.

S.No	Species	Florets/ infl.	Sex distribution (number)			Anthesis month and time					
						Nov-Feb(AM)		Mar-May(AM)		June- Oct(AM)	
			Ml	Bi	Ba	Ini	Com	Ini	Com	Ini	Com
1	*Apluda mutica* L.	135±50	-	46	52	7.15	8.00	6.30	7.30	6.30	7.30
2	*Bothriochloa ischaemum*(L.) Keng	220±31	-	44	54	7.30	8.30	6.30	7.10	6.00	7.15
3	*Chrysopogon aucheri* (Bioss.) Stapf	144±47	58	32	8	8.00	8.30	7.30	8.30	6.30	7.30
4	*C. serrulatus Trin*	134±16	60	30	10	7.30	8.00	7.30	7.45	6.15	7.45
5	*Cymbopogon caesius* (Nees ex Hook & Arn.) Stapf	219±9	54	40	6	6.30	7.00	6.00	7.00	6.00	7.00
6	*C.commutatus* (Steud.) Stapf	301±83	53	41	6	6.30	7.15	6.0	7.00	6.00	7.20
7	*C.jwarancusa* (Jones) Schult.	264±71	56	40	4	6.30	7.00	7.30	8.00	6.15	7.30
8	*C. jwarancusa* (Jones) Schult	348±98	59	31	10	6.30	7.20	7.15	8.00	6.20	7.40
9	*C.martinii* (Roxb.) Wats.	295±37	62	28	8	7.0	7.30	7.15	7.45	6.30	7.00
10	*Dichanthium annulatum* (Forssk.) Stapf	228±67	48	46	6	7.30	8.15	6.30	7.30	6.00	7.45
11	*Hyparrhenia hirta* (L.) Stapf	193±45	62	34	4	7.30	8.30	7.30	8.00	7.30	8.00
12	*Sorghum halepense* (L.) Pers.	253±44	-	72	28	6.30	7.30	6.30	7.00	6.00	7.30
13	*Themeda anathera* (Nees) Hack.	235±31	70	26	4	7.45	8.30	7.30	8.30	6.45	8.05
14	*T.anathera* (Nees) Hack.	219±54	67	21	12	7.30	8.30	7.15	8.15	6.10	8.00

Note: Infl=Inflorescence, Ml=Male, Bi=Bisexual, Ba=Barren, Ini=initiated, Com=completed, AM= Morning.

Table 3. Results of pollen fertility, germination, seed setting & seed germination.

S.No	Species	Pollen fertility		Pollen germination%		Seed Setting	Seed germination
		Mean %	F. values	Temp. Room (C°)	Temp. Incubator (C°)	%	%
1	*Apluda mutica* L.	85±3	0.31	8	8	5	80
2	*Bothriochloa ischaemum* (L.) Keng	87.20±2.15	17.26**	10	12	8	81
3	*Chrysopogon aucheri* (Bioss.) Stapf.	89±2.97	3.48*	35	28	6	81
4	*C. serrulatus Trin*	88.20±1.62	1.66	33	29	6	83
5	*Cymbopogon caesius* (Nees ex Hook & Arn.) Stapf.	88.20±0.86	4.02*	31	33	9	91
6	*C.commutatus* (Steud.) Stapf	85±1.92	9.32**	35	46*	8	89
7	*C.jwarancusa* (Jones) Schult	86±8.53	2.01	33	47**	7	95
8	*C. jwarancusa* (Jones) Schult	77.60±9.56	1.16	33	54***	8	93
9	*C.martinii* (Roxb.) Wats.	89±1.92	4.18*	48	53	7	81
10	*C. parkeri*	77.60±2.60	2.91**	29	64***	10	92
11	*Dichanthium annulatum* (Forssk.) Stapf	74.20±4.27	2.71*	43	34**	19	100
12	*Hyparrhenia hirta* (L.) Stapf	55.40±7.12	4.56*	31	32	3	83
13	*Sorghum halepense* (L.) Pers.	86.40±0.87	3.77*	45	37*	7	73
14	*Themeda anathera* (Nees) Hack.	86.60±1.21	11.51**	30	34	7	87
15	*T.anathera* (Nees) Hack.	89.40±1.50	11.53**	20	29	9	89

Note: *significant at 0.05, **at 0.05 and *** 0.001 level, Temp=Temperature.

These grasses are important pasture grasses in tropical and subtropical areas of the world. In Pakistan a few grasslands are available, besides how these grasses will respond in global warming scenario, is a big question. In developed countries sufficient work has been done and finally they developed resistance varieties of grasses for drought, frost, shade and temperature (Tompsett, 1976). Therefore a lot of work should be carried out in this regard. Table-1 postulated that some of these grasses are collected from cooler areas but they behave normally in considerable warm area like Karachi, increasing our knowledge toward the impact of climatic change scenario. It is suggested that increase of 2^{o}C temperature would not effect vegetative growth (Hussain *et al,* 2009) and anthesis behaviors of these species if water is not the limit factors.

Five staining reagents *i.e.* Iodine, Eosin yellow, Cotton blue, Acid fuchsin and Acetocarmine were used to test viability and fertility of pollen grains. *Dicanthium annulatum* from Sialkot show overall fertility of 64 ± 7 while except *Hypperrhenia hirta* (Swat) and *Cymbopogon jwarancusa* (Nathiagully), all grasses regardless of their original places produced at least 85% of viable, sustainable or fertile pollen grains. Most of the cases, (Table-2) one way analysis of variance shows significant difference among the different staining reagents for viability. Therefore, it may be calculated that higher amount of fertile pollen grains would provide higher amount of seed set in these grasses, however this was not the case and in contrast only a small number of seeds were produced by these grasses. Ahmed *et al* (1978) also recorded the same while working on three species of *Cymbopogon.*

Results of pollen fertility, pollen germination, seed setting and seed germination are placed in Table 3. Our experiments also showed that in *Cymbopogon jwarancusa* from Quetta and Islamabad, *Cymbopogon* co*mmutatus* and *Cymbopogon parkeri* from Ziarat, and *Dicanthium annulatus* from Sialkot, pollen grain germination significantly increases with increase in temperature (7^{o}C), indicating global warming would not be a limited factor at least for these grasses. In contrast reverse was the case with *Sorghum halepense* from Faisalabad, therefore we need to take special measure and try to create heat resistance variety in climatic change scenario. Nevertheless, pollen fertility do not relate to pollen germination, though condition provided in germination trial do not match the natural environmental conditions but poor seed set in these grasses are also reported by other workers. Hussain *et al* (1980) found the same while working on eight different grasses of tribe *Andropogoneae*. Various factors are also responsible for seed settling after pollination. Hussain *et al* (1983) and Hussain (2009) reported that various insects, fungi and birds like *Etrilda amandava* is responsible for poor seed set in these grasses. They also reported maximum female deficiency and male sterility in these grasses as compare to other flowering plants. However, it may be suggested that increase in temperature would not affect the pollen fertility and germination except in some species.

It is concluded that in less time and investment climatic change resistance grassland may be established in Pakistan. In addition it seems that there would be no impact of climatic change on vegetative, reproductive growth and development of these grasses. However more detailed investigation are recommended for concrete conclusion.

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