Botany Research International 8 (2): 41-46, 2015
ISSN 2221-3635

DOI: 10.5829/idosi.bri.2015.8.2.514

A Study of Punjab Grasses as Indicators of Environmental Change

Ashok Kumar, Sushant Sharma, Rajdavinder Kaur and A.S. Soodan

Systematics and Biodiversity Laboratory,
Department of Botanical and Environmental Sciences, Guru Nanak Dev University, Amritsar, India

Abstract: The adverse effects of anthropogenic activities on nature and natural resources are too well known to need emphasis. But, of late, realization has dawned that the cumulative effects of human activities are affecting the climatic regimes of the planet. Efforts are being made to understand the causes, dynamics and consequences of the phenomenon. First and foremost, we need to establish models to detect and monitor changes in the variety of parameters that jointly control the global and regional climate. Our studies on diversity and ecology of the grass flora of Punjab in recent years have shown that grasses are ideally suited as indicators of environmental change. They are a diverse group comprising nearly 10,000 species spread all over the globe, but the character that makes them an ideal group for monitoring environmental change is habitat specificity. Within Punjab, we have worked on the ecological preference of about fifty grass species. We have encountered both spatial and temporal variations in the composition of the grass flora of the region. Spatial variations, even in contiguous areas, were found to be related to the type of habitat: mesophytic (*Panicum maximum, P. antidotale, Paspalidium flavidum, Urochloa panicoides etc.*), xerophytic (*Aristida adscensionis, Bothriochloa pertusa, Heteropogon contortus*), halophytic (*Desmostachya bipinnata*), hydrophytic (*Paspalum paspaloides, Panicum paludosum*) and sciophytic (*Brachiaria reptans*). Equally notable are the seasonal variations. We have prepared a compendium of species occurring in different seasons of each type of habitat. For a typical mesophytic habitat seasonal variations are illustrated by grasses found in winter (*Thysanolaena maxima, Neyraudia arundinacea*), spring (*Poa annua, Eragrostis minor*) and summer (*Digitaria ciliaris, Brachiaria reptans*). The present paper reports our findings on spatial distribution and phenological phases of some grasses in the study area that may serve as a model for not only detecting the quantum and direction of climate change but also for assessment of the effects of such change on biological systems. For this purpose, permanent experimental stations will have to be established in various agro-climatic zones of the region.

Key words: Anthropogenic · Spatial · Temporal · Phenological · Climate Regimes

INTRODUCTION

Change in the climatic regimes of the globe is a geographical phenomenon evidenced in the geological history of the planet. There have been such geological events as the continental drift, glaciations, interglacial warming, volcanic eruptions etc. leading to mass migrations and redistribution of the fauna and flora. But with the advent of the industrial era, the world has witnessed an increasing rate of qualitative change in the gaseous composition of the atmosphere leading to global warming and consequent shift in the climatic regimes of planet.

The question of climatic change is being addressed in two ways which complement each other. One of them is aimed at formulation and execution of policies and practices that may help to control the qualitative change in the atmosphere. Efforts remained local till the establishment of the institution of Intergovernmental Panel on Climatic Change (IPCC) in the year 1988, followed by United Nations Framework Convention on Climate Change (UNFCCC) in the year 1992 and the legally binding Kyoto Protocol in the year 2005. The 15th meeting of the UNFCCC coinciding with the 5th meeting of the Kyoto protocol held in Copenhagen is the latest endeavour in policy formulation.

Corresponding Author: A.S. Soodan, Systematics and Biodiversity Laboratory, Department of Botanical and Environmental Sciences, Guru Nanak Dev University, Amritsar, India.

The other approach is experimental and is aimed at the assessment of the magnitude and dynamics of the problem, evaluation of the effects and strategies to mitigate them. Efforts are being made to develop models to study the effects of such changes on natural resources. Living organism are very sensitive to change in climatic conditions as they live in narrowly defined conditions, in a variety of ecosystems [1, 2, 3. Diverse type of plants (from grasses to trees) and animals from mollusks to mammals have found use as indicators of climatic change [4] Temporal shift in the calendar of phenological events are being evaluated for use as 'fingerprints' of change in the yearly climatic regimes [5-10]. For assessment of long term effects, shift in the distribution range and abundance of plant species are being evaluated as reliable indicators. Among plant groups, grasses have been extensibly employed both for long term and short term assessment in temperate and tropical grasslands [11-13].

Models based upon grasses are extremely relevant to the Indian conditions because the country has mainly a (sub) tropical climate that supports large grasslands or ecosystem showing overwhelming dominance of grasses. Grasses constitute the most ubiquitous elements of these ecosystems making them an ideal choice for monitoring environmental change. Moreover, with a land use heavily biased towards agriculture, the landscape of the country is occupied by a number of cultivated grasses. For the reasons cited above, grasses assume an even greater relevance in Punjab which has a tropical ecology and an agrarian economy. Thus, apart from cultivated fields, wild grass species dominate the rangelands as well. Even in the natural vegetation which occurs only in small patches and strips, grasses constitute the major elements.

MATERIALS AND METHODS

Area of Study: The entire state of Punjab constituted the area of study. Punjab is a part of the North West Himalayan region which is marked by a highly variable topography and high endemism of plants and animal species (Fig. 1). About a third of the angiosperms (including grasses) are endemic. Physiographically, Punjab is predominantly an alluvial plain. In the East and the North-East, it is bounded by hills which are the outer flankings of the Himalayas. Towards South-West it becomes uneven due to the occurrence of sand dunes and sand flats. Average elevation of the plain region is 200-300 m asl with the hills rising upto 500-600 m above sea level. The interfluvial plains are traversed by an elaborate system of canals originating at the headworks for Ravi at Madhopur and that of Satluj at Ropar.

Internet Sources.http://www.mapsofindia.com/

Fig. 1: Map of North Western Himalayas.

Punjab and the adjoining hills were scanned for inventorization of grass species and their habitat preference. However, a majority of species listed below were studied from the plain area of Punjab except *Tripogon jacquemontii,* which was encountered from the hill areas of Himachal Pradesh adjoining the Punjab territory. This species has been included to illustrate a lithophyte that could be used an indicator in the higher altitudes. The taxonomic study involved diagnosis and identification of the species. Grasses have a peculiar morphology and rather cryptic nature of diagnostic characters. The vegetative and reproductive morphology and phenology was studied by using standard formats of description [14]. The type of inflorescence and the micromorphologcal characters of the spikelet and the floret proved helpful in identification. The method of stereoscopic dissection and examination was followed. Stereophotomicrographs were also taken for morphometry and closer study of diagnostic characters. Species identified and employed for the present study are listed hereunder.

List of Species

Subfamily: Centothecoideae
Thysanolaena maxima (Roxb.) O. Ktze.

Subfamily: Pooideae
Phalaris minor (Trin.) Bor
Poa pratensis L.
Poa annua L.

Subfamily: Arundinoideae
Aristida adscensionis L.
Phragmites kraka (Retz.) Trin.

Subfamily: Chloridoideae
Cynodon dactylon (L.) Pers.
Desmostachya bipinnata (L.) Stapf.
Eragrostis minor Host
Eragrostis interrupta (Steud.) Stapf
Neyraudia arundinacea L.
Tripogon jacquemontii Stapf

Subfamily: Panicoideae
Bothriochloa pertusa (L.) A. Camus
Brachiaria reptans (L.) Gard. et C.E. Hubb.
B. ramosa (L.) Stapf
B. distachya (L.) Stapf
Cymbopogon citratus (DC) Stapf
C. martini (Roxb.) Wats
Digitaria ciliaris (Retz.) Koen.
Hemarthria compressa (L.) R. Br.
Heteropogon contortus (L.) P. Beauv.
Lasiurus sindicus Henr.
Oplismenus burmanii (Retz.) P. Beauv
O. composites (L.) P. Beauv.
Panicum antidotale Retz.
Panicum maximum Jacq.
Panicum paludosum Roxb.
Paspalidium flavidum (Retz.) A. Camus
Paspalum paspaloides (Michx.) Scribn.
Paspalum scrobiculatum L.
Saccharum bengalense Retz.
Saccharum spontaneum L.
Urochloa panicoides P. Beauv.

RESULTS AND DISCUSSION

Grasses meet all the requirements of being ideal indicators and biomonitors of environmental change. Widespread distribution throughout the globe is the first argument in their favour. They are also characterized by a narrow range of nutritional requirements. Thirdly, grasses are a large and a diverse group of plants with about 700 genera and 10,000 species [15]. Apart from taxonomic diversity, they display tremendous diversity of habitats. What is more important is that they are highly habitat specific. Moreover, the area under grasslands is likely to increase further on account of degrading factors like deforestation, desertification and unproductiveness of the arable land [16].

The study area being devoted to intensive agriculture, cultivated fields comprise the most important land use component. However, cultivated grasses are not ideally suited as indicators of environmental change, because of the moderating and buffering effects of the agricultural practice. Thus the data presented concerns grass species growing in natural habitats.

Long Term (diachronic) Effects: A close scrutiny of data reveals two important things about the grass species presently studied. First, as a group, they occupy diverse types of habitats. However, a very small percentage of them have a generalist behavior. A majority of the species display high specificity of habitat, on the basis of which species are put in different categories. A majority of species are mesophytic e.g. *Brachiaria distachya, B. ramosa, B. reptans, Panicum antidotale and P. maximum* (Fig. 2). However, all other types are represented in the present sample. *Cymbopogon citrates* and *C. martinii* (Fig. 3) belong to the category of xerophytic species growing in the arid parts. Even in sandy habitats, there are

Panicum maximum

Fig. 2:

Cymbopogon martinii

Fig. 3:

Lasiurus sindicus

Fig. 4:

Tripogon jacquemontii

Fig. 5:

Phragmites karka

Fig. 6:

Paspalum paspaloides

Fig. 7:

psammophytic species namely *Aristida adscensionis* and *Lasiurus sindicus* (Fig. 4). The present samples include a lithophytic grass species viz., *Tripogon jacquemontii* (Fig. 5) which grows on the bare rocks in the higher elevations. At such locations, where other plant groups are scanty, grasses constitute the dominant group which can be employed to monitor long term and short term environmental changes. At the other extreme of habitat we have marshy grasses like *Phragmites karka* (Fig. 6) which prefers banks of canals and streams. In the aquatic and semi-aquatic category, we have *Panicum paludosum, Paspalum paspaloides* (Fig. 7) and *Paspalum scrobiculatum*.

Within each of these, sub-types can be defined by other parameters such as presence of organic content, proximity to cultivated lands and the relief features. Therefore, diachronic changes in any of these parameters of habitat are expected to cause correlated changes in the distribution and abundance of the grass species. For the sake of brevity, we present only a few illustrative examples. In the mesophytic rangelands, generalist species viz. *Dichanthium annulatum, Bothriochloa pertusa* and *Cynodon dactylon* are the dominant ones. However, shady conditions promote the growth of *Brachiaria distachya, B. ramosa and B. reptans.* And the presence of organic matter in the soil is directly indicated by the abundance of *Oplismenus burmanii and O. compositus.* On the other hand moisture in the soil coupled with shade promotes *Paspalidium flavidum.*

In category of aquatic grasses, presence of low organic content promotes *Panicum paludosum* whereas higher concentrations of organic matter are conducive for the growth of *Paspalum paspaloides.* Therefore pollution of water bodies and slow flowing streams by organic material is indicated by a luxuriant growth of later named aquatic grass. However, when water is relatively free of organic load, *Panicum paludosum* begins to dominate. The critical level of the physico-chemical parameters at which this changeover occurs has to be determined experimentally. Similarly, grasses of the mesic and xeric habitats have exacting requirements determined by interplay of edaphic and ombrothermic conditions. Apart from a specificity of habitat, there are two other arguments in favour of grass species as indicators of environmental change. First, grasses are perhaps the only group of higher plants which are available throughout the globe and for most part of the yearly cycle. One could employ them as models for seasonal patterns. Secondly, grasses display a clear demarcation of the phenophases in the vegetative and reproductive phenology. Though it is not feasible to present data for all the species worked out in the present studies, we may list phenophases which mark a physiological shift in the life cycle. In the vegetative part of the life cycle, bud formation, bud burst, colouring and leaf drying are the important phases. In the reproductive phenology, we have boot formation, inflorescence emergence, stigma/ anther emergence, fruit set and maturity, disarticulation and dispersal. Even earlier the relation of phenophases with the climatic regimes has been cited as a valid argument for their role as models of climatic change [4]. Such effects on grasses need to be evaluated as shifts in the flowering and fruiting phases are expected to affect survival of these species. Any preponement or delay in flowering is likely to result in loss of synchrony and availability of pollinators like aphids, ants, birds and butterflies which help in pollination of plant species including grasses [17]. Shift in terms of fruit maturation and disarticulation are likely to affect dispersal which is effected by a variety of methods ranging from anemochory to myrmecochory. It must be understood that only a few grass species disperse their fruits and diaspores by autochory.

Short Term (Seasonal) Monitoring: Grasses have a distinctive morphology and phenology. Both annual and perennial grass species have a well defined growing period in the yearly cycle. Thus, they are classified as spring, summer and winter grasses. In the area of present study, we have classified the available species into these categories. We have collected empirical data on some grass species for major phonological events listed hereunder.

Vegetative phenophases

Bud formation
Bud burst
Leaf colouring and
Leaf drying

Reproductive phenophases

Boot formation
Inflorescence emergence
Stigma/ anther emergence
Fruit set and maturity
Disarticulation and dispersal

CONCLUSIONS

It emerges from our studies that grass species are endowed with a high degree of habitat specificity and distinctive phenology which make them ideal candidates for detection and monitoring of climatic changes both over long term and short term (seasonal) periods. Even earlier, the sensitivity of grass species to changes in the environmental conditions have been employed both at the level of grasslands as also individual species.

REFERENCES

1. Thornley, J.H.M., 1998. Grassland dynamics: An ecosystem simulation model. *Wallingford Oxon: CAB International.*
2. Root, T.L., J.F. Price and K.R. Hall, 2003. Fingerprints of global warming on wild animals and plants. Nature, pp: 421.
3. GPWG (Grass Phylogeny Working Group), 2001. Phylogeny and subfamilial classification of the grasses (Poaceae). *Ann Miss. Bot. Gard.,* 88: 373-457.
4. Thornley, J.H.M. and M.G.R. Cannellm, 1996. Temprate Grassland Responses to climate change: an Analysis using Hurley Pasture model. Annals of Botany, 80: 205-221,
5. Johnson, I.R. and J.H.M. Thornley, 1985. Dynamic model of the response of a vegetative grass crop to light, temperature and nitrogen. Plant, Cell and Env.,8: 485-499.
6. Walther G.R., E. Post, P. Convey, A. Menzal and C. Parmesan, 2002. Ecological responses to recent climate change. Nature, 416: 389-395.
7. Panario, D. and B. Mario, 1997. Climatic change effects on grassland in Uruguay. Cli. Res., 9: 37-40.
8. Sparks, T.H. and T.J. Yates, 1997. The effect of spring temperature on the appearance dates of British butterflies 1883-1993. Ecography, 20: 368-374.
9. Visser, M.E. and B. Christian, 2005. Shifts in phenology due to climate change: the need for a yardstick. Pro. Roy. Soci. Bot., 272: 2561-2569.
10. Fay, P.A., D. Jonathan, A.K. Carlisle and L.C. Scott 2003. Productivity responses to altered rainfall patterns in a C_4-dominated grassland. *Oec.* 137: 245-251.
11. Jones, M.B., M. Jongen and T. Doyle, 1996. Effects of elevated carbon dioxide concentrations on agricultural grassland production. *Agr.* and For. Met., 79: 243-252.
12. Parmesan, C. and G. Yohe, 2003. A globally coherent fingerprint of climate impacts across natural systems. Nature, pp: 421.
13. Visser, M.E., 2003. Variable responses to large-scale climate change in European Parus populations. Proc. R. Soc. B., 270: 367-372.
14. Hall, D.O., D.S. Ojima, W.J. Parton and J.M.O. Seurlock, 1995. Response of temperate and tropical grasslands to CO_2 and climate change. J. of Biogeo., 22: 537-547.
15. Dunn, P., 2004. Breeding dates and reproductive performance. Adv. Eco. Res., 35: 69-87.
16. Hughes, L., 2000. Biological consequences of global warming: is the signal already apparent? Trends Ecol. Evol., 14: 146-150.
17. Sukumar, R., H.S. Suresh and R. Ramesh, 1995. Climate change and its impact on tropical montane ecosystems in southern India. Journal of Biogeography, 22: 533-536.