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Amarjit Singh Soodan
Guru Nanak Dev University, India

Sushant Sharma
Guru Nanak Dev University, India

Ashok Kumar
Guru Nanak Dev University, India

Rajdavinder Kaur
Guru Nanak Dev University, India

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Amarjit Singh Soodan*, Sushant Sharma, Ashok Kumar, Rajdavinder Kaur
Guru Nanak Dev University, Amritsar, India
*Corresponding author e-mail : assoodan@gmail.com

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Introduction

Grasslands occupy almost half of the terrestrial expanse of India ranging from coastal to alpine regions. Whyte (1958) defined 'grassland as the land on which graminaceous species represent the dominance if not the exclusive vegetation'. Grasslands comprise the main source of fodder for the 500 million cattle population in the country besides providing habitat to several plant and animal species. But the grasslands are shrinking due to the pressure of intensive agriculture and urbanization not only in expanse but also in their biodiversity. In this context there is an urgent need to develop not only a policy towards a sustainable utilization of grassland resources but also to devise strategies to replenish and refurbish their productivity and biodiversity.

Grasses have an unmatched ecological significance as well. They occur in nearly all the terrestrial ecosystems and habitats of the world and provide cover to nearly a fifth of the land surface. Taxonomic diversification and geographic diversification occurred during the Eocene in several phases beginning with the crown node of bambusoid grasses (53mya) and continuing with the pooid (47-38 mya), chloridoid (35-25mya) and panicoid (26mya) groups (Kellogg, 2001). With their origin in the southern land masses, grasses are believed to have spread to Eurasia via the Indian land mass.

Materials and Methods

The restoration of grasslands is possible only through programmes of facilitated propagation of grass species both in the natural and managed ecosystems.

At the outset, we must understand that the term 'seed' in grasses is a botanical misnomer for two reasons. First that the fruit wall (the pericarp) is inseparably fused with the wall of the uniovular ovary making a one-seeded fruit the 'caryopsis'. Second, the caryopsis keeps covered by persisting bracts in the mature condition in a majority of grasses. It is only in small percentage of grass species that caryopsis is shed from the mother plant. In rest of the grasses, it makes a bigger morphological unit 'the diaspore' with the additional bracts (of the spikelet) that persist and help in dispersal by various agents. Diaspores were subjected to stereoscopic examination to study their structure *vis-à-vis* disarticulation from inflorescence.

Results and Discussion

Punjab, the area of present investigation, has a predominance of grasses both in the wilderness as also the cultivated fields. It is practically 'grassland of cultivated species' or a 'cultivated grassland'. Besides cultivated fields, grasses constitute the dominant elements of rangeland vegetation of the region. Despite a pre-dominance of grasses in natural and rangeland ecosystem. Punjab faces a shortage of fodder which get more acute during the pre-monsoon season and winter months (Annonymous, 2009). In view of ever increasing demand for food grains, diverting arable land to fodder production is neither feasible nor advisable. The only alternative is to enhance fodder production from non arable areas. Our research group has an ongoing programme of exploration, diversity distribution and dispersal of grass species of Punjab and neighborhood (Sharma, et al., 2010). The present paper presents our findings on the morphofunctional and diversity of diaspores of about fifty grass species

A scrutiny of table 1 reveals a wide range of diversity and structural organization of diaspore. The diversity seems to be related to both taxonomic affiliations and habitat preferences of the species. We may illustrate these relationships through some representative examples. In the present collection, members of subfamily Chloridoideae namely *Sporobolus diander* (Retz.) P. Beauv. And *Eragrostis ciliaris* (L.) R. Br., *E. Diplachnoides* Steud.,*E. interupta* (Steud.) Stapf. and*E. tenella* (L.) P. Beauv. ex Roem. & Schult. represented the simplest case as the caryopsis itself was found to comprise the dispersal unit. In these species caryopsis was free of the accessory bracts and was dispersed by whiffs of wind. Such

diaspores belongs to the group of 'unawned diaspore' for which wind is the main means of dispersal and fall in the group of anemochorous type.

Next level of structural complexity is represented by the species where 'anthoecium' is the diaspore (Table 1). In such species, caryopsis was enclosed by a fertile palea and lemma and occasionally, a reduced floret. In the subfamily Pooideae, weedy species *Phalaris minor* Retz. represents this stage. The anthoecia in this species were unawned. However in *Lolium temulentum* var. *temulentum* (L.) the fertile lemma of anthoecia bore an awn. Some members of subfamily Chlorioideae, namely *Cynodon dactylon* (L.) Pers. and *Desmostachya bipinnata* (L.) Stapf. also had anthoecia as the unit of dispersal.

Among panioid grasses *Arundinella nepalensis* Trin.) also had anthoecia with small lemma awn which helps to maintain buoyancy in the air. Among members of the subfamily Aristoideae *Aristida adscensionis* L. had anthoecia that bore a tripartite but passive awn that helps in rotation of the diaspore and its landing in the erect position. Rotation on the soil surface at the callus end with antrorsley directed beard helped in penetration and establishment. In our sample of grass species, members of subfamily Arundinoideae *viz.Arundo donax*, *Phragmites karka* (Retz.) Tri. ex Steud. And *P. australis* Trin. (Cav.) ex Steud. represented the next stage of structural elaboration of the diaspore. Their diaspore unit was found to be unit larger than the anthoecia but smaller than the entire spikelet. In these species, entire rachilla with all the florets (1-2 reduced one at the distal part) disarticulated above the glumes and spread as a single dispersal unit. The diaspore bore long hairs on the dorsal surface of the lemma in *Arundo donax* L. and on the rachilla in *Phragmites karka* (Retz.) Trin. ex. Steud. and *P. australis* (Cav.) Trin. ex. Steud. Further it may be awned as in *Echinochloa colona* (L.) Link, *E. crus-galli* (L.) P. Beauv. *Sorghum halepanse* (l.) Per. *Digitaria ciliaris* (Retz.) Koel. *Panicum maximum* Jacq. However in case of *Chrysopogon serrulatus* Trin. and*Cymbopogon martinii* (Roxb.) Watson and *C. Citratus* (DC.) Stapf a cluster of three spikelets comprised the dispersal unit. In the cluster, a central fertile spikelet is flanked by two sterile ones. These diaspores bore basal and hygroscopically active awns that play a dual function. In the first phase of dispersal, they help in attachment with the dispersal agents but after falling to the soil they help in horizontal movement of the diaspore by twisting movements of the awn and thus helps the second phase of dispersal. On reaching favorable microsites, hygroscopic movements burrow the diaspore into the soil and antrorsley directed backward beard hair prevent their back ejection. Still more complex diaspores were seen in the *Dichanthium annulatum*(Forssk.) Stapf.,*D. caricosum* (L.) A. Camus and *Bothriochloa pertusa* (L.) A. Camus. These species showed disarticulation of the rachis into parts each of which consisted not only of a fertile spikelet (which contains the caryopsis) and the sterile spikelet but also the subtending rachis segment. The fertile spikelet bore a geniculate and hygroscopically active awn which helps in dispersal and establishment. Entanglement of individual diaspore into cluster was seen in *Heteropogon contortus* (L.) P. Beauv ex Roem & Schult. Diaspore in *Cenchrus ciliaris* L. and *Cenchrus setigerus* vahl were found to be Multi-Seeded Units (MSU) comprising 2-3 fertile spikelets surrounded by rough and tough involucral bristles that account for the common name 'sandburs' for these species. In *Panicum capillare* L. the entire peduncle bearing numerous fertile spikelets (with caryopses), was found to comprise a single dispersal unit. Such grass species belongs to the group of tumble weeds which scatter individual spikelets (enclosing the caryopses) as they roll about.

Conclusion

Our studies have revealed that grass 'seed' collected at maturity represents the unit of dispersal (the diaspore) rather than simply a unit of propagation the caryopsis which is contained within and formed by an inseparable fusion of pericarp with the ovary wall. Variations in morpho-functional organization of diaspore in various grass species results from number and nature of additional bracts that persist in the diaspore and enclose the caryopsis. In some of the most important fodder species like *Hordeum* spp., *Avena* spp. etc. the persisting bracts are inseparably fused with the caryopsis. Dehusking before storage and transport with the purpose of reducing the bulk of the 'seed' should be carefully performed to avoid damage to the caryopsis and loss of germinability affecting adversely the success of programmes of facilitated propagation for fodder production.

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