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EFFECTS OF SEED DISPERSAL UNIT AND THE POSITION OF SEED RELATIVE TO SUBSTRATE ON GERMINATION OF THREE COMPOSITES

ABDUL WAJID AND S. SHAHID SHAUKAT

Department of Botany,
University of Karachi, Karachi-75270, Pakistan.

Abstract

Diaspore morphology has long been assigned a role for dispersal by various mechanisms. An experiment was designed to investigate the effect of dispersal unit and the position of seed relative to substrate on germination of three composites (*Iphonia grantioides, Tridax procumbens and Sonchus arvensis*). Seed morphology of the three species was studied and pappus appeared to influence the overall germination percentage. Diaspore having attached pappus and lying horizontally on the surface of the soil showed maximum germination compared to other positions. Diaspore having detached pappus and lying horizontally on the soil surface showed lower germination percentage than the seed with attached pappus. The angle of contact with soil is also important besides pappus which presumably regulates water absorption by seed and consequently the rate and overall germination percentage.

Introduction

Dispersal is a mechanism of transporting the seed from parent plant to a new site that might be suitable for germination. Plants exhibit a number of strategies for seed dispersal. Among them, the shape of seeds plays a vital role in dispersal. The seeds of Asteraceae have pappus which play an important role in this phenomenon (Sheldon & Burrows, 1973). Dispersing seeds land in different ways because of heterogeneous environment and slight difference in shape may result in different positions of seeds on soil surface (Harper *et al.*, 1970). Moreover, dispersal, dormancy and the ability to germinate depend upon the entire dispersal unit (Harper *et al.*, 1971; Harper, 1977). Harper *et al.*, (1965) concluded that seeds of different species differ in their requirements for conditions suitable for germination. The varied micro-environments provided on soil surface act selectively to determine a number of "safe" germination sites.

Diaspore morphology has been interpreted in past for dispersal by wind or passively by animals (Pijl, 1972). However, experimental work by various workers (Harper *et al.*, 1965; Sheldon, 1974) has shown that seed is not only adapted for dispersal but also for placing the seed in a suitable position to ensure maximum water uptake for germination and to locate specific sites on the soil surface for successful establishment of the seedlings (Harper *et al.*, 1970). Peart (1981) demonstrated that the orientation and position of the diaspore on the surface of the soil influences germination. The awned diaspore resulted in significantly higher germination percentage of *Microlaena stipoides* compared to deawned diaspore (Peart, 1981). Besides, the standing position was helpful in increasing germination in *M. stipoides* while horizontal position did not yield better results.

The aim of this investigation was to study the effect of position of seeds in relation to substrate and to evaluate the significance of pappus of Asteraceae seeds in the germination process.

Materials and Methods

Iphonia grantioides (Boiss.) A. Anderb., Tridax procumbens L., and *Sonchus arvensis* f. glabrescens (Guenth., Grab. & Wimm.) Kirp. were selected for the present study.

Iphonia grantioides grows on rocky soil while *Tridax procumbens* and *Sonchus arvensis* grow in moist habitats often as weeds. The seeds of *I. grantioides* and *T. procumbens* were collected from Karachi University Campus during September - October, 1987 while that of *S. arvensis* were collected from Gadap fields in March, 1987. Seeds were stored in plastic bags at room temperature for about 1 month (*I. grantioides* and *T. procumbens*) or nearly 7 months (*S. arvensis*). Observations were made on the external morphology of the seeds.

The study was designed to investigate effect of pappus and the type of landing position of the seed in relation to substrate on germination. The seeds were placed on or in sterilized loamy sand contained in 14 cm diameter earthen pots moistened with distilled water.

The following treatments were examined:

i) Diaspore horizontal with attached pappus and placed on the soil surface (normal-landing).
ii) Diaspore horizontal with detached pappus and placed on the soil surface.
iii) Diaspore horizontal with attached pappus and sown at a depth of 5 mm.
iv) Diaspore horizontal with detached pappus and half buried in soil.
v) Diaspore vertical with pappus uppermost and half buried in soil.
vi) Diaspore vertical with detached pappus uppermost and half buried in soil.
vii) Diaspore vertical with attached pappus being lowermost and half buried in soil.
viii) Diaspore vertical with detached pappus being lowermost and half buried in soil.
ix) Diaspore vertical with attached pappus lowermost and placed on the soil surface (fortuitous landing).

The experiment was conducted in laboratory using a completely randomized design. The temperature ranged from 26°C to 28°C and light intensity at the top of pots was 3000 Lux.

Each treatment was replicated 3 times. There were 20 seeds in each replicate. Germination was recorded regularly upto a period of 15 days. Germination was taken to be the emergence of radicle. The factorial analysis of variance (FANOVA) was performed on arcsine transformed data (Bartlett, 1947) of % germination. Statistical procedures employed are those described in Orloci & Kenkel (1985).

Results

EXTERNAL SEED MORPHOLOGY

i) Iphonia grantioides: The narrowly oblong achene-proper was 2.6±0.2 mm in length and the length of pappus 6.4±.1 mm. (Fig.1a). Pappus hairs projecting outwards are rigid, filiform to the base and bear small bristles. Achenes have 10 ribs of sclerenchymatic cells interspaced with thin layers of parenchymatous cells.

ii) Tridax procumbens: The length of achene-proper was 2.5-2.7 mm and the length of the pappus about 5 mm (Fig.1b). Achene is brown in colour, turbinate or oblong, silky, and densely pilose. Pappus is composed of several plumose setae (feather-like). As the

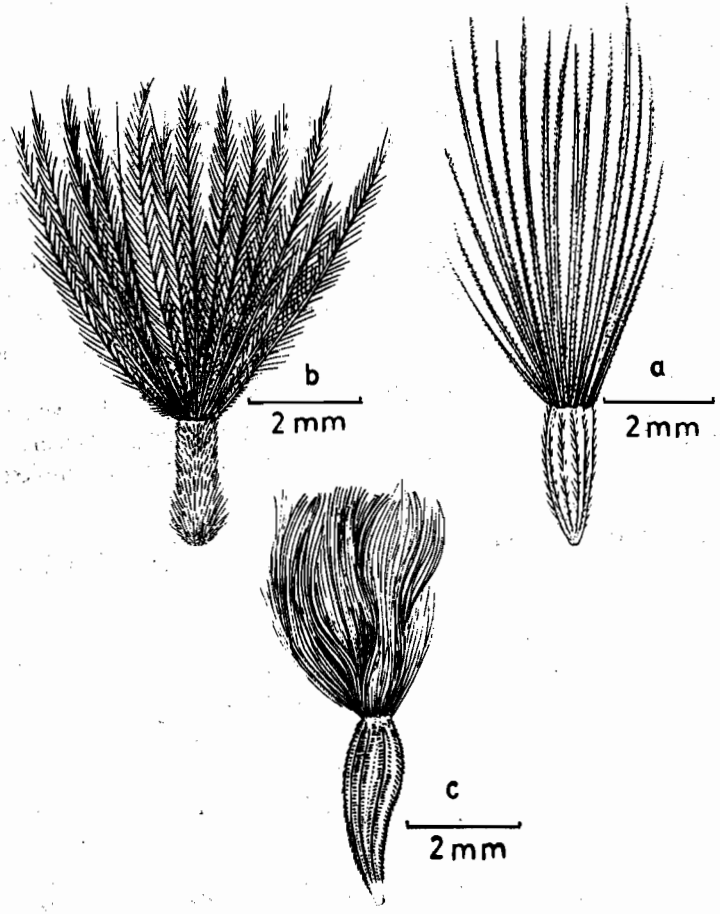

Fig.1. The diaspore morphology of a)*Iphonia grantioides*, b) *Tridax procumbens* and c) *Sonchus arvensis*.

pappus in expanded form is voluminous, it helps the seed to remain floating for a longer period. The pappus surface of *Tridax procumbens* bears longer bristles than those of *Iphonia grantioides*.

iii) Sonchus arvensis: Achenes are 2.5-3.5 mm, ellipsoid, each face is 4-5 ribbed, rugose and dark brown. The pappus is 10-12 mm in length. Achene-proper are narrow, sub-compressed with thick regular ribs on each face. The pappus hairs are in two rows and consist of fine bristles and finer capillacious hairs (Fig.1c).

GERMINATION

Initial germination varied with the position of seeds and was essentially completed by 13th day. Generally, the percentage germination in all the positions was low except for horizontally lying position with attached pappus on the soil surfce. Table 1 gives the results of FANOVA. The species, positions and days all showed highly significant

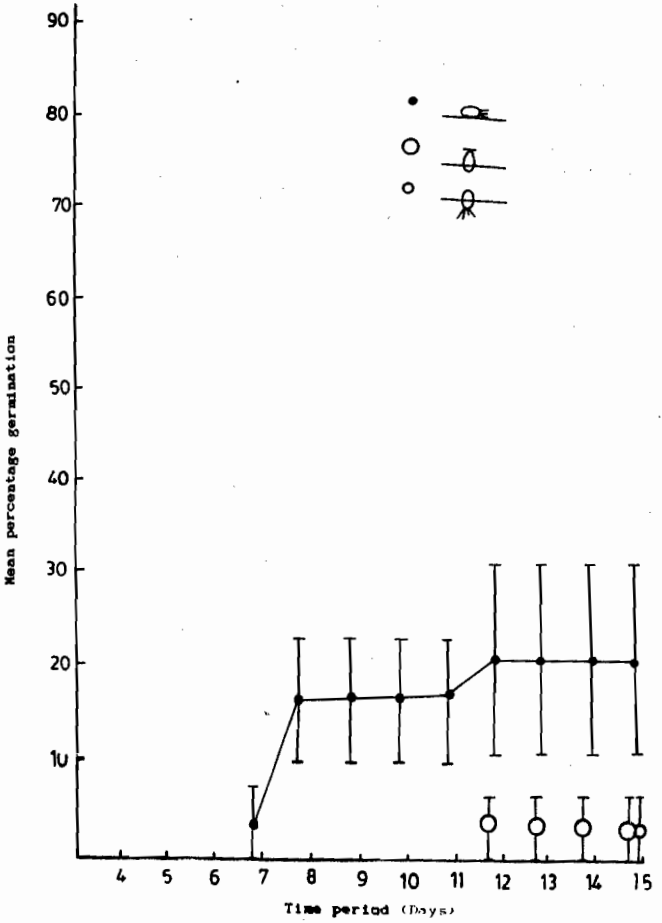

Fig.2. The progress of germination of *Iphonia grantioides* when diaspore was variously placed in or on the soil. Wherever standard errors are very small, they are not shown.

differences in percentage germination ($P < 0.001$ for each factor). The interactions of factors were also significant ($P < 0.001$).

i) Iphonia grantioides: The germination started on 7th day of imbibition in case of horizontally lying diaspore having attached pappus and showed the highest germination compared to all other positions with pappus attached or not (Fig.2). It was also clear that *I. grantioides* required exposure and gave maximum germination on the soil surface. The diaspore with attached pappus and horizontally placed on soil surface showed the highest mean germination. Contrary to this, the diaspore having detached pappus and horizontally placed over the substrate showed no germination. Seeds in other positions did not germinate.

ii) Tridax procumbens: On an overall basis, the percentage of germination was highest in this species (Fig.3). The diaspore having attached pappus and horizontally placed started

Table 1. FANOVA table for the germination percentage. Where A, B and C represent species, positions and days while AB, AC, BC and ABC represent interactions. Arcsine transformed data of percentage germination was used.

Sources of variation Treatment	Sum of squares	D.F.	Mean square	F
A	24040.164	2	12020.082	289.657***
B	106076.485	8	13259.561	319.526***
C	33196.763	14	2371.197	57.141***
AB	59108.061	16	3694.254	89.023***
AC	15775.352	28	563.405	13.577***
BC	39087.399	112	348.995	8.410***
Error	30723.530	224	137.159	3.305***
Total	341620.820	1214	---	---

*** P <0.001

germinating on 4th day of imbibition whereas in case of detached pappus condition, there was no germination. The former position showed the maximum germination compared to any other landing position. The standing diaspore with detached pappus uppermost and half buried in the soil showed less germination compared to the seeds with attached pappus in the same position. In the latter, germination started earlier i.e., on 4th day while in the former case germination started on 9th day of imbibition. The seeds which were buried in soil showed a low percentage germination.

iii) Sonchus arvensis: The time of initial germination varied with the position (Fig.4). The horizontally lying diaspore with pappus on surface of the soil started germinating on 6th day of imhibition. It also showed the highest mean percentage germination compared to other positions. The horizontally lying diaspore having no pappus on the surface of soil commenced germination on 9th day of imbibition. All other positions started germinating usually between 10th-13th day of imbibition, indicating disadvantage of position with respect to diaspore lying on the soil surface. Half buried standing diaspore, pappus lowermost showed a high percentage germination after horizontally lying diaspore with pappus on surface of soil.

Discussion

The results demonstrate that position of achene when it lands on the soil surface or the position on or in the soil is very important in the process of germination. When the diaspore makes a full contact with the soil, the rate and the final percentage of germination is enhanced. It was long believed that adaptations in morphology help to disperse the diaspore but various experiments conducted by Harper *et al.*, (1970), Sheldon (1974) and Peart (1979, 1981) have shown that adaptations such as pappus in case of Asteraceae, awns in case of Poaceae are helpful in germination. The best position in the three species studied was diaspore horizontally lying on soil surface with attached pappus. All other

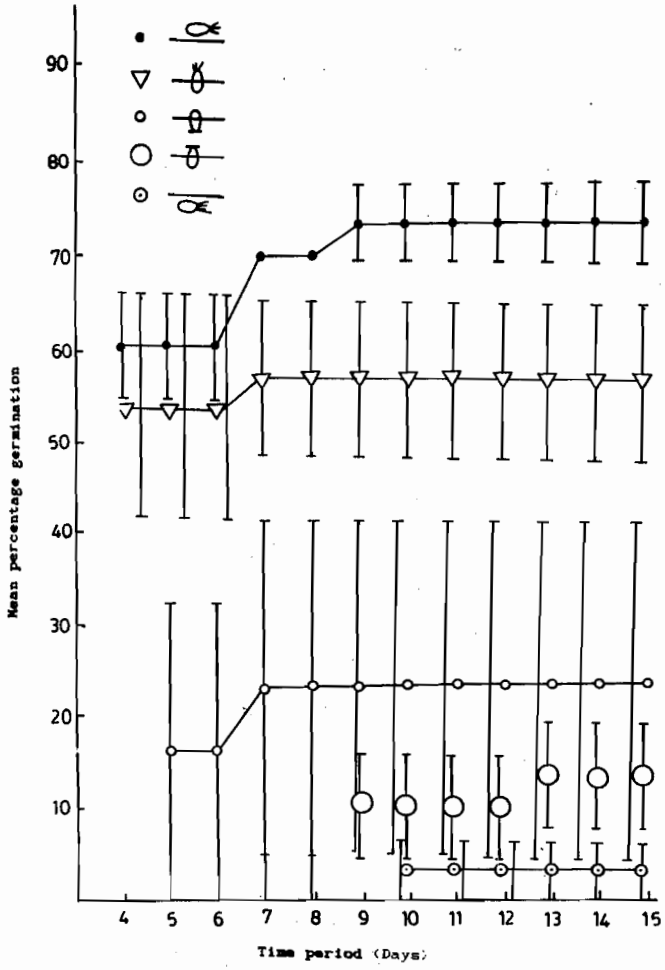

Fig.3. The progress of germination of *Tridax procumbens* when diaspore was variously placed in or on the soil. Wherever standard errors are very small, they are not shown.

positions showed lower germination percentage. In case of detached pappus, however, the seeds were fully in contact with the soil but decreased percentage germination resulted. The rigid pappus of some species (e.g., *Leontodon*), serves to maintain a constant angle between the soil surface and the diaspore and a similar effect is produced in some grasses such as awns of *Aristida* species (c.f. Peart, 1979).

Diaspore of *I. grantioides* have rigid almost straight hairs projecting outwards due to which the contact with substrate is incomplete in the normal landing position. On the other hand, the pappus of *S. arvensis* are more dense, soft, fine with long hairs which presumably are more effective in the absorption of water when in contact with moist soil compared to the pappus of *I. grantioides*.

Seeds vertically placed on soil surface with the pappus facing downwards (a type of landing sometimes seen in the field) either resulted in no germination (*I. grantioides* and

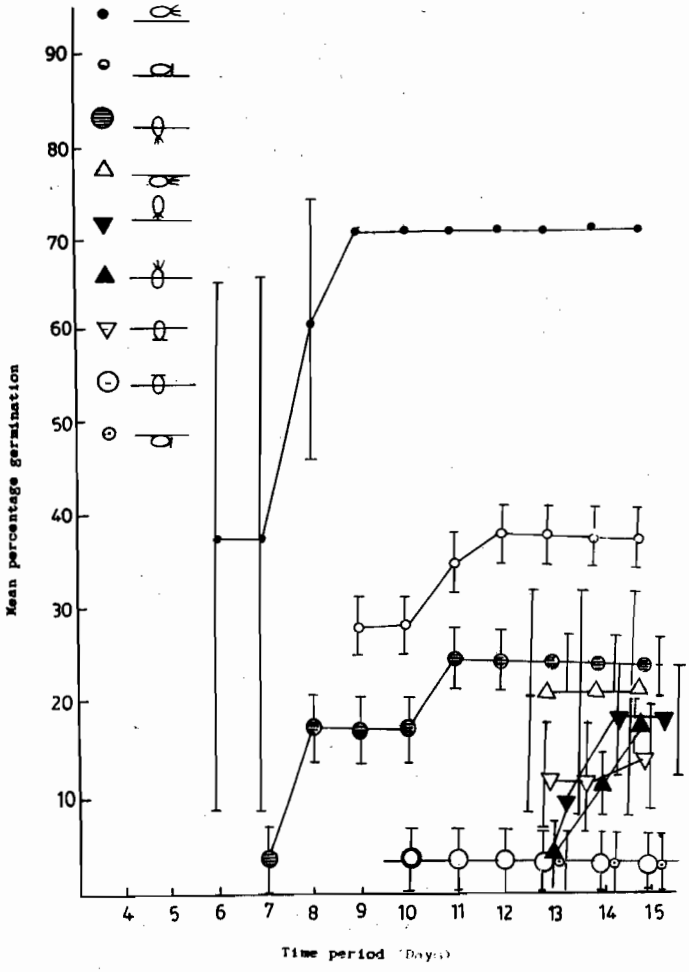

Fig.4. The progress of germination of *Sonchus arvensis* when diaspore was variously placed in or on the soil. Wherever standard errors are very small, they are not shown.

T. procumbens) or low germination percentage (*S. arvensis*). Evidently, the degree of contact that achene proper makes with the soil surface, which consequently determines the rate of hydration, is of considerable importance. The level of hydration enough to germinate a seed is achieved when water uptake across the seed-substrate interface exceeds the water loss across seed atmosphere interface. The more a seed is in contact with the water supplying substrate and lesser the seed atmosphere contact the greater will be the net hydration (Harper & Benton, 1966). This is attained readily in case of normal landing but not so in fortuitous landing.

The seeds which were buried in the soil showed no germination or low germination presumably due to the absence of exposure to light. The seeds of all three species seem to require light for their germination. Though the mechanism of photoregulation of

germination of the Compositae seeds is not known, the adaptive significance of light requirement is obvious. While *T. procumbens* and *S. arvensis* are weeds, *I. grantioides* occurs in open communities with scanty vegetation. The frequent emergence of the seedlings of these species in open habitats particularly after disturbance suggests their requirement for light. Failure of certain weeds like *Plantago* spp., to establish in closed grasslands has been ascribed to the inability of their light requiring seeds to germinate under the herbage canopy (Sagar & Harper, 1960). Furthermore, induced dormancy of many common weeds is broken by light when the seeds are exposed as a result of disturbance such as ploughing (Wesson & Wareing, 1969a,b).

Seed burial is known to impose dormancy (Harper *et al.*, 1970; Harper, 1977). The mechanism of this dormancy is regulated through a multitude of factors (Mayer & Poljakoff-Mayber, 1975). The induced dormancy ensures that seeds do not germinate if the chances are that the seedling emergence will be restricted owing to soil/vegetation barier which would lead to decreased probability of seedling survival. Moreover, the viable seeds contributing to the seed bank in soil may give rise to a flush of seedlings when exposed and subjected to a safe site (Harper *et al.*, 1965). In case of weeds or pioneer species, such as the ones under study, large seed banks are necessary for the persistence of the populations (Kellman, 1974; Roberts & Ricketts, 1979).

Diaspore morphology plays a significant role for a variety of functions such as dispesal, location of microsites on the soil surface, orientation for germination, etc. The work reported here suggests that the position of seeds in or on the soil surface, degree of contact with the soil surface and the presence of pappus play a significant role in germination. Presumably these primarily determine the fulfillment of light requirement and the rate of hydration of achenes.

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