Watsonia, **15**, 265–267 (1985)

The significance of multigerm seedballs in the genus *Beta*

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ABSTRACT

The presence of multigerm seedballs in the genus *Beta* (Chenopodiaceae) is noted. The distribution of such a multigerm seedball could effectively overcome problems caused by long-distance dispersal and subsequent isolation of such obligately outbreeding species. This hypothesis was tested by assessing the extent of intra-seedball hybridization and successful seed production, which demonstrated that such seedball progenies are interfertile and so can colonize new areas in isolation from the parent populations.

INTRODUCTION

The occurrence of a glomerule containing several seeds is comparatively rare within the angiosperms. Such multigerm seedballs are found in the family Chenopodiaceae in the genera *Spinacia* L. and *Beta* L. Multigermicity within *Spinacia* has been examined previously (Astley & Ford-Lloyd 1981) and it was concluded that this character permits the survival of these dioecious plants following the colonization of new areas occurring outside the pollen range of the parent populations.

In the genus *Beta* a range of breeding behaviour exists encompassing self-fertility and self-incompatibility. The incompatibility system is genetically controlled by a complex gametophytic system governed by at least four loci, each with a number of alleles, and is further influenced by modifying genes (Larsen 1977). A diversity of life-cycles also exists including strict annuals and short-term perennials. The association between life cycle and breeding behaviour will be examined in a future publication.

The wild xenogamous members of *Beta* section *Beta* have a wide and largely littoral distribution. It is known that a large proportion of mature seeds produced by the end of the flowering season are shed in the immediate vicinity of the maternal plant. Eventually individuals establish in the surrounding area and become incorporated into the larger parent population. Some of the seed, however, instead of establishing locally may be dispersed over greater distances.

The major agent of long distance dispersal of the multigerm seedballs is believed to be tidal movements of the sea. Darwin reported in 1855 (cited in Barrett 1977) estimated potential dispersal distances of over several hundred miles and other observations indicated that seed immersed in cold salt water for periods of 30 days still had good levels of germination.

The successful colonization of areas within the Mediterranean region by the self-fertile plants of section *Beta* can be readily understood. Baker (1955) and Stebbins (1957) have both presented a large amount of data supporting the correlation between long-distance dispersal, colonization of isolated areas and self-fertilization in various species of plants.

The *Beta* populations found on shores around the North Sea, including those of the British Isles, and some found around the Mediterranean are largely self-incompatible. Such a breeding system would normally present problems after long distance dispersal and subsequent establishment because an obligately outcrossing individual relies on foreign pollen to effect fertilization. However,

it is postulated that the dispersal of a multigerm seedball, as found in the section *Beta*, would effectively overcome this problem. Such a solution would result in the simultaneous establishment of cross-compatible individuals in very close proximity, basically resulting in a small 'founder' population of two to several plants.

Baker (1965) mentioned the case of self-incompatible *Raphanus* species in which the whole fruit is distributed, stating that several seedlings germinate together but that these do not compete with each other so destructively that only one plant attains maturity. He observed that four or five plants could successfully reach maturity, setting reduced numbers of seed. Astley & Ford-Lloyd (1981) found potentially inter-fertile male and female plants arising from the same seedball in the wild, dioecious species of *Spinacia*. While they found competition between individuals from the same seedball, in no case did the competition prevent the plants attaining maturity and setting seed. The present study examines individuals from within the multigerm seedballs (termed seedball population) of *Beta vulgaris* L. and their ability or otherwise to effect cross- and self-pollination.

MATERIALS AND METHODS

The material used in this study, listed in Table 1, was chosen for availability, known outcrossing behaviour and to represent as wide a range of material within *Beta vulgaris* as possible.

Three seedballs per accession were used. The seeds were grown in standard plastic plant pots using John Innes No. 1 compost. The plants were given a vernalization treatment of 6°C with a 16-hour day for seven weeks. The plants were grown 'in situ': plants emerging from individual seedballs were allowed to grow and compete throughout their life cycle. The numbers emerging, establishing and reaching flowering were noted. At the onset of flowering, single branches of all individuals were isolated using bags made of polypropylene non-woven material in order to check on the breeding behaviour of the individual plants. The seedball progenies were also isolated to prevent inter-seedball pollination. This allowed free pollen flow between plants within each seedball population. After flowering was completed the pollination bags were removed and the inflorescences allowed to mature. Seed set was assessed and seedball populations classified accordingly.

RESULTS

The results are presented in Table 1. All plants grew well and flowered at approximately the same time. Competition was observed between the plants within the seedball populations. However this was not sufficient to prevent the weaker individuals from reaching maturity and effecting pollination even when they had reduced stature. It was noted that flower number and pollen production was reduced in the weaker individuals.

Of the 60 multigerm seedballs examined seedling numbers ranged from 2 to 5. All plants examined when individually isolated set no seed indicating that they were self-incompatible. Out of the 60 seedball populations examined, 54 set good seed while six did not. All six seedball populations consisted of two individuals only.

As observed by Astley & Ford-Lloyd (1981) in *Spinacia*, there were marked time differences in the opening of flowers within the multigerm flower cluster, with two to four days between successive flowers opening.

DISCUSSION

The hypothesis that the production of a multigerm seedball can overcome potential problems arising after long-distance dispersal and subsequent isolation of self-incompatible individuals appears to be justified. It is confirmed in the present study that different incompatibility specificities are present within seedball populations ensuring cross-compatibility and that this occurs in the large majority of multigerm seedballs.

The multigerm character found within the genus *Beta* section *Beta* allows the species successfully to colonize new areas, as is evident by the occurrence of isolated populations. While the initial

TABLE 1. RESULTS OF SEEDBALL INVESTIGATIONS IN *BETA VULGARIS*

Seed from collection in Department of Plant Biology, Birmingham University.

Subspecies of *Beta vulgaris*	Source	Description	Mean number of seedlings per seedball	Number of seedball populations setting seed (out of 3)
cicla var. *cicla*	Turkey	Primitive cultivar	2.3	3
" " "	Corfu	Primitive cultivar	2.0	2
cicla var. *flavescens*	U.K.	Commercial cultivar	3.7	3
maritima var. *maritima*	Hungary	North Sea coast type	2.7	3
" " "	Berlin Bot. Gdns	North Sea coast type	4.0	3
vulgaris	Turkey	Local cultivar	2.3	2
"	Turkey	Local cultivar	3.3	3
"	Turkey	Local cultivar	2.7	2
"	Turkey	Local cultivar	2.3	3
"	Turkey	Primitive landrace	3.0	3
"	Turkey	Local cultivar	2.3	3
"	Turkey	Local cultivar	2.7	3
"	Turkey	Primitive landrace	3.0	3
"	Turkey	Primitive landrace	2.3	2
"	Vavilov Inst.	U.S.S.R., cultivar	2.0	3
"	Vavilov Inst.	China, cultivar	2.3	2
"	Vavilov Inst.	U.S.S.R., cultivar	3.3	2
"	Vavilov Inst.	U.S.S.R., cultivar	3.3	3
"	India	Local cultivar	3.7	3
"	Corfu	Local cultivar	2.3	3

population may have a restricted gene pool, in subsequent years and generations this may be enlarged by contact with other populations.

Finally, as noted by Astley & Ford-Lloyd (1981), the staggered flower-opening within the multigerm clusters at the time of pollination should increase the possibility of fertilization by different pollen parents and so widen the genetic base of the individuals within the founder seedball population.

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(*Accepted July 1984*)