Theor Appl Genet (1988) 75: 807–810

# Buffering effect of B-chromosome system of *Trigonella foenum-graecum* against different soil types

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Received September 3, 1987; Accepted September 29, 1987
Communicated by J. Mac Key

**Summary.** Accessory (B-) chromosomes have been reported in many plants in various regions of the world. Studies on natural populations of certain plants like *Phleum phleoides* revealed that B-chromosomes were present in different frequencies in different habitats indicating a correlation between B-frequency and environmental conditions. The present experiment was performed to determine the response of B-chromosome carrier and non-carrier plants of *Trigonella* to different soil conditions. When the morphological data was subjected to analysis of variance, it was found that the carrier plants exhibited uniformity of characters in the different soil types, while the non-carrier plants exhibited considerable variability. The conclusion that can be drawn from this experiment is that B-chromosomes act as a buffering agent, neutralising the variability effect of different soil types.

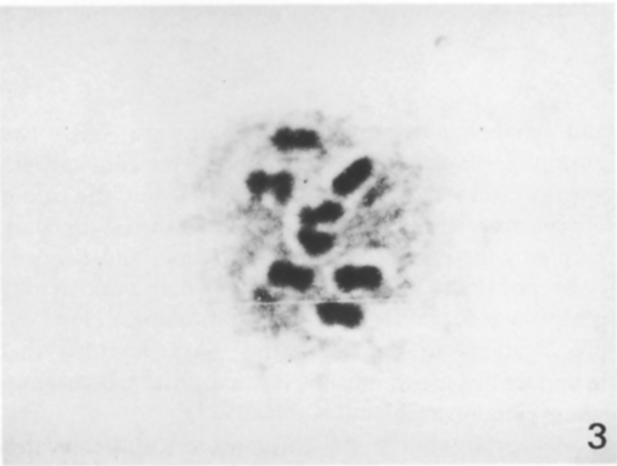
**Key words:** *Trigonella foenum-graecum* – B-chromosomes – Carriers and non-carriers – Edaphic factors – Buffering agent

## Introduction

B-chromosomes are present in the cells of carrier plant species and are distinguishable by being dispensable and non-homologous with the chromosomes of the normal complement. They were first reported by Stevens in 1908 in the animal species *Diabotrica soror.* In plants, B-chromosomes were first recognised in maize by Longley (1927). There has been much controversy regarding the nature and activity of B-chromosomes. Earlier, they were considered to be nuclear parasites, but recent research has proven that these extra chromosomes have distinct genetic exophenotypic and endophenotypic effects. There are only two examples of exophenotypic effects viz. *Haplopappus gracilis* (Jackson and Newmark 1960) where the colour of achenes is changed from brownish-red to dark purple by the presence of B-chromosomes and *Plantago coronopus* (Paliwal and Hyde 1959), where male sterility genes were located on the B-chromosomes. However, investigations in our laboratory have revealed that male sterility genes are not located on the B-chromosomes (Raghuvanshi and Kumar 1983).

A higher number of B-chromosomes almost invariably has an adverse effect on fertility and vigour. Muntzing (1963) found that rye plants with four or more B-chromosomes were virtually sterile. The endophenotypic effects include a lowering of chiasma frequency as in *Lolium perenne* (Jones and Rees 1967), *Trigonella foenum-graecum* (Pant and Raghuvanshi 1980), or an increase in chiasma-frequency as in *Festuca mairei* (Malik and Tripathi 1970) and *Impatiens balsamina* (Raghuvanshi and Mahajan 1982). Relationships between certain ecological conditions and B-chromosome occurrences have been reported in *Centaurea scabiosa* (Frost 1958), *Clarkia elegans* (Lewis 1951), *Festuca pratensis* (Bosemark 1956) and *Lilium aulatum* (Ogihara 1962).

This paper presents the results of an investigation of carrier and non-carrier plants of *Trigonella foenum-graecum* grown on different soil types. *Trigonella foenum-graecum* is a winter annual, economically important for its seeds and leaves. Two types of cells are present in carrier plants, one with $2n = 16$ and the other with $2n = 16 + 2B$. Whenever present in a cell, B-chromosomes are always two in number. In pollen mother cells they regularly pair to form a bivalent that undergoes normal orientation on a spindle equator followed by anaphasic separation. Subsequent behaviour of the



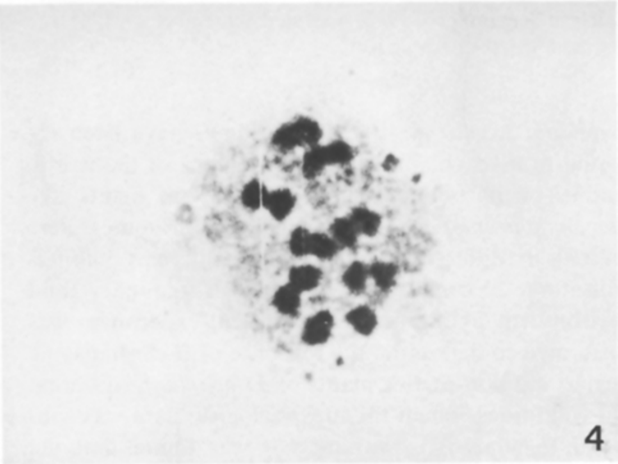


**Fig. 1.** *Trigonella foenum-graecum* grown on sand and normal soil types

**Fig. 2.** *Trigonella foenum-graecum* grown on organic and usar soil types

**Fig. 3.** Metaphase 1 of noncarrier PMC showing 8 bivalents (2x = 16)

**Fig. 4.** Metaphase 1 of carrier PMC showing 9 bivalents (2x = 16 + 2B)

B-chromosomes is normal and they are transmitted through both male and female gametes.

## Materials and methods

Seeds of *Trigonella foenum-graecum* were sown in four different soil types: usar, organic, sand and control. Usar was collected from Sitapur road, sand was taken from the banks of the river Gomti, organic was pure cattle dung (biological fertilizer) and ordinary field soil not fed with fertilizer was used as a control. The seeds did not germinate in pure usar soil; so a mixture of usar and garden soil in the ratios 1 : 1, 1 : 4, 1 : 8, 1 : 12 and 1 : 16 were tried for germination. The seeds germinated in the 1 : 16 usar soil mixture and this proportion was used for the experiment. Fifteen centimeter earthen pots were used. Ten seeds were sown per pot in 3 replicates of 20 pots each. The replicates of the different soil types were kept under similar environmental conditions. Buds of appropriate size from 20–25 randomly selected plants of each replicate were fixed in 1 : 3 acetic alcohol containing iron for 24 h. Ten plants from each replicate and a total of thirty plants per soil type were investigated. Anther smears in acetocarmine were prepared and 20 metaphases of each plant were studied for chromosome number and configuration. All morphological parameters were studied at maturity. Both cytological and morphological data were statistically analysed.

## Results

The number of A-chromosomes in *Trigonella* is $n = 8$. Some plants had two types of pollen mother cells, one with eight bivalents and the other with nine bivalents. The extra bivalent was formed by B-chromosomes and behaved normally like the A-chromosomes.

At metaphase I, the chiasma frequency/chromosome of the non-carrier plants grown on organic, usar, sand and control ranged between 0.892 and 0.681, 0.822 and 0.682, 0.872 and 0.656, and 0.851 and 0.647, respectively (Figs. 1 and 2). The chiasmafrequency per chromosome of the carrier plants of organic, usar, sand and control ranged between 0.809 and 0.033, 0.769 and 0.661, 0.823 und 0.704, and 0.792 and 0.686, respectively. A lower chiasma frequency was observed in the carrier plants when compared with the non-carriers in all soil types. The largest difference in chiasma frequency/chromosome between carriers and non-carriers was observed in the control followed by organic, usar and sand (Figs. 3 and 4).

All the morphological parameters viz. height, no. of branches, no. of nodes, internodal distances, stem perimeter and fruit–flower ratio were studied and statistically analysed. A general depression was observed in the AM ± SE values of the morphological characters of the carrier plants.

The morphological parameters were subjected to analysis of variance in order to find the effect of different soil types on the morphology of non-carrier and carrier plants. All M.S. values except for the number of flowers/plant were found to be significant, for non-carriers, indicating the impact of soil type as more relevant for non-carriers than for carriers. On the other hand, M.S.S. values for the carriers were non-significant except for height after 1 month, leading to the conclusion that different soil types had almost no effect on the morphology of the carriers. Variability within the carriers growing on different soil types was insignificant (Table 1).

## Discussion

The number and cytological behaviour of B-chromosomes of *Trigonella foenum-graecum* is well established. They have a definite lowering effect on the chiasma-frequency of the carrier plants in comparison to the non-carriers (Pant and Raghuvanshi 1980).

The fact that needs to be emphasized is the comparative response of carrier and non-carrier plants to different soil treatments. While analysing *Phleum* and *Festuca* populations, Bosemark (1956, 1957) found a correlation between carrier frequency and the nature of soil. In *Phleum* the B-chromosomes were more frequent in soils low in organic matter, while in *Festuca* there was a positive correlation between B-frequency and clay content of the soil.

There have been various reports of the ecological response of B-chromosomes. Frost (1958) analysed natural populations of *Centaurea scabiosa* in Scandinavia, Finland, parts of England, France, Germany, Austria and Yugoslavia and revealed that the accessories were present in all investigated areas but in dif-

**Table 1.** Significance values after analysis of variance of various morphological characters and chiasma frequency of Trigonella plants with $2n=16$ vs. $2n=16+2B$ when grown in different soil types

| | Height after one month | Height at maturity | Branches | Nodes on main shoot | Nodes on lateral branch | Inter-nodal length | Stem perimeter | Fruits/plant | Flowers/plant | Pod length | Seeds pod | Chiasma frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | | | | | | | | | | | | |
| B-Non carrier | 1.37 | 4.47 | 4.68 | 3.61 | 0.84 | 1.9235 | 8.6678 | 1.84848 | 1.02 | 0.9230 | 0.91 | 2.458365 |
| B-Carrier | 0.576 | 0.70 | 0.0234 | 0.83 | 0.40 | 0.345020 | 0.005645 | 0.135684 | 0.59 | 0.21 | 0.388 | 0.883463 |
| Treatment | | | | | | | | | | | | |
| B-Non carrier | 47.38* | 27.60* | 34.16* | 5.09* | 7.07* | 174.05* | 97.2727* | 6.06075* | 4.46* | 13.7969* | 15.33* | 0.162867 |
| B-Carrier | 5.55* | 4.56 | 1.567 | 0.60 | 1.44 | 3.778 | 1.758088 | 1.4339 | 1.99 | 1.7 | 2.73 | 1.07316 |

* Significant at 0.05 probability

ferent frequencies. Plants with and without B-chromosomes have different selective values under different environmental conditions. B-chromosomes of *Secale cereale* (Muntzing 1957) had a positive selective value in Korea, in contrast to the accessories of highly bred European varieties. B-chromosomes were found to impart greater selective value, advantage or adaptability to the carriers when the plants of *Trigonella foenum-graecum* (Pant and Raghuvanshi 1980) and *Plantago* (Raghuvanshi and Kumar 1983) were subjected to density stress conditions. Bosemark (1967) discussed the selctive value of accessory chromosomes and suggested that in certain genotypes they may exercise a compensatory influence on quantitatively varying characters, thereby improving phenotypic balance. The results of the present experiment indicate that the different soil types had a significant effect on the non-carriers: the non-carriers taken from different soil types were widely different in their morphology. The carriers, however, were found to be indifferent to edaphic changes and exhibited uniformity of characters in the different soil types. The B-chromosomes regarded earlier as optional extras or nuclear parasites played an important role, acting as buffering agents and imparting uniformity to the morphological characters of the carriers grown on different soil types.

Grun (1959) considered each population as a balanced environmental genetic system. According to him B-chromosome genes are beneficial only when they occur with specific A-chromosome genotypes and under specific environmental conditions. This interpretation may apply to *Festuca pratensis* (Bosemark 1956, 1957) and *Centaurea scabiosa* (Frost 1954, 1958a, b), where B-chromosomes have demonstrated a stimulatory effect on growth rate of plants having certain genotypes and where there is a relationship between environmental conditions and B-chromosome distribution. Darlington proposed in 1956 that B-chromosomes increase the variability and, in the long run, the adaptability of the species. It has been demonstrated by Moss (1956) that accessory chromosomes in rye increase the phenotypic variability in certain characters. He concluded that the adaptive significance of accessory chromosomes in rye might depend on their ability to increase variability due to outbreeding. In certain genotypes they may exercise a compensatory influence on quantitatively varying characters and improve phenotypic balance (Bosemark 1967).

*Acknowledgement.* Financial assistance from the Department of Science and Technology is duly acknowledged.

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