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Short Communication

Allelic relationship between spontaneous and induced mutant genes for stem fasciation in chickpea

S. Srinivasan[1], P. M. Gaur[1,2] and B. V. Rao[1]

[1]International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India; [2]Corresponding author, E-mail: p.gaur@cgiar.org

With 2 tables

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Abstract

Stem fasciation is a morphological abnormality observed in plants where the stem is widened and leaves and flowers or pods are clustered at the apex. Several spontaneous mutants and one induced mutant for stem fasciation are found in chickpea (*Cicer arietinum* L.). This study was aimed at determining allelic relationship between spontaneous and induced mutant genes controlling stem fasciation and effects of stem fasciation on grain yield. Two spontaneous (ICC 2042 and ICC 5645) and one induced (JGM 2) stem fasciation mutants were crossed in all combinations, excluding reciprocals. The F_1 and F_2 plants from a cross between the two spontaneous mutants had fasciated stem. This indicated the presence of a common gene (designated *fas1*) for stem fasciation in the two spontaneous mutants. The F_1s of the crosses of the induced mutant JGM 2 with both spontaneous mutants had normal plants and segregated in a ratio of 9 normal : 7 fasciated plants in F_2. Thus, the gene for stem fasciation in the induced mutant JGM 2 (designated *fas2*) is not allelic to the common gene for stem fasciation in spontaneous mutants. The two genes in dominant condition produced normal non-fasciated stem. The fasciated and the non-fasciated F_2 plants did not differ significantly for number of pods per plant, number of seeds per plant, grain yield per plant and seed size, suggesting that it is possible to exploit the fasciated trait in chickpea breeding without compromising on yield.

Key words: *Cicer arietinum* — allelic relationship — fasciation — genetics — induced mutant — spontaneous mutant

Several spontaneous and induced mutants are found in chickpea (*Cicer arietinum* L.). One of such mutants is stem fasciation, which is characterized by widening of the main stem and clustering of flowers and pods at the apex with low level of branching. Fasciation has been reported in more than 100 vascular plant families and especially prevalent in species with an indeterminate growth habit (Jones 1935). The fasciation may affect any specific part of the plant, such as a stem, a branch, an inflorescence or roots. Stem fasciation mutants have been identified in many food legumes, including pea (Darbishire 1911), soybean (Albertsen et al. 1983), pigeonpea (Bhatnagar et al. 1964), mungbean (Singh 1981), lentil (Tyagi and Gupta 1991) and chickpea (Knights 1993). Fasciation trait has been extensively studied in pea and utilized in development of fodder varieties (Scheibe 1965). This study was aimed to study the allelic relationship of genes controlling stem fasciation between spontaneous and induced mutants and relationship of stem fasciation trait with grain yield in chickpea.

Two spontaneous fasciated mutants (ICC 2042 and ICC 5645) and one induced fasciated mutant (JGM 2) were used as parents in the crosses used in this study. Both spontaneous mutants were obtained from GenBank of ICRISAT, while the induced stem fasciation mutant, described by Gaur and Gour (1999) was obtained from Jawaharlal Nehru Agricultural University (Jabalpur, India). JGM 2 is registered with National Bureau of Plant Genetic Resources (New Delhi, India) with INGR number 03061.

These selected mutant lines were crossed in all combinations, excluding reciprocals. The parental lines, F_1s and F_2 populations were grown in an unreplicated block with spacing of 30×10 cm^2 at ICRISAT (Patancheru, India), during post-rainy season 2004/2005. The crop was grown under rainfed conditions following standard agronomic practices and plant protection measures. Observations were recorded on 10 plants taken randomly from each parental line and each F_1 and on all F_2 plants (minimum 175 plants) from each cross that segregated for fasciation trait. The computer program LINKAGE-1 (Suiter et al. 1983) was used to test goodness-of-fit for expected genetic ratios.

The three fasciated mutants differed significantly in days to flowering, days to maturity, plant height, average maximum width of stem fasciation, number of primary branches per plant, number of pods per plant, number of seeds per plant, grain yield per plant and 100-seed mass. ICC 5645 flowered 18–20 days earlier and matured 13–15 days earlier than the other two mutants. The average maximum width of stem fasciation was less in JGM 2 (0.66 cm) than that in ICC 2042 (0.90 cm) and ICC 5645 (0.97 cm). ICC 2042 had lower grain yield because of fewer primary branches per plant, fewer pods and seeds per plant and smaller seed than other two mutants.

The F_1 and F_2 plants from ICC $2042 \times$ ICC 5645 had fasciated stem, indicating that the fasciation gene in these spontaneous mutant lines is the same. The two crosses between induced and spontaneous fasciation mutants (JGM $2 \times$ ICC 2042 and JGM $2 \times$ ICC 5645) had normal F_1s (no fasciation). The F_2 from each of these crosses segregated for normal and fasciated plants in a ratio of 9 : 7 (Table 1), indicating that the recessive gene for stem fasciation in the induced mutant JGM 2 is not allelic to the recessive gene for stem fasciation in spontaneous mutants. Thus, two loci control stem fasciation in these lines. Knights (1993) assigned gene symbol *fas* for the gene controlling fasciation in the spontaneous mutant studied

Table 1: Expression of stem fasciation in F_1 and F_2 of crosses involving different fasciated mutants

Cross	F_1	F_2		Expected F_2 ratio	$\chi2$	P-value
		Normal	Fasciated			
JGM 2 × ICC 2042	Normal	107	68	9 : 7	1.77	0.201
JGM 2 × ICC 5645	Normal	109	69	9 : 7	1.63	0.216
ICC 2042 × ICC5645	Fasciated	0	192	–	–	–

by him. The mutant studied by Knights was not available for allelism test. We propose to designate the spontaneous mutant gene for stem fasciation in ICC 2042 and ICC 5645 as *fas1* and the induced mutant gene for stem fasciation in JGM 2 as *fas2*. The two genes in dominant condition (*Fas1_ Fas2 _*) produce normal plants (no fasciation). Thus, the accessions ICC 2042 and ICC 5645 have the genotype *fas1 fas1 Fas2 Fas2* and the mutant JGM 2 has the genotype *Fas1 Fas1 fas2 fas2*.

Stem fasciation has been reported to be controlled by a recessive gene in pea (Święcicki 2001), pigeonpea (Bhatnagar et al. 1964, Sinha et al. 1976), soybean (Takagi 1929, Albertsen et al. 1983), mungbean (Dwivedi and Singh 1990), urdbean (Mahna et al. 1989), lentil (Tyagi and Gupta 1991), grasspea (Waghmare et al. 2001) and chickpea (Knights 1993, Gaur and Gour 1999) and by a dominant gene in lettuce (Eenink and Garretsen 1980). Lamprecht (1952) identified two different genes (*fa* and *fas*) for stem fasciation in pea and suggested possibility of involvement of additional genes in expression of this trait. Further studies on induced and spontaneous stem fasciation mutants in pea confirmed that two different loci control stem fasciation in this legume (Święcicki and Gawowska 2004).

The expression of fasciation varied considerably from plant to plant and from one branch to another within same plant. Variable expressivity of fasciation because of environmental conditions has been reported earlier in many crops, including pea (Marx and Hagedorn 1962), lettuce (Bowring 1974, Eenink and Garretsen 1980) and *Arabidopsis* (Gisela et al. 1996). The maximum width of fasciated stem appears to vary considerably from one growing condition to another. Gaur and Gour (1999) recorded 4.0 cm maximum width of stem fasciation in JGM 2 at Jabalpur (central India), while in this study conducted at Patancheru (southern India) the maximum width of stem fasciation recorded was 2.5 cm. Thus, stem fasciation can be enhanced by providing favourable growing conditions for expression of this trait. There is a potential for exploiting fasciation trait in developing ornamental cultivars in chickpea (Gaur and Gour 1999).

The effect of stem fasciation trait on seed yield and its components (number of pods per plant, number of seeds per plant and 100-seed mass) was assessed by comparing the mean values of fasciated with non-fasciated F_2 plants in two crosses (JGM 2 × ICC 2042 and JGM 2 × ICC 5645) that segregated for stem fasciation (Table 2). The fasciated and the non-fasciated plants did not differ significantly for any of these traits. However, the fasciated plants had slightly higher values for yield, number of pods per plant and number of seeds per plant in cross JGM 2 × ICC 2042 and slightly lower values in the cross JGM 2 × ICC 5645. The earlier studies on stem fasciation mutants in chickpea have compared stem fasciation mutants with their respective parental lines and found that the fasciated mutants had larger seed but lower yield than their parental lines (Knights 1993, Gaur and Gour 1999). No report is available on comparison of fasciated and non-fasciated plants in a segregating generation. This study suggests the possibility of exploiting fasciation trait in chickpea breeding without compromising on grain yield, provided the trait is transferred to suitable genetic background. The accumulation of pods at the apical region of the plant has some advantages and disadvantages. It can facilitate mechanical harvesting and reduce the production cost (Tyagi and Gupta 1991). However, the concentration of pods on the top canopy of main stem may lead to lodging of plants (Knights 1993) and most probably makes plants more sensitive to drought during shorter flowering period.

Fasciation has been reported to have some yield advantage in soybean (Gottschalk and Wolf 1983), pea (Blixt and Gottschalk 1975) and lentil (Tyagi and Gupta 1991). Two commercial fodder varieties of pea have been developed using spontaneous fasciated mutant (Scheibe 1954, 1965). Some mutants in soybean (Leffel 1994a,b) and pea (Gottschalk 1977, 1979) have also been used in developing promising recombinant lines. Further studies on different cross-combinations and development and evaluation of progeny with improved agronomic traits are needed to assess the utility of stem fasciation trait in chickpea improvement.

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Table 2: Comparison of fasciated and non-fasciated plants in F_2 for grain yield and its components

Cross	Plant type	Mean ± SE for different characters			
		Number of pods per plant	Number of seeds per plant	Grain yield per plant (g)	100-seed weight (g)
JGM 2 × ICC 2042	Normal	49.7 ± 3.7	68.8 ± 5.1	7.4 ± 0.5	11.3 ± 0.5
	Fasciated	52.5 ± 6.6	72.8 ± 9.4	7.9 ± 0.9	11.1 ± 0.4
	t-Probability	0.7	0.7	0.8	0.8
JGM 2 × ICC 5645	Normal	49.0 ± 4.6	73.8 ± 7.2	7.7 ± 0.8	10.5 ± 0.4
	Fasciated	44.7 ± 5.8	65.7 ± 8.0	7.2 ± 1.0	10.1 ± 0.4
	t-Probability	0.6	0.5	0.7	0.6

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