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INDUCED MUTATIONS FOR FASCIATION IN LENTIL (*LENS CULINARIS* MED.)

B. S. TYAGI AND P. K. GUPTA*

Department of Agricultural Botany
Institute of Advanced Studies, Meerut University, Meerut 250005

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ABSTRACT

A mutant with fasciation in the upper part of stem was isolated in lentil (*Lens culinaris*) following combined treatment of gamma rays and EMS (200 Gy + 0.1% EMS). During the later stages of plant growth, due to slight flattening of stem and branches at the shoot apex, the plant appeared like a cluster of closely fused branches. Unlike earlier reported fasciated mutants in lentil, which were sterile [1], these fasciated mutants were fully fertile having normal reproductive organs, and thus are being maintained in homozygous state. Pods per bunch ranged from 2–10 as against 1–3 in the control. The mutants also differed from control in chlorophyll a and b content and other quantitative characters. The segregation data suggested monogenic recessive nature of the mutation.

Key words: *Lens culinaris*, gamma rays, EMS, fasciation.

Stem fasciation is known to occur as a heritable change. Although, spontaneous mutants with fasciation have been reported in the past in soybean [2], *Pisum* [3], pigeonpea [4] and lupin [5], their economic importance was recognised only in recent years, when fasciation was induced in pea using mutagenic treatments [6]. Even though mutants having fasciation in some cases were shown to have no practical value, as in green gram [7], generally they have given increased yield. For instance, a fasciated mutant of soybean isolated in Korea gave very high seed production, and fasciated pea mutants were used for producing a great variety of different useful recombinant types [6, 8–16].

The increase in yield of fasciated plants is often associated with increased number of flowers accumulated in the upper region of the plants, thus producing more seeds. Induced fasciation was observed during a study of induced mutations in lentil, and the mutants thus obtained were analysed for several morphological and agronomic characters, which suggested increased productivity. The results of this study are presented and discussed.

*Addressee for correspondence.

MATERIALS AND METHODS

Dry seeds of uniform size and shape with 10.5% moisture content of two well adapted varieties, L 830 and PL 639, of lentil were subjected to combined treatments of gamma rays and EMS. The seeds of both the varieties were treated with 50 Gy, 100 Gy and 200 Gy doses of gamma rays, after which the seeds were soaked in aqueous solution of EMS in combination such that the lower dose of gamma rays is combined with higher concentration of EMS (50 Gy + 0.3% EMS) and vice versa (200 Gy + 0.1% EMS). Treatment of 100 Gy was combined with 0.2% of EMS. The seeds were washed in running water for 30–35 minutes after each chemical treatment. In every treatment (including controls), 300 seeds were sown in 10 rows, each row with 30 seeds. Plants in a row were kept at 15 cm and the rows were spaced at 25 cm. For raising M_2 generation, M_1 plants were harvested as single plant progenies. Thirty seeds from each plant were sown at 10 cm distance within a row, and the rows were sown at 23 cm. Along with several other mutation types, mutants with stem fasciation were isolated in 200 Gy + 0.1% EMS in cv. L 830.

The chlorophyll a and b were quantitatively estimated with the help of spectrophotometry as suggested by Arnon [17].

RESULTS

Germination and mutation frequencies. A mutation with stem fasciation was isolated in M_2 generation after the combined treatment of gamma rays and EMS (200 Gy + 0.1% EMS) in the variety L 830. Germination of seeds in fasciated mutants was comparable to the control. The mutation freqency was recorded on the basis of M_1 plants (M_2 progenies) and M_2 seedlings (M_2 population). The M_2 population of this treatment, which consisted of 2300 plants in 92 plant progenies, showed segregation in two progenies, each with two fasciated plants, thus showing mutation frequency of 0.174% M_2 plants or 2.17% M_2 families.

Inheritance pattern. When M_2 generation of this treatment was carefully studied, segregation was observed in 2 out of 92 M_2 progenies only. One of them had eight normal and two mutant plants, and the other had seven normal and two mutants ($P_{3:1}$ = 0.70–0.80 and 0.80–0.90, respectively). To confirm the segregation and inheritance pattern in M_3 generation, seed from five normal looking plants from each of the two M_2 progeny rows showing fasciated mutants were sown in M_3 generation. Plants in seven rows were normal, two rows did not germinate and only one row exhibited segregation with five normal and two mutant plants ($P_{3:1}$ = 0.80–0.90).

Plant morphology. Data on plant morphology and quantitative traits were recorded in the fasciated mutant in homozygous condition in later generations. The mutant was grown in four rows along with the parent and data recorded on at least 25 plants. The stem growth and branching during early stages of development were normal. However, during the later stages, slight flattening of the stem and branches was noticed. The height of the mutant plants ranged from 30.5 to 46 cm. At shoot apex, the plant appeared like a cluster of closely fused branches giving a "bunchy top" appearance, carrying many leaves and flower buds around the nodes of the fasciated stem. Reproductive organs were, however, normal. There was an apparent increase in the flower bearing zone, branches per plant, internode length, pods per bunch, grain yield, and 100-seed weight (Table 1). Pods per bunch in the fasciated plants ranged from 2–10, against 1–3 in the parent variety. Harvest index increased with grain yield. Mean 100-seed weight was higher (2.50 g) than that in the control (1.81 g).

Table 1. Quantitative characters of fasciated mutants in variety L 830 (control) of lentil (*Lens culinaris* Med.) in M_3 generation

Character	Fasciated		Control	
	range	mean ± SD	range	mean ± SD
Germination (%)	74 – 86	80.00 ± 4.00	76 – 82	80.00 ± 2.00
Plant height (cm)	30.5 – 46	39.00 ± 2.00	27 – 31.50	29.11 ± 2.25
Flower bearing zone (cm)	20 – 26	23.00 ± 2.42	18 – 21.40	19.20 ± 1.58
Branches per plant	14 – 23	17.40 ± 2.67	4 – 6	5.15 ± 1.31
Internode length (cm)	2.9 – 3.5	3.13 ± 0.19	1.9 – 2.8	2.00 ± 0.13
Days to 50% flowering	110 – 118	115.0 ± 1.72	108 –113	109.00 ± 1.70
Maturity (days)	134 – 144	140.00 ± 2.20	138 – 145	140.00 ± 2.00
Pods/bunch	2 – 10	—	1 – 3	—
Biological yield/plant (g)	11.40 – 18.50	15.11 ± 3.40	9 – 13	11.00 ± 2.38
Grain yield/plant (g)	5 – 9	6.80 ± 1.30	3.2 – 5.5	4.50 ± 0.99
Harvest index (%)	40.30 – 48.00	44.50 ± 2.80	37.4 – 41.5	39.04 ± 3.88
100-seed weight (g)	2.20 – 3.00	2.50 ± 0.20	1.60 – 2.0	1.81 ± 0.21

Chlorophyll Content. The chlorophyll a and b content was estimated for fasciated plants in M_3 generation and were compared with the parent variety (Table 2). Chlorophyll a content was 3.49 mg/100 g of tissue in the mutant and 3.27 mg/100 g of tissue in the control, while chlorophyll b content was much lower in the mutant (1.13 mg) than that in the control (5.73 mg/100 g of tissue). Thus, total chlorophyll content (a+b) in the mutant was approximately half (4.62 mg) that of the control (9.02 mg/100 g of tissue). The ratio of chlorophyll a and b was higher in the mutant plants (3.09 in mutant, 0.57 in control).

Table 2. Chlorophyll content in the fasciated mutants of lentil (*Lens culinaris* Med.)

Plant type	Chlorophyll content, mg/100 tissue			Ratio a/b
	chloro-phyll a	chloro-phyll b	total	
Control	3.27	5.75	9.02	0.57
Fasciated	3.49	1.13	4.62	3.09

DISCUSSION

The fasciation of stem and branches observed in the present study was associated with the formation of a large number of flower buds, particularly in the terminal region of the plants. The segregation data suggest monogenic recessive nature of this mutation. Fasciation is known in a number of crops including pea [6, 10, 12, 13, 16, 18] as a monogenic trait [19, 20], digenic [21], trigenic influenced by several modifiers [22], or monogenic with a series of multiple alleles [23]. Spontaneous mutants for fasciation have been reported in other legumes, such as soybean [2–4], pigeonpea [4], and lupin [5]. These fasciation mutants have been considered economically important for pea in Europe [5] and for soybean in Korea [14]. Fasciated plants of *Vigna radiata* are, however, known to be without any practical value due to the presence of abnormal flowers and increased pollen sterility [7]. In lentil also, the two fasciation mutations ("fasciata-1" and "fasciata-2") reported by Sharma and Sharma [1] were found to be sterile, thus, having no economic value.

Fasciation does not alter the structure and development of an individual flower or fruit. It is the concentrated pod set that is attractive from the standpoint of uniformity in maturity, since the inflorescences are usually borne over a relatively short period of time. The mean height increased from 29 cm (control) to 39 cm in the fasciated plants. The pod bearing zone also increases by about 4 cm, thus increasing the height (by as much as 6 cm) above the point of pod bearing. The concentration of pods at the top offers some promise by fascilitating the harvesting operation. A machine capable of removing only the very top of the plants leaving lower portion of the plants in the field might well reduce production costs. This lower part, incorporated into the soil, would provide valuable organic matter.

Gottschalk and Hussein [6] described pea mutants with increased number of flowers, leading to more pods/plants, associated with synchronous ripening of pods, which results in an increased seed production. The harvest index increased in fasciation mutants with simultaneous increase in grain yield as well as total biological yield. There are reports of negative association between grain yield and 100-seed weight in lentil, therefore, it was considered impossible to improve both the characters simultaneously [25, 26]. In the fasciation mutants, the mean values of both characters increased. Spontaneous fasciated mutants of pea have been used for developing some commercial varieties [27, 28], for instance, Gelin [29] used X-ray induced fasciated pea mutants to develop a variety "Stral Pea". We hope that the fasciation mutants of lentil described here will be utilized in future programmes of lentil improvement.

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