

Seed production potential in birdsfoot trefoil (*Lotus corniculatus* L.)

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Abstract

Lotus corniculatus (birdsfoot trefoil) is a perennial forage legume for pastures and has a high nutritive value. It tolerates infertile, acidic, drought or wet soil conditions. It does not cause bloat even if grazed directly, because of the presence of condensed tannins. It is palatable nutritious, high in protein and very digestible to cattle, sheep and horses. Compared to other pasture species, the forage quality and protein content remains high for longer periods even after the plants start going to seed. However, it suffers from low seed yields and pod shattering has been found to be a major reason for it. During the present study, eighteen populations of *Lotus corniculatus* were collected from mid hill Himalayas and raised at IGFR Regional Research Centre, Palampur. The populations were compared for their potential to set seed. The study revealed that in all populations observed seed set was far less than the expected seed yield. Further, it was found that pod shattering is not the sole reason for low seed set in birdsfoot trefoil. Other factors, such as the indeterminate period of flowering, flower bud abortion, lack of pollination and genetic factors may also contribute towards low seed yield.

Introduction

Lotus corniculatus is a perennial plant though not long lived, that has an extensive root system with strong tap root. Under favorable conditions, it may produce up to 100 stems and reach a height of 2 – 3 ft. The growth form can range from prostrate to erect with numerous stems arising from a well developed crown and branches arising from axils. Leaves are pentafoliate, alternately on short stalks with two leaflets at the petiole base resembling stipules.

It is a tetraploid ($2n = 24$) showing mostly bivalent pairing and tetrasomic inheritance. Flowering is indeterminate continuing for long time. Flowers are borne in an umbel at the end of a short stem. Each umbel consists of five bright yellow flowers. Flowers are bisexual and are largely cross pollinated by bees. Pressure is exerted by bee on the keel causing the staminal filaments to push a quantity of pollen out of tip. The pollen is exerted onto the ventral surface of the bee's thorax and thereby it is carried from one flower to another resulting in pollination.

Lotus corniculatus is a forage legume for pastures having high nutritive value. It does not cause bloat when direct grazed, because of the presence of condensed tannins. It tolerates

infertile, acidic, drought or wet soil conditions. It is palatable, nutritious, high in protein and very digestible to cattle, sheep and horses. Even after the plants start going to seed, forage quality and protein content remain high for much longer than other pasture species. However, it suffers from low seed yields and pod shattering has been identified as a major contributing factor. Lack of sufficient yield has prevented its spread (Anderson, 1955; McGraw and Beuselinck, 1983; Metcalfe *et al.*, 1957). During this present study, 18 populations of *Lotus* were studied for their seed setting potential and to find out the factors responsible for the gap in expected and observed seed yields.

Material and methods

About 25 – 30 plants of eighteen populations of *Lotus corniculatus* were collected from the mid hills of Himalayas and were raised at IGFR Regional research Centre, Palampur. In each population of twenty plants in the field, five plants were marked and data on umbel count, pod count and seed count per plant was collected. Data on umbel count and pod count was obtained in the field itself. When the plants were in full bloom, umbels on five plants in each population were counted and an average obtained. Similarly when plants attained maturity, the total number of pods (shattered as well as non shattered) on five plants in each population was counted and an average obtained. Ten non shattered pods from each population were removed and measured with scale to find out pod size. These pods were opened separately and seed/pod counted.

On each marked plant, ten umbels were marked to find ovule count/ovary and ovule fertility. For ovule fertility, the young buds from five umbels in each population were fixed in fixative (ethyl alcohol and acetic acid in the ratio 3:1) for 24 hrs. Then ovaries were separated and mounted in Lewis stain. The cover-slips were pressed gently and unfertilized ovules were counted. The buds from rest of five umbels fixed after pollination and fertilized ovules were counted.

Pollen fertility and chromosome count of these populations were also worked out using aceto-carmine squash technique.

Results and discussion

During the present study of 18 populations, it was found that the single ovary in each floret contains 20 to 46 ovules and within each population ovule number varied. Ovule fertility varied from 60 to 90% in these populations (Table 1). The pods were formed at right angles at the end of peduncle in the shape of a birdsfoot. Three to five pods were formed at each umbel. The pod size varied from 2.0 to 3.5 cm and each pod contained 14 to 25 seeds (Table 2). The total number of pods harvested from each plant varied from 7 to 307. Of these, 5 to 162 were shattered (Table 3) and rest were intact i.e. 0.84% to 79.5% were shattered and rest were intact (Figure1). The total seed harvested from a single plant varied from 112 to 4935.

Table 1. Ovule count and fertility (%) in various *Lotus* collections.

<i>Collection no.</i>	<i>No. of ovules/ovary*</i>	<i>Ovule fertility (%)</i>
L 125	35.4±2.05	86.40
L 126	37.1±2.32	89.77
L 127	38.9±1.02	67.57
L 128	34.0±1.53	79.11
L 129	37.7±2.00	81.85
L 132	39.4±1.57	75.29
L 133	29.4±2.01	66.45
L 134	36.6±2.13	60.30
L 135	38.3±0.94	85.29
L 136	37.1±2.02	86.39
L 137	37.4±1.91	73.35
L 139	34.9±1.90	64.75
L 141	30.9±1.83	84.06
L 142	35.1±1.93	79.60
L 391	34.3±1.42	86.32
W 1	38.9±0.80	73.69
W 2	39.1±1.08	87.63
W 3	40.0±0.99	90.50

*Mean ± S.E.

Table 2. Average data on pod parameters in various *Lotus* collections.

<i>Collection no.</i>	<i>No. of umbels/Plant*</i>	<i>No. of pods/Umbel*</i>	<i>No. of pods/Plant*</i>	<i>Pod size(cm)*</i>	<i>Seeds/pod*</i>	<i>Seeds/plant*</i>
L 125	41±2.91	4±0.2	94±4.1	2.5±0.2	20.0±1.7	1257±91.8
L 126	52±2.98	4±0.3	119±7.1	2.6±0.1	22.2±2.8	2129±368.3
L 127	107±4.03	5±0	400±15.0	2.7±0.1	14.6±1.1	4935±409.0
L 128	45±2.81	4±0.2	102±6.1	2.4±0.2	15.0±1.8	1691±55.4
L 129	85±6.45	5±0	307±30.0	2.6±0.1	18.8±2.2	3843±293.4
L 132	77±6.19	5±0	295±15.2	2.8±0.2	21.8±3.0	2835±278.1
L 133	23±3.17	1.5±0.3	7±1.0	2.1±0.2	13.7±2.5	112±26.0
L 134	38±3.28	3.5±0.3	71±10.2	2.6±0.1	18.4±1.9	802±55.1
L 135	58±5.82	4±0.3	150±18.7	2.7±0.1	25.0±3.0	2485±497.5
L 136	44±3.34	3±0.4	80±9.5	2.6±0.2	22.8±1.5	949±106.6
L 137	37±2.86	3±0.4	56±7.1	2.6±0.2	16.6±1.9	763±75.3
L 139	42±6.27	3.5±0.3	76±7.3	2.4±0.2	15.6±1.5	910±316.0
L 141	39±1.92	3±0.4	66±8.9	2.2±0.1	13.6±1.3	480±45.4
L 142	53±4.69	4.5±0.2	149±13.2	2.5±0.1	19.2±2.7	1540±299.1
L 391	45±3.38	3±0.5	80±4.7	2.4±0.1	15.2±2.4	803±72.6
W 1	29±2.16	2.5±0.5	32±6.4	2.7±0.1	16.2±1.6	133±32.4
W 2	33±3.81	2.5±0.6	39±5.2	2.7±0.1	20.6±4.0	868±36.0
W 3	46±4.78	3.5±0.5	92±11.2	2.8±0.1	20.6±1.3	2146±270.3

*Mean ± S.E.

Table 3. Pod shattering (%) in various *Lotus* collections.

<i>Collection no.</i>	<i>Total no. of pods/plant*</i>	<i>Shattered pods /plant*</i>	<i>% age shattering</i>
L 125	94±4.1	52±3.1	55.32
L 126	119±7.1	17±3.7	0.84
L 127	400±15.0	149±8.8	37.25
L 128	102±6.1	39±6.3	38.24
L 129	307±30.0	162±27.1	52.77
L 132	295±15.2	162±10.4	54.92
L 133	7±1.0	5±1.4	71.43
L 134	71±10.2	45±6.3	63.38
L 135	150±18.7	83±8.0	55.33
L 136	80±9.5	26±4.7	32.5
L 137	56±7.1	14±2.1	25.0
L 139	76±7.3	37±3.7	48.68
L 141	66±8.9	43±3.5	65.15
L 142	149±13.2	90±8.0	60.40
L 391	80±4.7	27±1.8	33.75
W 1	32±6.4	22±4.2	68.75
W 2	39±5.2	31±3.8	79.49
W 3	92±11.2	69±6.2	75.00

*Mean ± S.E.

**Figure 1.** Branches of *Lotus corniculatus* bearing shattered and intact pods.

During the present study it was found that the ovule count/ovary ranged from 20 to 46 and of these 14 to 25 developed into seeds. Earlier, Bader and Anderson (1962) reported that of 20 to 70 ovules/ovary of *Lotus corniculatus*, 2 to 35 develop into seeds whilst Hansen (1953) concluded that the average number of seeds per pod is 19.

Theoretically each plant has the potential to produce seed equivalent to fertile ovules/ovary x no. of pods/umbel x umbels/plant. However, during the present study, it was found that none of the populations produced as much seed as expected. Seaney and Henson (1970) reported that the gap between theoretical and actual seed yield is enormous. Seed or pod shattering is a serious problem in *Lotus*. Winch *et al.* (1985) stated that even though seed yields can potentially be as much as 750 kg/ha, the average yields obtained in Ontario are around 110 kg/ha i.e. 85% seed is lost due to shattering. Earlier, Winch and MacDonald (1961) have correlated three physiological stages of pod with seed development and shattering. Anderson (1955) and Metcalfe *et al.* (1957) considered relative humidity as the single most important factor affecting seed pod shattering. The time of pod shattering is related to the maturity of pods (Anderson, 1955; MacDonald and Winch, 1957), the environmental conditions and the individual genetic differences of the plants (Metcalfe *et al.* 1957).

The eighteen populations, which were studied, differed in the extent of pod shattering. This concurs with the work of Grant (1996), who reported considerable variation in degree of indehiscence among *Lotus* populations grown under greenhouse conditions. The pod shattering in 18 populations ranged from 0.84% to 79.5% but the observed seed yields are 6 to 37% of expected yield. Even if, the seed loss due to shattering (no. of shattered pods x average no. of seeds/pod) is taken into consideration, the observed seed yields are still 8 to 49% of the expected yield and on average only 35% seed yield is obtained (Table 4). This suggests there is still a gap of 51% to 92% in seed yield attributable to other factors. This can be attributed to indeterminate period of flowering and at the time of harvesting all the pods are not at same stage of maturity. During the present study, all the populations except L 391 started blooming in the month of March and were harvested in May. Since population L 391 came into bloom after harvesting of other populations, it was harvested in July. The other factors, which could be responsible for low seed yields are flower bud abortion, lack of pollination and genetic factors. Another interesting feature that emerges from the present study is the enormous variability among populations. Significant variability for pod shattering, number of umbels/plant was recorded. In the future this can be exploited for isolation of lines with lesser pod shattering and higher seed yield.

Table 4. Expected and observed seed yield/plant in various *Lotus* collections.

Collection No.	Seed yield/plant		Seed loss due to shattering ³	Expected seed yield ²	Gap (%) in seed yield
	Expected ¹	Observed			
L 125	5016	1257	1040	3976	68.4
L 126	6928	2129	377	6551	67.5
L 127	14063	4935	2175	11888	58.5
L 128	4842	1691	585	4257	60.3
L 129	13115	3843	3046	10069	61.8
L 132	11421	2835	3532	7889	64.1
L 133	674	112	68	606	81.5
L 134	2935	802	828	2107	61.9
L 135	7577	2485	2075	5502	54.8
L 136	4231	949	593	3638	73.9
L 137	3045	763	232	2813	72.9
L 139	3318	910	577	2741	66.8
L 141	3035	480	585	2450	80.4
L 142	6671	1540	1728	4943	68.8
L 391	3996	803	410	3586	77.6
W 1	2080	133	356	1724	92.3
W 2	2829	868	639	2190	60.4
W 3	5828	2146	1421	4407	51.3
Average	5644.7	1593.4	1126	4518.7	64.7

¹ Expected seed yield (1) = Fertile ovule x average no. of umbels/plant x average no. of pods/umbel

² Expected seed yield (2) = Expected seed yield (1) – seed loss due to shattering

³ Seed loss due to shattering = average no. of seed /pod x no. of shattered pods/plant

References.

- ANDERSON S.R. 1955. Development of pods and seeds of birdsfoot trefoil (*Lotus corniculatus* L.) as related to maturity and to seed yields. *Agronomy Journal*, **47**, 483 – 487.
- BADER K.L. and ANDERSON S.R. 1962. Seed yields of birdsfoot trefoil, *Lotus corniculatus* L. as affected by pre-harvest clipping combined with control of injurious insects. *Agronomy Journal*, **54**, 306 – 309.
- GRANT W.F. 1996. Seed pod shattering in the genus *Lotus* (Fabaceae): a synthesis of diverse evidence. *Canadian Journal of Plant Science*, **76**, 447 – 456.
- HANSEN H.W. 1953. Developmental morphology of *Lotus corniculatus* L. *Iowa State College Journal of Science*, **27**, 563 – 600.
- MACDONALD H.A. and WINCH J.E. 1957. Birdsfoot trefoil seed production. Department of Agronomy, New York State Coll. Agric., Cornell Univ., Ithaca, NY no. 57-18, Mimeographed.

- MCGRAW R.L. and BEUSELINCK P.R. 1983. Growth and seed yield characteristics of birdsfoot trefoil. *Agronomy Journal*, **75**, 443 – 446.
- METCALFE D.S., JOHNSON I.J. and SHAW R.H. 1957. The relation between pod dehiscence, relative humidity and moisture equilibrium in birdsfoot trefoil, *Lotus corniculatus*. *Agronomy Journal*, **49**, 130 – 134.
- SEANEY R.R. and HENSON P.R. 1970. Birdsfoot trefoil. *Advances in Agronomy*, **22**, 119 – 157.
- WINCH J.E. and MACDONALD H.A. 1961. Flower, pod and seed development relative to the timing of the seed harvest of Viking birdsfoot trefoil (*Lotus corniculatus* L.). *Canadian Journal of Plant Science*, **41**, 523 – 532.
- WINCH J.E., ROBINSON S.E. and ELLIS C.R. 1985. Birdsfoot trefoil seed production. Factsheet no. 85-111, Ontario Ministry of Agriculture and Food, Toronto, ON pp: 1 – 4.