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Visualizing Components of Seed Yield to Identify Plant Ideotype in Field Pea (*Pisum sativum* L.)

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The yields of pulse crops in general and field pea in particular have stagnated hence a study was undertaken to suggest a model plant type in field pea utilizing F_4 populations of six crosses. Observations were recorded for nine traits on 120 randomly selected plants in each cross to work out genetic variability and phenotypic correlations which were further utilized for drawing the inferences to shape out an ideal plant type. Based on these, the model field pea plant with a combination of characteristics such as leafiness more number of primary branches and pods per plant, longer pods, with higher number of seeds per pod, round and large seed size was envisaged. The effect of different qualitative traits on yield contributing characters revealed that leafy and round seeded plants could be favorable components of high yield.

Key words: Field pea, ideotype, selection

Among the pulse crops, field pea (*Pisum sativum* L.) is one of most important grain legume globally. It is used for several, purposes like fresh cooked or mixed with certain other vegetables. It is also used processed such as soups, canned, frozen and dehydrated forms. Field pea is highly nutritive and major proportion of seeds contains digestible proteins, carbohydrates, fat, minerals and vitamins. It contains 20 to 28 % protein, 60 to 65% carbohydrates, 2% fat and other mineral matter and is also a rich source of calcium. Field pea occupied about 0.76 million hectare area in our country with the total production 0.71 million tones during 2011-12 (Anonymous, 2013).

In view of the vital role of field peas in Indian agriculture, comparatively less attention has been paid by the breeders and geneticists. Productive varieties can be tailored by manipulating plant characters through breeding. The ideal plant type of any crop can be developed depending on comparative contribution of plant characters on its yielding ability in varying agro-climatic conditions. Snoad (1985) suggested leafless plant type of field pea in which besides low vegetative growth, the risk of lodging is also reduced and therefore, the crop can be more easily harvested, even mechanically. However, additional information is required to identify better plant type than the existing one for further improvement in yield. Keeping these facts in view, the present investigation was undertaken to determine the effect of selection in one character on other yield components and to suggest the model plant type in field pea.

Materials and Methods

The present study was carried out at the Pulses Research Area of Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The experimental materials comprised of F_4 populations of six crosses [Cross I - Arkel ×

HFP 8712, Cross II - Bonneville × HFP 9103, Cross III - HFP 8711 × EC 15210, Cross IV - Green 211 × (Rachna × EC 15210), Cross V - Green 211 × (Bonneville × HUP-11) and Cross VI - (Bonneville × HUP-11) × (HFP 8712 × EC 15210)]. From these F_4 populations, 120 plants were taken randomly from each cross for recording of observations at the time of maturity on nine characters *viz.,* plant height (cm), number of pods per plant, pod length (cm), number of seeds per pod, grain yield per plant (g), 100-seed weight (g), leafiness/leaflessness (number of leaflets/leaves), seed colour (coloured or white) and seed shape (wrinkled or round). Data was analyzed as per Al-Jibouri *et al*. (1958) and Panse and Sukhatme (1967) to work out phenotypic correlations and genetic variability which were further utilized for drawing the inferences to shape out an ideal plant type. Finally with the help of relationship and selection effects, model plant type in field pea has been suggested.

Results and Discussion

Association among various plant characters particularly those having strong relationship with seed yield play a vital role in formulating the models of improved plant type. In fact, the construction of such model plants is nothing but arriving at the optimum levels of expression of each component character, ultimately resulting in maximum seed yield. However, in actual practice while constructing such formulated models through breeding, several difficulties arise. In breeding for model or optimal plant types, a breeder would most probably be dealing with more than one character at the same time. Much of the information available on association of plant characters with grain yield is based on the data of limited number of genetic background and usually does not go beyond suggesting that number of pods per plant and seeds per pod show strong positive association with seed yield as would perhaps be expected even conceptually on a priority ground [Jonsson *et al*. (1994), Sharma and Khan (1996), Ranalli and Candilo (1998), Nawab *et al.* (2008), Togay *et al.* (2008) and Sharma *et al.* (2009)].

The plants with these model features can be isolated through simple selection (due to their high heritability) in segregating generations of appropriate crosses. The breeder should preferably involve multiple crosses for this purpose and consider Ramanujam's (1975) advice as well who noted that lack of progress in grain legume improvement might not be due to lack of genetic variability *per se* but due to lack of an ideotype that breeder should look for. Since these crops are grown in varying environmental conditions and cropping system with diverse cultural practices, no single plant type will be optimum for all production systems. Blixt and Vase (1984) suggested that looking at ideotype for a long term point of view, the most important aspect is not to get too firmly tied to any one concept because the characteristics thought to be desirable today may have to be revised in the light of genetic information, different cultural practices and pricing policy.

In the present study, F_4 (individual plants) and F_4 mean based on populations of six crosses were used for calculating association analysis of seed yield with other yield component characters (Table 1). The effect of extreme selection for different characters on other yield contributing characters (Table 2) revealed that selection on plant height basis had no impact on yield and yield contributing characters. It is a growth character and related to growth parameters as it was positively associated with node number and plant height at which first pod appears, means higher is the plant height higher will be node number and higher will be the plant height at which first pod would appear on the plant. The plant height did not show any apparent effect on other traits studied.

The selection effect based on number of pods per plant on other traits studied depicted that as number of pods per plant is directly associated with yield per plant *i.e.* higher the pods per plant more

will be the grain yield per plant. Thus, it is one of the most important yield attributing character. Number of pods per plant has also been found to be dependent upon number of primary branches per plant. More the number of primary branches per plant more will be the pods per plant and ultimately more will be the grain yield per plant. Number of pods per plant may be associated with pod length and number of seeds per pod in some cases where difference was significant (cross-II, III and IV) as evident from the table. Thus, number of pods per plant was mainly related to yield and yield attributing characters. The table also revealed that number of pods per plant had no association with growth parameters studied *i.e.* node number and plant height at which first pod appears and the plant height.

As the pod length is also a yield component, so it was always positively correlated with grain yield. A further perusal of the Table 2 revealed that more is the pod length more will be grain yield per plant. It also had significant impact on the seeds per pod or we can say longer is the pod more will be the number of grains inside it as observed in all six crosses which ultimately lead to higher yield. The association of pod length with other yield attributing characters *i.e.* number of primary branches/plant, number of pods/plant and 100-seed weight was not clearly demonstrated as in some cases it was found to be significant whereas, in other cases it was non-significant and of both the negative and positive magnitudes. On the other hand, pod length had no relationship with growth parameters like number and height at which first pod appear and plant height.

The table further revealed that number of seeds/pod had direct effect on seed yield per plant and pod length in all six crosses. The relationship between the number of seeds per pod and number of primary branches/plant was also significant in cross number II and cross number III, whereas, the association of seeds per pod with node number and plant height at which first pod appears was negative in four crosses which may be due to less translocation of photosynthates towards seed because more is the vegetative growth lesser will be translocation of photosynthates towards the reproductive part.

The relationship of grain yield per plant with other traits studied and the scrutiny of table indicated that 100-seed weight, number of pods per plant and number of seeds per pod are the most important components for seed yield and their higher values are desired in model plant. In all crosses the relationship of yield per plant with these three parameters *viz*., 100-seed weight, number of pods per plant and pod length has significant high values are also desirable for a model plant type. Although it is not always necessary as evident from table 2 in cross II, III and V where the values are significant. However, in other crosses (IV and VI) the values are positive but non-significant and in cross I it is negative. High number of primary branches per plant also desirable for getting higher grain yield per plant. First three characters *i.e.* node number and plant height at which first pod appears and plant height had no relevance as far as yield per plant is concerned. As these traits do not have a direct effect on plant yield. However, some time they may affect on plant yield through indirect effect via some other traits. Thus, a high yielding plant may have high or low expression for these traits.

A perusal of Table 2 indicated that 100-seed weight is an important component of seed yield as the number of pods and primary branches per plant have high values for these traits are desirable in model plant as evident from table in all six crosses. There was no definite trend for other traits. The relationship of 100-seed weight and node number at which first pod appears was significant only in cross II, whereas, with plant height, it was significant in cross IV only. There were both types of data available, negative as well as positive for many characters.

Table 1: Phenotypic correlation coefficients in F_4's (single plant and progeny mean) of field pea

Character	Pool base	Cross-I	Cross-II	Cross-III	Cross-IV	Cross-V	Cross-VI
	1. Plant height (cm) with no. of primary branches / plant						
F_4	0.013	0.025	-0.015	0.019	0.043	-0.016	0.124**
F_4m	0.001	0.041	-0.033	0.020	0.090	-0.054	-0.022
	1. Plant height (cm) with no. of pods / plant						
F_4	-0.003	0.077	-0.012	-0.013	-0.009	-0.008	0.137**
F_4m	0.088**	0.127	-0.028	-0.008	0.019	-0.005	0.151
	1. Plant height (cm) with pod length (cm)						
F_4	0.345**	-0.012	-0.048	0.027	-0.036	0.113**	-0.042
F_4m	-0.022	-0.027	-0.012	0.014	-0.078	0.132	-0.041
	1. Plant height (cm) with no. of seeds / pod						
F_4	-0.018	-0.080	-0.128**	0.044	0.014	0.106**	-0.0111
F_4m	-0.034	-0.158	-0.198*	0.034	0.010	0.137	-0.025
	1. Plant height (cm) with yield / plant						
F_4	-0.029	0.015	0.007	-0.069	0.103**	0.044	0.068
F_4m	0.052	0.032	0.012	-0.099	0.136	0.081	0.074
	1. Plant height (cm) with 100 seed weight						
F_4	-0.014	0.042	0.024	-0.140	0.216**	-0.044	-0.065
F_4m	-0.004	0.047	0.055	-0.157	0.239**	-0.047	-0.073
	2. Number of primary branches/plant with no. of pods / plant						
F_4	-0.012	0.517**	0.748**	0.688**	0.462**	0.572**	0.612**
F_4m	-0.137**	0.552**	0.812**	0.761**	0.501**	0.684**	-0.642**
	2. Number of primary branches/plant with pod length (cm)						
F_4	0.056**	0.015	0.115**	0.158**	-0.014	0.084	-0.004
F_4m	0.240**	0.034	0.180*	0.341**	-0.166	0.164	0.963**
	2. Number of primary branches/plant with no. of seeds / pod						
F_4	0.061**	0.037	0.089*	0.107**	0.050	0.035	-0.011
F_4m	0.149**	0.187**	0.207**	0.262**	0.149	0.069	0.519**
	2. Number of primary branches/plant with yield / plant						
F_4	-0.026	0.331**	0.566**	0.497**	0.369**	0.346**	0.380**
F_4m	-0.057	0.486**	0.591**	0.588**	0.454**	0.459**	-0.322*
	2. Number of primary branches/plant with 100 seed weight						
F_4	0.588**	-0.001	0.075	0.048	0.135**	0.149**	-0.038
F_4m	0.108**	0.038	0.112	0.055	0.196*	0.238**	0.402**
	3. No. of pods/plant with pod length						
F_4	-0.009	-0.047	0.091*	0.070	-0.043	0.047	-0.090*
F_4m	0.075*	-0.048	0.159	0.197*	-0.131	0.124	-0.658**
	3. No. of pods/plant with no. of seeds / pod						
F_4	0.084**	-0.022	0.059	0.022	0.042	-0.019	-0.089*
F_4m	-0.047	-0.148	0.144	0.156	0.119	0.057	-0.421**
	3. No. of pods/plant with yield / plant						
F_4	0.013	0.593**	0.738**	0.604**	0.550**	0.439**	0.498**
F_4m	0.648**	0.575**	0.725**	0.597**	0.667**	0.545**	0.468**
	3. No. of pods/plant with 100 seed weight						
F_4	0.005	0.021	0.034	0.003	0.127**	0.151**	-0.011
F_4m	0.100	0.034	0.021	-0.002	0.187**	0.252**	-0.287**
	4. Pod length (cm) with no. of seed / pod						
F_4	-0.008	0.029	0.102*	0.844**	-0.023	0.777**	0.752**
F_4m	0.061	0.127	0.201*	0.933**	-0.041	0.852**	0.694**
	4. Pod length (cm) with yield / plant						
F_4	-0.020	-0.002	0.111**	0.325**	-0.053	0.391**	0.365**
F_4m	-0.027	-0.014	0.190*	0.450**	-0.154	0.538**	-0.212**
	4. Pod length (cm) with 100 seed weight						
F_4	0.036*	-0.042	0.513**	-0.002	-0.095*	0.082*	0.091*
F_4m	0.063	-0.142	0.466**	0.011	-0.231*	0.098	0.401**
	5. No. of seeds/pod with yield / plant						
F_4	0.018	0.643**	0.448**	0.391**	0.364**	0.409**	0.486**
F_4m	0.327**	0.494**	0.449**	0.485**	0.352**	0.587**	0.292**
	5. No. of seeds/pod with 100 seed weight						
F_4	0.230**	-0.054	-0.032	0.010	0.153**	0.152**	0.116**
F_4m	0.068	-0.102	-0.016	0.020	0.180*	0.199*	0.308**
	6. Yield/ plant with 100 seed weight						
F_4	0.407**	0.326**	0.146**	0.410**	0.343*8	0.377**	0.411**
F_4m	0.418**	0.452**	0.272**	0.565**	0.519**	0.556**	0.328**

The effect of presence and absence of leaf on other characters revealed that leafy plants were taller than leafless plants in all the crosses but the difference was

significant in cross I, II, IV and V. Similarly, node number at which first pod appears was also high in leafy plants in cross I, III, IV and V. Height of plants at which first pod appeared did not follow a fixed trend as it was more in leafy plants in cross I, II and V whereas, also more in leafless plants in cross III, IV and VI. In case of number of primary branches per plant significant differences were observed only in two crosses *i.e.* in cross IV and VI which was in favour of leafy plants, and in other cases also leafy plants have more primary branches per plant than leafless plants. Similarly, number of pods/plant was more in leafy plants and the differences were significant only in case of cross III and IV. Thus, for more number of pods per plant leafy plants are preferred. Similarly, pod length and number of seeds/pod also favoured the leafy plants. Therefore, the yield was higher in leafy plants in four crosses (Cross I, II, VI significantly higher and in cross V non-significant) whereas cross III expressed no difference and IV predicted that leafless plants yielded more than leafy plants though the difference was non significant.

Effect of seed shape on expression of different characters in field pea suggested that round seeded plants were higher yielding as compared to wrinkled seeded plants. This was because of better performance of yield attributing characters in round seeded plants. Hundred seed weight was significantly higher in round seeded as compared to wrinkled seeded plants in all six crosses. Hence, number of seeds per pod was also higher in round seeded plants in all six crosses. As far as number of primary branches per plant, number of pods per plant and pod length are concerned their performance was in both the directions *i.e.* positively significant, negatively significant or at par in different cases for different crosses for round and wrinkled seeds. Among the growth parameters plant height was more in round seeded plants as compared to wrinkled seeded plants. In case of node number and height at which first pod appeared the result was again in favour of round seediness in four crosses (Cross I, II, IV and V) and in cross III and VI wrinkled seediness also favoured. Thus, round seediness is more desirable in model plant type.

The effect of seed colour on different characters in field pea revealed that seed colour did not perform in a fixed manner in relation to other characters in different crosses. In case of node number at which first pod appears and 100-seed weight, five crosses favoured white seeds, whereas, in case of pod length five crosses favoured green seeded and one cross favoured white seeded. Similarly, plant height favoured white seed in two crosses and green seeded in four crosses. In case of plant height at which first pod appears and grain yield per plant favoured in four crosses for white seededness and two crosses for green seededness. For number of primary branches per plant, number of pods per plant and number of seeds per pod, both green and white seededness favoured in three crosses each.

In the present study character associations and simple comparison of high yielding *vis-a-vis* low yielding lines for morphological and other traits as well as a comparison of lines with high *vis-a-vis* low expression of different traits for seed yield was also used in identifying the model plant features. The directed selection for one trait may have some impact on other characters through correlated response. Keeping in view the above relationships, the model field pea plant coming out from the present study should be leafy with more number of primary branches per plant so that more will be the pods per plant, longer the pods so as to have higher the number of seeds per pod, round and bolder seed size so that more will be the grain yield per plant. The effect of different qualitative traits on yield contributing characters revealed that leafy and round seeded plants are favoured for yield components, however, seed colour showed fixed trend in majority of the crosses.

Earlier as well, a high value of these three major components of seed yield *i.e.* pods per plant, seeds per pod and seed weight had been found desirable in the model plant [Jonsson *et al*. (1994), Singh (1997) Sharma and Khan (1996), Ranalli and Candilo (1998), Nawab *et al.* (2008), Togay *et al.* (2008) and Sharma *et al.* (2009)]. But due to inverse relationships between some combinations of them, it is practically impossible to increase all of them simultaneously. Hence, a modest compromise between them too has to be made, especially if any one of them has very high expression, the other two have to be modest.

Table 2: Mean performance of plants with extreme expression of one character on other different traits in F_4 generations of field pea

Of plant height (cm) on different other traits								
1	Node No. at which 1st pod appear	Max.	11.49	11.80	11.60	11.99	11.54	11.14
		Mini.	10.05	10.21	10.80	10.96	10.08	10.36
		Diff.	**1.44***	**1.59***	**0.80***	**1.03***	**1.46***	**0.78***
2	Height of plant (cm) at which 1st pod appear	Max.	40.45	51.41	68.37	69.30	43.01	54.01
		Mini.	28.16	25.43	31.26	27.71	27.28	32.10
		Diff.	**12.29***	**25.98***	**37.11***	**41.72***	**15.73***	**21.91***
3	Yield/plant (g)	Max.	11.71	10.25	9.24	12.52	13.29	13.73
		Mini.	12.76	10.38	10.11	11.82	12.05	13.45
		Diff.	**-1.05**	**-0.13**	**-0.87**	**0.70***	**1.24**	**0.28**
4	100-seed weight (g)	Max.	16.82	16.25	14.38	17.88	16.15	16.53
		Mini.	17.09	15.84	15.41	16.86	16.31	16.63
		Diff.	**-0.27**	**0.41**	**-1.03**	**1.02***	**-0.06**	**-0.10**
Of No. of pods/ plant on different other traits								
1	Node No. at which 1st pod appear	Max.	10.84	11.06	11.57	11.34	10.86	11.41
		Mini.	11.01	10.86	11.02	12.00	10.44	10.35
		Diff.	**-0.17**	**0.20**	**0.55**	**-0.64**	**0.42**	**1.06***
2	No. of primary branches/plant	Max.	90.33	79.93	110.10	119.74	77.18	95.72
		Mini.	74.84	84.99	115.29	101.05	73.33	86.29
		Diff.	**15.49***	**-5.06**	**-5.19**	**18.69**	**3.85***	**9.43**
3	No. of pods/plant	Max.	1.83	1.55	2.01	1.84	1.81	1.92
		Mini.	2.43	2.54	2.83	2.39	2.37	2.31
		Diff.	**0.40***	**0.99***	**0.82***	**0.55***	**0.56***	**0.39***
4	Pod length (cm)	Max.	6.12	6.84	5.98	7.71	6.28	7.25
		Mini.	6.51	5.93	5.75	6.11	6.02	5.98
		Diff.	**-0.37**	**0.91***	**0.23***	**1.60***	**0.26**	**1.27**
5	No. of seeds/pod	Max.	3.91	3.98	3.84	3.71	3.67	3.70
		Mini.	4.23	3.74	3.60	3.45	3.59	3.97
		Diff.	**-0.32**	**0.24***	**0.24***	**0.32***	**0.08**	**-0.27**
6	Yield/plant (g)	Max.	15.26	12.68	13.26	18.14	16.07	15.28
		Mini.	10.20	8.08	7.55	9.72	10.29	12.30
		Diff.	**5.06***	**4.60***	**5.71***	**8.42***	**5.78***	**2.98***
7	100-seed weight (g)	Max.	16.81	15.53	14.92	17.83	17.07	16.54
		Mini.	16.88	16.89	14.56	16.43	15.58	17.06
		Diff.	**0.07**	**-1.36**	**0.36**	**1.40***	**1.49***	**-0.52**
Of pod length (cm) on different other traits								
1	Node No. at which 1st pod appear	Max.	10.87	10.81	11.75	11.38	11.46	10.71
		Mini.	10.96	10.95	11.30	11.74	11.10	11.39
		Diff.	**-0.09**	**-0.14**	**0.45**	**-0.36**	**0.36**	**-0.58***
2	No. of pods/plant	Max.	2.24	2.24	2.56	2.18	2.14	2.24
		Mini.	2.11	1.84	2.18	2.02	2.03	2.07
		Diff.	**0.13**	**0.40***	**0.38***	**0.16**	**0.11**	**0.17**

3	Pod length (cm)	Max.	18.69	17.85	19.81	20.08	21.56	19.61
		Mini.	18.44	16.04	17.52	20.04	20.69	21.05
		Diff.	**0.25**	**1.81***	**2.29***	**0.04**	**0.87**	**-1.44**
4	No. of seeds/pod	Max.	5.07	4.44	4.15	4.03	4.09	4.29
		Mini.	3.94	3.42	3.17	3.02	2.94	3.09
		Diff.	**1.03***	**1.02***	**0.98***	**1.01***	**1.15***	**1.20***
5	Yield/plant (g)	Max.	14.72	11.74	12.19	16.40	15.22	14.43
		Mini.	12.16	9.09	8.33	10.13	9.75	11.64
		Diff.	**2.56***	**2.65***	**3.86***	**6.31***	**5.47***	**2.79***
6	100-seed weight (g)	Max.	16.35	19.18	14.72	17.94	16.92	17.12
		Mini.	16.73	16.37	14.82	16.42	16.56	16.06
		Diff.	**-0.38**	**2.81***	**-0.10***	**1.52***	**0.36**	**1.06**
Of No. of seeds per pod on different other traits								
1	No. of primary branches/plant	Max.	73.16	73.38	117.80	126.60	87.23	95.11
		Mini.	90.87	78.27	107.20	126.58	75.61	93.76
		Diff.	**-17.71***	**-4.89**	**10.60**	**0.02**	**11.62**	**1.35**
2	No. of pods/plant	Max.	2.25	2.18	2.43	2.05	2.06	2.27
		Mini.	2.13	1.82	2.18	2.00	2.04	2.10
		Diff.	**0.12**	**0.36***	**0.25***	**0.05**	**0.02**	**0.17**
3	Pod length (cm)	Max.	17.32	17.35	18.60	21.88	20.89	20.02
		Mini.	18.60	15.30	17.48	20.27	20.83	21.11
		Diff.	**-1.28**	**2.05***	**1.12**	**1.61**	**0.06**	**-1.09**
4	No. of seeds/pod	Max.	6.67	6.72	6.22	6.72	6.70	7.72
		Mini.	5.02	5.62	5.32	5.43	5.04	5.23
		Diff.	**1.65***	**1.10***	**0.90***	**1.24***	**1.66***	**2.49***
5	Yield/plant (g)	Max.	13.95	11.80	11.50	17.31	15.27	15.16
		Mini.	10.72	8.21	7.87	9.41	9.64	11.50
		Diff.	**3.23***	**3.59***	**3.63***	**7.90***	**5.63***	**3.66***
Of yield per plant on different other traits								
1	Node No. at which 1st pod appear	Max.	10.87	11.04	11.75	11.50	11.09	11.15
		Mini.	11.60	10.86	10.90	12.05	10.99	11.04
		Diff.	**-0.73***	**0.18**	**0.85**	**-0.55**	**0.10**	**0.11**
2	No. of pods/plant	Max.	2.36	2.40	2.75	2.42	2.28	2.66
		Mini.	1.19	1.66	2.10	1.87	1.87	2.20
		Diff.	**1.17***	**0.74***	**0.65***	**0.55***	**0.41***	**0.46***
3	Pod length (cm)	Max.	21.13	19.69	21.50	25.68	24.34	25.09
		Mini.	15.70	14.30	15.74	16.90	18.68	19.28
		Diff.	**5.43***	**5.39***	**5.76***	**8.78***	**5.66***	**5.81***
4	No. of seeds/pod	Max.	6.38	6.41	6.12	6.53	6.41	6.78
		Mini.	6.40	5.86	5.52	6.35	5.46	6.39
		Diff.	**-0.02**	**0.55***	**0.60***	**0.18**	**0.95***	**0.39**
5	Yield/plant (g)	Max.	4.43	4.12	4.01	4.75	3.89	4.08
		Mini.	3.67	3.62	3.38	3.03	3.22	3.40
		Diff.	**0.76***	**0.50***	**0.63***	**1.72***	**0.67***	**0.68***
6	100-seed weight (g)	Max.	18.45	18.23	16.16	18.68	18.07	17.39
		Mini.	14.97	14.31	12.56	16.06	15.44	15.45
		Diff.	**3.58***	**3.92***	**3.60***	**2.62***	**2.63***	**1.94***
Of 100-seed weight (g) on different other traits								
1	Node No. at which 1st pod appear	Max.	10.71	11.33	11.45	11.74	11.08	11.42
		Mini.	11.00	10.75	11.07	11.48	11.07	11.43
		Diff.	**-1.00**	**3.01***	**1.00**	**0.63**	**0.03**	**-0.03**
2	No. of primary	Max.	87.50	88.26	102.23	139.32	79.02	88.01

	branches/plant	Mini.	83.51	72.54	114.40	94.63	82.71	90.71
		Diff.	**3.99**	**15.72**	**-12.17**	**44.69***	**-3.69**	**-2.70**
3	No. of pods/plant	Max.	2.12	1.97	2.37	2.26	2.14	2.22
		Mini.	2.06	1.93	2.28	2.05	1.98	2.12
		Diff.	**0.06**	**0.04**	**0.09**	**0.21***	**0.16***	**0.10**
4	Pod length (cm)	Max.	18.07	16.82	18.36	22.32	22.00	20.87
		Mini.	17.74	16.53	17.90	20.07	19.88	19.84
		Diff.	**0.33**	**0.29**	**0.46**	**2.25**	**2.12***	**0.97**
5	No. of seeds/pod	Max.	6.00	6.51	5.81	6.22	6.14	7.00
		Mini.	6.68	6.15	5.73	6.98	5.98	5.95
		Diff.	**-0.68**	**0.36**	**0.08**	**-0.76***	**0.16**	**1.05**
6	100-seed weight (g)	Max.	14.24	11.42	12.70	16.67	15.43	14.10
		Mini.	9.88	8.41	7.68	10.92	10.33	11.16
		Diff.	**4.36***	**3.01***	**5.02***	**5.75***	**5.10***	**3.94***
Expression of different characters in presence and absence of leaf in fieldpea (L = Leafy; LL = Leafless)								
1	Node No. at which 1st pod appear	L	11.05	10.88	11.62	11.68	11.26	10.89
		LL	10.41	10.40	11.10	10.70	10.67	10.85
		Diff.	**0.54***	**0.48**	**0.52***	**0.98***	**0.59***	**0.04**
2	Height of plant (cm) at which 1st pod appear	L	34.52	34.98	49.79	48.51	35.90	42.48
		LL	32.92	34.60	51.96	53.47	33.94	43.18
		Diff.	**1.60**	**0.38**	**-2.17**	**-4.96***	**1.96***	**-0.70**
3	Plant height (cm)	L	85.99	80.84	112.29	116.66	82.74	93.51
		LL	78.63	72.90	113.76	124.10	78.48	91.57
		Diff.	**7.36***	**7.94***	**1.47**	**7.44***	**4.26***	**1.84**
4	No. of primary branches/plant	L	2.17	2.07	2.36	2.26	2.08	2.23
		LL	2.17	1.80	2.31	2.09	2.07	2.08
		Diff.	**0.00**	**0.27**	**0.05**	**0.17***	**0.01**	**0.15***
5	No. of pods/plant	L	18.10	17.08	18.34	20.97	20.92	20.71
		LL	18.39	16.30	17.42	22.79	21.07	20.77
		Diff.	**0.29**	**0.78**	**0.92***	**1.82***	**0.15**	**0.06**
6	Pod length (cm)	L	6.18	6.31	5.81	6.93	6.02	6.31
		LL	6.02	6.03	5.81	6.88	5.91	5.78
		Diff.	**0.16**	**0.28**	**0.00**	**0.05**	**0.11**	**0.53***
7	No. of seeds/pod	L	3.99	3.84	3.69	3.76	3.58	3.73
		LL	3.87	3.77	3.69	3.53	3.55	3.57
		Diff.	**0.12**	**0.07**	**0.00**	**0.23***	**0.03**	**0.16***
8	Yield/plant (g)	L	12.50	10.38	9.96	13.38	12.62	13.47
		LL	11.45	9.39	9.96	14.59	12.41	12.80
		Diff.	**1.50***	**0.99***	**0.00**	**-1.21***	**0.21**	**0.67***
9	100-seed weight (g)	L	17.09	16.47	14.36	17.33	16.61	11.65
		LL	16.39	14.87	14.79	18.17	16.37	11.22
		Diff.	**0.70***	**1.60**	**-0.43***	**-0.84***	**0.24**	**0.43***
Effect of seed shape on expression of different characters in fieldpea (R=round; W=wrinkled)								
1	Node No. at which 1st pod appear	R	11.17	11.01	11.42	11.49	10.96	10.85
		W	10.75	10.70	12.00	8.80	10.58	11.85
		Diff.	**0.38***	**0.31***	**-0.58***	**2.69***	**0.38***	**-1.00***
2	Height of plant (cm) at which 1st pod appear	R	35.17	36.91	50.62	49.70	35.64	42.64
		W	33.43	32.70	51.96	36.00	29.95	43.10
		Diff.	**1.74***	**4.21***	**-1.34**	**13.70***	**5.69***	**-0.46**
3	Plant height (cm)	R	87.98	86.18	138.60	118.73	81.50	93.25
		W	81.92	74.24	112.64	112.80	73.17	87.00
		Diff.	**6.06***	**11.84***	**15.96***	**5.93**	**8.33***	**6.25***

4	No. of primary branches/plant	R	2.16	2.02	2.34	2.13	2.08	2.98
		W	2.18	2.11	2.60	1.40	2.07	2.25
		Diff.	**-0.02**	**-0.90**	**0.26**	**0.73***	**0.01**	**0.73***
5	No. of pods/plant	R	18.04	16.76	17.94	21.41	21.17	20.65
		W	18.24	17.44	23.00	15.20	20.23	23.00
		Diff.	**-0.20**	**-0.68***	**-5.06**	**6.21***	**0.94**	**-2.35***
6	Pod length (cm)	R	6.10	6.26	5.81	6.34	5.94	6.22
		W	6.21	6.23	5.70	6.92	6.03	5.27
		Diff.	**-0.11**	**0.03**	**0.11**	**-0.98***	**0.09**	**0.95***
7	No. of seeds/pod	R	4.08	3.93	3.69	4.34	3.52	3.72
		W	3.88	3.87	3.54	3.70	3.46	3.03
		Diff.	**0.20**	**0.06**	**0.15**	**0.64***	**0.06**	**0.69***
8	Yield/plant (g)	R	12.73	10.43	11.10	13.67	12.66	13.39
		W	11.97	10.29	9.85	10.48	11.61	10.94
		Diff.	**0.86***	**0.14**	**1.25**	**2.19**	**1.05***	**2.45***
9	100-seed weight (g)	R	17.24	17.15	14.53	17.53	16.62	16.58
		W	16.74	15.60	13.54	15.59	15.67	15.58
		Diff.	**0.50***	**1.55***	**0.99***	**1.94***	**0.95***	**1.00***
Effect of seed colour on expression for different characters of fieldpea (W = White; G = Green)								
1	Node No. at which 1st pod appear	W	11.16	10.87	11.43	11.60	10.59	11.01
		G	10.76	10.86	10.60	11.07	11.07	10.62
		Diff.	**0.40***	**0.01**	**0.83**	**0.53***	**-0.48***	**0.39***
2	Height of plant (cm) at which 1st pod appear	W	36.38	36.53	50.67	49.34	33.47	43.04
		G	32.19	33.87	44.20	50.31	35.20	41.90
		Diff.	**4.19***	**2.71***	**6.47***	**-0.97**	**-1.73***	**1.14**
3	Plant height (cm)	W	91.82	86.85	112.84	117.50	75.68	90.66
		G	77.96	76.47	114.60	120.57	83.05	94.27
		Diff.	**13.86***	**10.38***	**-1.76***	**-3.07**	**-7.37***	**-3.61***
4	No. of primary branches/plant	W	2.20	2.02	2.34	2.16	2.06	2.11
		G	2.15	2.09	2.00	2.03	2.09	2.60
		Diff.	**0.50**	**-0.07**	**0.34***	**0.13***	**0.02**	**-0.49**
5	No. of seeds/pod	W	3.96	3.76	3.69	3.72	3.58	3.65
		G	3.99	3.89	3.72	3.67	3.51	3.78
		Diff.	**-0.03**	**0.13***	**-0.03**	**0.05**	**0.07**	**-0.13***
6	Yield/plant (g)	W	12.56	10.46	9.86	13.46	13.02	13.30
		G	12.12	10.30	7.76	14.18	12.33	13.32
		Diff.	**0.44**	**0.16**	**2.12***	**-0.72**	**0.69**	**-0.32**
7	100-seed weight (g)	W	17.00	17.77	14.53	17.39	16.77	16.34
		G	16.98	15.53	14.28	7.89	16.28	16.96
		Diff.	**0.02**	**2.24***	**0.25**	**0.50***	**0.49***	**-0.62***

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