

Development of dual purpose cowpea culture (*Vigna unguiculata* (L.) Walp.) with high grain yield

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Received 06 July 2019; received in revised form 02 November 2020; accepted 20 January 2021

Abstract

Yield improvement is the major breeding objective in cowpea. In the present study, F₃ derived populations (23 selected F₃ plants) of two cowpea crosses, namely, H10 (Anaswara x PKB3) and H11 (Anaswara x PKB4), were evaluated along with check parent Anaswara for yield and protein content and pedigree selection was imposed to select superior transgressive segregants. After screening F₄, F₅ and F₆ generations of the two crosses, five lines (of which four from cross H11 and one from cross H10) were selected which were found superior to parent Anaswara in grain yield. Moreover, tender green pods had good organoleptic value, suggesting the utility as dual-purpose type. Comparison of mean showed that these plants outclassed the parental performance. Superior culture identified here can be further evaluated in replicated yield trials and tested for stability over locations and seasons.

Key words: Cowpea, Grain yield, Protein content, Selection.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important pulse crop providing good source of protein and is often referred to as poor man's meat. It is a versatile crop with seeds being utilised as pulse, green pods as vegetable, and leaves as forage. Being a nitrogen fixing legume, it helps in restoring soil fertility. It is a hardy crop grown as intercrop and also in summer fallows. On dry weight basis, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat and 60.3 per cent carbohydrates, and it is a rich source of calcium and iron (Gupta, 1988).

Three major cultivated subgroups of cowpea include *V. unguiculata* ssp. *unguiculata* (dual purpose type), *V. unguiculata* ssp. *cylindrica* (grain type) (Syn: *V. unguiculata* ssp. *catjang*, *V. sinensis* ssp. *catjang*.) and *V. unguiculata* ssp. *sesquipedalis* (vegetable type). Yield improvement in cowpea without

compromising protein content is a difficult task. de Silva et al. (2016) reported that the cowpea inbred lines having the highest protein contents exhibited the lowest grain yields upon evaluation of forty-four inbred lines and cultivars of cowpea. They pointed out the prominent phenotypic cost of protein in cowpea seed production. Correlation studies on 15 cultivars of cowpea grown in three locations proved that grain yield was negatively correlated to protein content ($r = -0.87$) (Oluwatosin, 1997). According to Kar et al. (2000) the protein content of pods and seeds did not show any significant correlation with pod yield, implying that selection for protein content should not be detrimental to yield. They suggested that hybridisation followed by pedigree method of selection at a later generation simultaneously for protein content as well as yield be advocated for developing desirable plant types. Tchiagam et al. (2017) screened 10 varieties of cowpea and the values of seed crude protein ranged

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between 20.79 to 31.78 per cent, and among the F_1 progenies, protein content varied from 22.23 to 32.67 per cent. Eleven Arkansas cowpea breeding lines were evaluated by Ravelombola et al. (2016) who reported that the average seed protein content was 25.4%. Moreover, the value ranged from 23.7% to 27.4% with a standard deviation of 1.9%. They observed significant effects of genotype, environment (location), and genotype by environment for the total seed protein content in cowpea. The broad sense heritability (H^2) for cowpea seed protein was 57.8 per cent.

Santos et al. (2012) reported transgressive segregation for seed protein content in the F_2 population of cowpea cross IT97K-1042-3 \times Canapu, with individual plants displaying up to 34.1 per cent protein content. Generation mean and variance analyses revealed additive gene effects for seed protein content. They suggested that the seed protein content in cowpea could be improved *via* standard breeding methods such as by pedigree selection or single pod descent.

Hybridisation between genetically diverse parents and selection from the transgressive segregants is found to be a promising opportunity for combining grain yield and protein content. The main objective of the present study was to select the best lines from F_4 , F_5 and F_6 generations showing high grain yield coupled with high seed protein content.

Material and methods

Hybridisation programme was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellanikkara to combine grain yield and protein content in cowpea. Hybridisation was

done in L X T mating design, with six lines and four testers, which resulted in 24 crosses (Table 1). From these hybrids, two elite hybrids, namely, H 10 (Anaswara x PKB 3) and H 11 (Anaswara x PKB 4), were identified as superior with respect to yield and protein content (Table 2). The parents PKB-3, PKB-4 (vegetable type) and Anaswara (dual purpose type) were semi-trailing in habit. These hybrids were advanced to F_2 and F_3 generations and pedigree selection imposed to select superior

Table 2. Features of selected F_1 families

Characters	H 10	H 11
Plant height (cm)	65.20	66.28
Number of branches per plant	8.20	7.92
Days to first flowering	40.35	42.20
Days to first harvest	44.29	52.38
Days to last harvest	105.34	102.39
Number of pods/plant	67.16	65.31
Length of pod (cm)	31.28	29.12
Single pod weight (g)	3.64	3.52
Number of seeds / pod	19.57	20.05
Hundred seed weight (g)	23.57	21.20
Grain yield/ plant (g)	155.55	146.20
Protein content (%)	30.03	30.06

individual plants with high yield and protein content. From the F_2 generation of these two crosses, 23 lines were selected based on number of pods, total grain yield and protein content. They were eight lines from the H 10 (Anaswara x PKB 3) population and fifteen lines from the H 11 (Anaswara x PKB 4) populations. Further screening of F_3 generation, twenty three lines were selected, which included 11 lines from cross H10 and 12 lines from cross H11. These twenty three plants selected from F_3 generation of two crosses constituted the material for the study.

Twenty seeds each of the 23 lines selected from F_3 , along with parent Anaswara were sown in the

Table 1. Genotypes used in Line x Tester mating design

Line/ Tester	AV-5 (T1)	PKB-3 (T2)	PKB-4 (T3)	Sharika (T4)
Vellayani Jyothika (L1)	H1	H2	H3	H4
Bhagyalakshmi (L2)	H5	H6	H7	H8
Anaswara (L3)	H9	H10	H11	H12
Vyjayanthi (L4)	H13	H14	H15	H16
Lola (L5)	H17	H18	H19	H20
Kanakamony (L6)	H21	H22	H23	H24

experimental field on 25-10-2017 (early rabi season). The plot size was 240 m². The row-to-row distance was 50 cm and the plant-to-plant distance was 50 cm. All field and intercultural operations like main field preparation, manuring, irrigation, weeding and plant protection were followed according to the recommended package of practices of KAU (2011). The pedigree of the experimental material is as in Figure 1.

Similarly, F₅ and F₆ generations were evaluated with 20 plants per selected line from preceding

generations. The F₅ generation was raised during kharif season and F₆ generation during late rabi season. Observations were recorded on 12 characters *viz.* plant height (cm), number of branches, days to first flowering, days to first harvest, days to last harvest, number of pods per plant, length of pod (cm), pod weight (g), number of seeds per pod, hundred seed weight (g), grain yield per plant (g) and protein content (%). The protein content of seeds for each individual plant was estimated by Lowry’s method (Sadasivam and Manickam, 2008). In F₆ generation, in addition to the 12 characters, fibre content of green pods (husk alone from pods at vegetable harvest stage) of promising plants was estimated. Also, organoleptic evaluation was carried out on cooked green cowpea pods (vegetable cowpea) from the superior plants identified in F₆ generation to find its utility as vegetable type.

Results and Discussion

Progeny of 23 lines derived from F₃ generation were evaluated and genetic parameters on F₄ population of H10 and H11 (Table 3 and 4) were estimated. Sivasubramanian and Madhavamenon (1973) classified PCV and GCV as follows: Low : < 10 per cent, Moderate : 10-20 per cent, High : > 20 per cent. Characters like length of pod, pod weight, number of seeds/pod, hundred seed weight and grain yield exhibited moderate to high genetic coefficient of variance (GCV) in F₄ of H10, which indicated

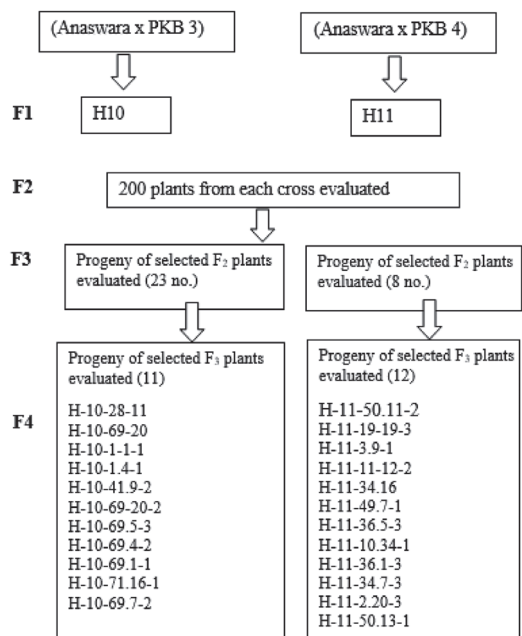


Figure 1. Pedigree of study material

Table 3. Genetic parameters in F₄ generation of H10

Characters	Phenotypic variance	Genotypic variance	Environmental variance	PCV (%)	GCV (%)	H ²	GA	GAM (%)
Plant height (cm)	493.43	48.74	444.69	19.36	6.08	9.87	4.52	3.94
Number of branches	0.51	0.07	0.44	19.56	7.06	13.04	0.19	5.22
Days to first flowering	8.02	1.69	6.33	6.06	2.77	21.02	1.23	2.62
Days to first harvest	13.31	9.22	4.09	5.38	4.48	69.26	5.20	7.68
Days to last harvest	24.43	19.16	5.27	5.09	4.50	78.43	7.99	8.22
Number of pods/plant	15.76	11.56	4.20	11.21	9.60	73.35	5.99	16.91
Length of pod (cm)	14.18	6.67	7.51	20.37	12.83	39.71	3.08	16.65
Pod weight (g)	0.35	0.13	0.22	29.81	17.99	36.42	0.44	22.35
Number of seeds / pod	5.32	2.62	2.70	16.84	11.82	49.27	2.34	17.07
Test weight (g)	7.78	7.62	0.16	15.85	15.69	98.00	5.63	31.97
Grain yield/ plant (g)	791.99	666.97	125.02	32.45	29.77	84.21	48.80	56.26
Protein content (%)	2.04	1.46	0.58	5.97	5.05	71.56	2.11	8.82

Table 4. Genetic parameters in F₄ generation of H11

Characters	Phenotypic variance	Genotypic variance	Environmental variance	PCV (%)	GCV (%)	H ²	GA	GAM (%)
Plant height (cm)	569.21	124.52	444.69	20.48	9.57	21.87	10.75	9.22
Number of branches	0.45	0.01	0.44	18.56	2.89	2.43	0.18	5.02
Days to first flowering	7.68	1.35	6.33	5.94	2.49	17.57	1.00	2.15
Days to first harvest	6.26	2.17	4.09	3.72	2.19	34.46	1.78	2.64
Days to last harvest	21.67	16.40	5.27	4.83	4.19	75.68	7.26	7.53
Number of pods/plant	11.64	7.44	4.20	9.72	7.77	63.91	4.49	12.79
Length of pod (cm)	7.64	0.13	7.51	14.10	1.83	1.70	0.10	0.49
Pod weight (g)	0.22	0.00	0.22	24.76	0.00	0.00	0.00	0.00
Number of seeds/pod	4.95	2.25	2.70	16.27	10.97	45.45	2.08	15.20
Test weight (g)	4.88	4.72	0.16	12.29	12.08	96.72	4.40	24.50
Grain yield/ plant (g)	673.98	548.96	125.02	29.64	26.74	81.45	43.55	49.70
Protein content (%)	1.78	1.20	0.58	5.74	4.71	67.41	1.86	8.01

scope for selection for these characters. In F₄ of H11, number of pods per plant, number of seeds per pod, hundred seed weight and grain yield/plant exhibited moderate to high GCV.

Yield is a complex trait determined by many component characters, having low heritability. In crop improvement programmes, breeders choose to have simultaneous selection for many contributing characters in addition to the major characters like yield that is more likely to be influenced by environment. Selection for yield and its associated components can improve the efficiency of selection in plant breeding programmes (Romanus et al., 2008).

According to Johnson et al. (1955) heritability is classified as follows: Low : < 30 per cent, Moderate : 30-60 per cent, High : > 60 per cent. They classified genetic advance as per cent of mean as follows: Low : < 10 per cent, Moderate : 10-20 per cent, High : > 20 per cent. High heritability coupled with high genetic advance indicates additive gene effect and thus selection for character will be effective. High heritability accompanied by low genetic advance is an indicative of non-additive gene action and selection will not be rewarding. In the present study, in F₄ generation, high heritability coupled with high genetic advance was given by test weight and grain yield per plant in both the crosses, so selection for

these characters was effective. Number of pods per plant and number of seeds per pod gave high heritability accompanied by moderate genetic advance, indicating scope for selection for these characters.

Based on the observed pattern of genetic variability, heritability and genetic advance of different characters, selection criteria were developed, consisting of a combination of five factors *i.e.* number of pods/plant, total grain yield/plant, seeds per plant, hundred seed weight and seed protein content. Since less variability and heritability were observed for protein content, and it was found to be influenced by environment, minimum value was given in the criteria, so that no valuable germplasm (yield) was lost during selection. The criteria were developed such that it was superior to the parent Anaswara. Individual plants having minimum of the set value for these four factors were selected and forwarded to the next generation. Singh and Mehndiratta (1970) reported that discriminant function of three components such as number of pods/plant, number of grains/pod and 100-grain weight resulted in 33.3 per cent more efficiency than direct selection for grain yield. Wilson (2004) suggested the independent manipulation of yield and protein content, so that improvement could be achieved through the selection of individual lines that presented either intermediate grain yield and

protein content values or mean values above that of the experimental means.

The selection criteria were as follows:

Number of pods/ plant: > 34

Number of seeds per pod:>15

Hundred seed weight:>14.5g

Grain yield / plant: > 100 g / plant

Protein content: > 20%

The details of the selected individual plants of crosses H10 and H11 are given in Table 5 and Table 6. The grain yield of selected plants varied from 103.53g to 164.17g per plant and protein content varied from 20.64 per cent to 27.40 per cent. The superior plants identified from F₄ generation were

forwarded to F₅ generation, and 20 plants each of the above listed plants were evaluated along with check parent Anaswara.

Based on the segregation pattern observed, the plants were grouped into two different categories in F₅ generation- one with medium long pods and small seeds closely packed within the pod, and the other type with long fleshy pods and bold seeds. Cowpea seeds are classified into small (<12 g/100 seeds), medium (12-18 g/100 seeds) and large (<18 g/100 seeds) (Drabo et al., 1984). The type of pods are shown in Fig.2.

Hence, separate selection criteria were developed for both the types consisting of characters like

Table 5. Features of individual cowpea plants selected from F₄ generation of cross H 10

Plant	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/ plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/ plant (g)	Protein content (%)
H-10-71.16-1-9	126	5	43	67	100	41	24.50	3.13	17.50	21.20	152.11	25.88
H-10-71.16-1-15	170	4	45	68	93	37	27.00	4.60	17.50	21.20	137.27	26.83
H-10-69.1-1-7	116	3	44	67	98	39	18.00	2.20	16.90	17.80	124.95	23.46
H-10-69.1-1-16	135	5	43	66	93	45	17.75	2.39	18.25	15.80	129.75	23.85
H-10-69-5-3-5	110	4	46	57	108	45	17.50	1.98	16.00	14.70	105.80	23.42
H-10-69-5-3-17	120	4	46	67	97	42	18.00	2.07	17.00	14.50	103.53	22.89
H-10-69-5-3-18	120	5	41	57	100	44	14.80	1.90	17.00	14.20	105.30	22.65
H-10-1.4-1-19	145	4	44	61	106	43	18.00	2.26	15.80	16.10	109.38	25.90
H-10-69.7-2-18	155	5	45	69	93	44	24.00	3.04	18.25	18.80	150.96	22.80
H-10-69.7-2-17	140	5	44	69	92	41	28.30	3.80	20.00	19.70	161.54	23.12
H-10-69.7-2-14	135	4	45	66	100	44	20.30	2.50	16.50	22.20	161.17	27.40
H-10-69.7-2-16	150	4	45	69	106	38	24.00	2.50	16.10	23.00	140.07	23.05
H-10-1.4-1-18	120	4	45	67	93	43	17.50	1.95	15.60	16.10	105.30	23.29
Anaswara	124.16	3.41	44.83	65.50	96.00	36.25	20.55	2.49	14.21	17.74	91.36	22.8
Mean of F ₄ of H10	114.68	3.64	46.75	67.83	97.18	35.41	18.49	1.97	13.70	17.60	86.74	23.90
Range in F ₄	80.0-192.0	3.0-6.0	41.0-54.0	56.0-79.0	82.0-110.0	29.0-45.0	10.0-28.3	1.1-4.6	9.5-20.0	10.3-24.9	47.9-161.5	

Table 6. Features of individual cowpea plants selected from F₄ generation of cross H 11

Plant	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/ plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/ plant (g)	Protein content (%)
H-11-3.9-1-1	115	4	45	67	85	44	19.20	2.15	17.01	19.80	148.19	25.18
H-11-3.9-1-7	110	4	44	70	95	38	18.00	2.40	17.20	16.30	105.20	22.80
H-11-3.9-1-10	84	3	51	68	95	37	21.00	2.20	18.10	15.60	104.47	25.25
H-11-2.20-3-14	140	3	51	66	100	44	24.80	2.58	17.60	21.20	164.17	26.42
H-11-10.34-1-16	170	5	44	68	100	41	23.20	2.90	16.80	23.00	158.42	24.29
H-11-10.34-1-18	135	4	49	66	96	41	20.75	2.98	15.02	23.80	146.56	26.23
H-11-36.5-3-8	120	3	43	65	95	41	22.50	2.75	17.00	19.50	135.91	20.64
H-11-36.5-3-15	129	3	45	68	103	39	21.00	3.25	17.00	20.80	137.90	20.99
H-11-49.7-1-8	130	4	50	69	98	37	24.20	2.90	16.50	17.50	117.52	23.80
H-11-34.16-15	155	3	45	71	101	34	25.00	2.80	17.20	21.40	125.14	24.50
Mean of F ₄ of H11	116.52	3.62	46.63	67.21	96.46	35.10	19.60	1.89	13.67	17.97	87.59	23.24
Range in F ₄	80.0-190.0	3.0-6.0	41.0-55.0	60.0-75.0	79.0-106.0	30.0-44.0	10.5-26.5	1.1-3.6	9.2-19.1	12.1-23.8	47.1-169.5	



Type 2

Number of pods - 30
 Number of seeds/ pod -15
 Pod length-24 cm
 Hundred seed weight-14g
 Grain yield - 90g/plant
 Protein – 22%

The features of the selected plants from H10 and H11 are listed in Table 7 and Table 8. The grain yield of selected plants ranged between 85.20 g and 106.1 g per plant and protein ranged between 22.50 per cent and 26.10 per cent. The selected plants were forwarded to F_6 generation and 20 plants per selected line were evaluated. Using the same set of traits in the selection criteria, five superior plants were selected, one from cross H10 and four from cross H11. The selection criteria were as follows.

Type 1

Number of pods - 40
 Number of seeds/ pod – 16
 Pod length- 21 cm
 Hundred seed weight- 14.5g
 Grain yield - 105g/plant
 Protein – 20%

Type 2

Number of pods - 35
 Number of seeds/ pod -16
 Pod length-26cm
 Hundred seed weight- 17.5g
 Grain yield - 110g/plant
 Protein - 21%

Figure 2. Two types of pods obtained

number of pods, number of seeds per pod, pod length, hundred seed weight, grain yield and protein content. Based on these set criteria, five individual plants from cross H10 (one type 1 and four type 2) and 17 plants from cross H11 (five type 1 and twelve type 2) were selected and forwarded to F_6 generation. The selection criteria were as follows.

Type 1

Number of pods - 35
 Number of seeds/ pod – 16
 Pod length –20 cm
 Hundred seed weight-11.5g
 Grain yield - 85g/plant
 Protein – 22%

Table 7. Features of individual cowpea plants selected from F_5 generation of cross H 10

Plant	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/ plant	Length of pod (cm)	Pod weight (g)	No. of seeds/ pod	Test weight (g)	Grain yield/ plant (g)	Protein content (%)
H-10-71-16-1-9-15	240.00	7.00	55.00	73.00	115.00	33.00	27.30	3.65	17.60	17.52	102.50	24.03
H-10-69.5-3-18-12	184.00	4.00	54.00	73.00	114.00	36.00	21.50	3.12	18.50	14.80	98.56	22.50
H-10-71.16-1-15-10	262.00	4.00	55.00	73.00	123.00	36.00	26.20	3.80	17.50	16.90	99.56	25.90
H-10-69.7-2-16-15	190.00	4.00	54.00	73.00	123.00	32.00	27.60	3.89	18.20	16.20	94.60	25.40
H-10-69.7-2-14-10	185.00	4.00	55.00	74.00	124.00	30.00	28.00	3.80	18.50	14.10	90.60	24.80
Anaswara	202.21	3.16	59.63	78.47	127.84	29.79	25.15	2.50	15.75	14.55	68.66	23.80
Mean of F_5 of H10	169.37	3.41	59.36	78.71	121.59	30.92	21.48	2.30	15.89	13.07	65.23	23.99
Range in F_5	128.0-262.0	3.0-7.0	51.0-67.0	71.0-86.0	112.0-132.0	26.0-36.0	17.0-28.0	1.43-3.89	13.0-19.8	10.45-17.52	47.48-102.5	

Table 8. Features of individual cowpea plants selected from F₅ generation of cross H 11

Plant	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/plant (g)	Protein content (%)
H-11-10.34-1-16-11	220.00	3.00	55.00	73.00	135.00	35.00	27.00	2.95	15.50	17.44	91.88	25.40
H-11-2.20-3-14-13	295.00	5.00	53.00	73.00	126.00	38.00	26.50	2.30	15.60	16.02	96.44	23.70
H-11-2.20-3-14-16	290.00	6.00	53.00	73.00	124.00	38.00	26.66	2.28	15.75	16.27	98.40	24.80
H-11-2.20-3-14-7	181.00	4.00	65.00	84.00	130.00	32.00	24.10	1.68	16.80	15.80	90.10	23.80
H-11-3.9-1-1-11	251.00	4.00	54.00	78.00	118.00	38.00	20.50	1.97	16.30	12.63	85.80	26.10
H-11-3.9-1-1-12	210.00	4.00	53.00	73.00	115.00	40.00	20.60	2.20	17.60	11.86	85.20	23.40
H-11-3.9-1-1-18	260.00	4.00	52.00	73.00	114.00	40.00	21.10	2.34	18.10	12.12	90.10	26.10
H-11-3.9-1-1-19	261.00	4.00	53.00	73.00	114.00	40.00	21.20	2.32	18.20	11.34	85.55	23.80
H-11-10.34-1-18-16	265.00	5.00	54.00	73.00	123.00	34.00	27.60	2.99	18.20	14.38	90.98	24.50
H-11-10.34-1-18-17	260.00	5.00	52.00	73.00	121.00	36.00	26.30	2.00	15.90	14.90	90.50	24.70
H-11-34-16-1-15-13	210.00	3.00	57.00	73.00	116.00	34.00	26.80	3.40	18.00	16.30	99.75	23.70
H-11-36.5-3-15-1	210.00	4.00	56.00	73.00	115.00	32.00	27.00	3.80	16.00	17.30	90.57	23.80
H-11-36.5-3-15-2	250.00	5.00	53.00	73.00	115.00	35.00	26.70	3.89	17.10	16.80	100.54	24.10
H-11-36.5-3-15-16	260.00	5.00	52.00	73.00	115.00	33.00	26.40	3.67	16.80	15.20	90.26	23.50
H-11-3.9-1-7-13	201.00	5.00	57.00	73.00	120.00	34.00	22.00	3.19	18.00	14.80	90.28	23.80
H-11-49.7-1-8-10	165.00	3.00	62.00	80.00	120.00	31.00	28.30	4.73	17.60	17.40	94.50	25.30
H-11-49.7-1-8-16	235.00	5.00	57.00	74.00	124.00	33.00	28.40	3.81	18.10	17.60	106.10	25.40
Mean of F ₅ of H11	201.50	3.80	59.39	78.70	121.62	31.75	23.27	2.46	15.71	14.37	72.43	24.42
Range in F ₅	130.0-310.0	3.0-6.0	51.0-67.0	72.0-85.0	112.0-135.0	26.0-40.0	18.0-28.4	1.38-4.73	13.1-19.0	10.4-18.2	55.4-106.1	

Table 9. Features of cowpea plants selected in F₆ generation

Plant	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/plant (g)	Protein content (%)	Green pod weight (g)	Pod husk crude fibre (%)
Type 1														
H11-3.9-1-7-13-7	150	5	59	78	120	43	22	3.17	18	14.50	105.00	23.40	6.72	35.10
H11-3.9-1-1-18-13	180	4	65	85	105	43	21	3.27	19	14.80	120.82	20.53	6.80	37.80
Type 2														
H11-49.7-1-8-10-15	204	6	50	71	112	42	28	3.92	18	20.23	152.60	25.50	11.90	31.44
H10-71-16-1-9-15-12	162	4	57	74	112	37	27	4.07	16	19.20	113.50	21.87	11.75	32.52
H11-2.20-3-14-16-12	169	3	53	71	102	37	26	3.85	17	17.68	112.50	24.40	11.30	30.80
Anaswara	115	3.16	63.50	83.50	111	28.83	25.35	3.28	15.35	17.61	80.27	23.65	10.80	36.93

Green pod weight at vegetable harvest stage and crude fibre in pod husk at green tender stage were estimated in the selected plants and compared to parent Anaswara. The green pod weight in type 1 was near to 11.00 g, whereas of type 2 was around 6.70g. Pod husk fibre content also ranged from 30.80 to 37.80 per cent. The features of the selected plants are given in the Table 9. The grain yield of



Figure 4. Pods of selected plants

selected plants ranged between 105.00g to 152.60g and protein content ranged between 20.53 per cent and 25.50 per cent. Seeds and pods of selected plants are presented in Figures 3 and 4 respectively.

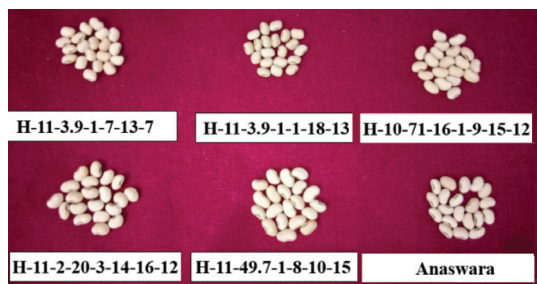


Figure 3. Seeds of selected plants

The selected plants from F₆ generation were subjected to organoleptic evaluation to find their

Table 10. Average scores recorded in organoleptic evaluation

Plant number	Appearance	Texture	Colour	Taste	Overall acceptability
H11-3.9-1-7-13-7	6.62	6.63	6.95	6.20	6.41
H11-3.9-1-1-18-13	5.87	5.87	6.12	5.87	6.03
H11-49.7-1-8-10-15	6.12	5.91	6.38	6.05	6.30
H11-2-20-3-14-16-12	6.81	6.72	6.87	6.93	7.09
H10-71-16-1-9-15-12	6.52	6.74	6.89	6.60	6.68
Anaswara	6.35	6.23	6.77	6.58	6.47

suitability for use for vegetable purpose. The average scores obtained for various parameters as recorded by a panel of 15 members in nine-point hedonic scale are given in Table 10.

Three plants of type 2 and one plant from type 1 were found promising to be used as a dual purpose type with high grain yield and protein content on par with Anaswara.

Variance for each of the characters within the F_6 families was estimated to evaluate the homogeneity

of the lines and data are given in Tables 11 and 12. Analysing variance values in F_6 generation families, variance within most of the families were comparable to that of Anaswara for number of branches, number of pods per plant, length of pod, pod weight, number of seeds per pod, test weight, grain yield and seed protein content. This indicated that families were homogeneous and did not segregate further. Considering mean values of selected families (Table 13), it was observed that the families exhibited higher mean values than parent Anaswara for characters like number of pods

Table 11. Variance of F_6 families of cross H10

	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/ plant (g)	Protein content (%)
H10-69.5-3-18-12	2407.36	1.25	7.87	11.85	7.42	3.62	0.82	0.03	0.41	0.33	9.16	1.10
H10-71.16-1-15-10	174.10	2.10	61.57	28.62	3.66	1.88	1.34	0.48	1.05	0.20	55.91	0.52
H10-71-16-1-9-15	853.17	1.88	17.97	19.90	6.15	10.63	1.90	0.09	0.47	0.75	144.67	5.34
H10-69.7-2-16-15	569.41	0.41	20.00	11.43	5.84	8.21	0.89	0.14	0.85	1.41	93.02	1.20
H10-69.7-2-14-10	532.11	1.78	5.28	2.11	5.44	6.94	0.18	0.01	0.26	0.24	36.28	0.80
Anaswara	923.61	0.88	8.27	5.91	6.15	8.15	0.63	0.11	1.34	0.26	216.44	0.55

Table 12. Variance of F_6 families of cross H11

	Plant height (cm)	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/plant	Length of pod (cm)	Pod weight (g)	No. of seeds / pod	Test weight (g)	Grain yield/ plant (g)	Protein content (%)
H11-2-20-3-14-13	286.21	0.50	0.50	3.36	7.70	2.21	0.18	0.03	0.19	0.20	23.52	0.56
H11-34-16-1-15-13	1605.14	1.00	7.47	10.53	6.76	9.59	1.06	0.11	0.75	1.46	97.87	0.82
H11-2-20-3-14-16	2353.74	1.55	29.46	29.69	35.41	14.69	0.67	0.09	0.75	0.56	171.48	0.18
H11-36.5-3-15-2	1650.00	1.11	6.11	3.78	2.11	6.69	0.57	0.02	0.36	0.25	71.90	0.64
H11-3.9-1-1-19	277.90	1.33	19.48	25.00	5.29	0.90	2.71	0.03	2.52	0.21	35.02	0.87
H11-49.7-1-8-10	2294.42	2.75	25.48	33.34	10.84	7.76	3.94	0.18	1.96	1.26	390.43	1.48
H11-3.9-1-1-11	294.86	3.10	32.86	27.47	9.23	5.47	2.57	0.05	1.47	0.36	86.35	0.50
H11-36.5-3-15-1	1135.86	0.25	12.36	10.69	4.50	6.11	1.86	0.03	0.61	0.78	82.68	1.12
H11-10.34-1-16-11	1723.61	2.28	47.25	13.36	6.25	6.61	2.61	0.06	0.30	1.34	124.51	2.00
H11-36.5-3-15-16	411.16	1.51	14.32	15.88	11.79	2.90	0.53	0.11	0.42	0.58	18.17	0.82
H11-49.7-1-8-16	2010.30	0.80	0.70	5.00	8.80	2.30	0.34	0.09	0.03	0.19	11.25	0.62
H11-3.9-1-1-12	578.02	1.72	12.15	11.11	4.42	4.27	2.08	0.13	1.54	0.84	84.60	1.21
H11-3.9-1-1-18	3112.28	2.25	5.86	20.94	16.44	10.11	2.17	0.25	2.06	0.72	316.26	0.56
H11-10.34-1-18-16	1706.67	1.87	1.87	3.20	1.07	8.00	0.83	0.19	0.25	0.13	76.22	0.85
H11-2-20-3-14-7	613.17	1.39	6.01	18.90	4.27	7.16	0.93	0.12	0.52	0.20	92.30	0.65
H11-3.9-1-7-13	1192.84	0.95	24.80	36.64	27.03	5.67	3.72	0.16	1.36	0.54	133.75	1.81
H11-10.34-1-18-17	426.00	0.48	27.81	25.90	9.57	2.62	0.48	0.17	0.74	1.99	86.56	0.24
Anaswara	923.61	0.88	8.27	5.91	6.15	8.15	0.63	0.11	1.34	0.26	216.44	0.55

Table 13. Family mean values for selected plants in F₆

	Plant height	No. of branches	Days to first flowering	Days to first harvest	Days to last harvest	No. of pods/plant	Length of pod (cm)	Pod weight	No. of seeds / pod	Test weight	Grain yield/plant	Protein content
Type 1												
H11-3.9-1-7-13	85.7	4.21	57.2	74.8	110	39.9	19.2	2.52*	16.6*	12.9	85	22.2
H11-3.9-1-1-18	93.6	3.00	62.9	81.8	111	38.1	18.1	2.35*	15.4	12.8	77	20.5
Type 2												
H11-49.7-1-8-10	138	3.85	57.4	77.4	107	36.1	25.6	3.78*	15.6	18.3	102*	23.8
H11-2-20-3-14-16	146	3.13	61.2	80.4	110	30.2	25.6	3.61	15.3	18.3	87.4	24.1
H10-71-16-1-9-15	106	3.33	57.2	76.4	109	31.6	25.6	3.66	15.3	18.5	89	23.9
Anaswara	119	3.17	63.5	83.5	111	28.8	25.4	3.29	15.2	17.6	80.9	23.7

per plant, number of seeds per pod, pod weight (type 2) and test weight (type 2). Type 1 plants belonged to medium seed type and type 2 to large seed type as per classification given by Drabo et al. (1984). Plant height (type 1), days to first flowering, days to first harvest and days to last harvest exhibited lower mean value than Anaswara. So the pedigree selection done in F₄ and F₅ generations resulted in positive shift for characters like grain yield, number of pods per plant, and number of seeds per pod. Also selection resulted in negative shift for characters like days to first flowering, days to first harvest and days to last harvest. Seed protein content did not exhibit much gain; the family averages of selected lines were on par with Anaswara. Also, sufficient homozygosity had been achieved in F₆ generation.

Five lines identified with high yield and moderate seed protein were found to be superior to Anaswara and could be used as dual purpose. The identified lines were H11-3.9-1-7-13-7, H11-3.9-1-1-18-13, H11-49.7-1-8-10-15, H10-71-16-1-9-15-12, and H11-2-20-3-14-16-12. Identified plants could be evaluated in replicated yield trials and tested for stability over locations and seasons.

Acknowledgement

The first author is thankful to Kerala Agricultural University for providing research fellowship for conducting the research.

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