Engineering and Scientific International Journal (ESIJ)
Volume 9, Issue 1, January – March 2022
ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Segregation of Flower and Pod Colour Inheritance in F2 and F3 Generations of Cowpea (Vigna unguiculata (L.) Walp.)

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Abstract— Cowpea (Vigna unguiculata L. Walp) is a multi-purpose, underutilized legume crop mostly grown in dry tropical areas. It is one of the most important food legume crops, exhibits considerable morphological variability in its wild as well as cultivated forms. The present investigation was carried out in F 1 , F 2 and F 3 generations of four inter sub-specific crosses (RC101×Vyjayanthi, RC101× Vellayani jyothica, ACM 05-02×Ettumanoor local and ACM 05-07× Vyjayanthi) of cowpea to study the inheritance pattern of flower pod colour in F 2 and F 3 generations. Inheritance of flower colour and pod colour in cowpea has followed a qualitative pattern. Purple flower colour is dominant over white colour flower whereas, purple colour pod is partially dominant over green pod colour. A segregation ratio of 3 purple: 1 white flower colour in F2 generation of two crosses indicated that white flower colour is controlled by single recessive. Whereas segregation ratio of F2 1 green; 2 Light purple: 1 purple colour pod indicated that purple colour pod is partially dominant over green pod colour and it's governed by single gene.

Keywords *— Cowpea; Flower Colour; Food Legume Crops.*

1. Introduction

Cowpea [Vigna unguiculata (L.) Walp.], Fabaceae (2n = 2x =22)] is an important dual purpose (food and forage) legume crop widely grown under low input production systems and in arid and semi-arid agro-ecologies of the world. It is eaten as a grain pulse, green pod and green seeds (Belay and Fisseha, 2021). Cowpea can be grown quite successfully under conditions that are totally unsuitable for the common bean Pandiyan et al. (2020). It is cultivated on about 14.5 million hectares on the world'sarable land, with an annual grain production of 6.2 million metric tons, and out of this, Africa accounts for 83.4 % (Kebede and Bekeko, 2020; Owusu et al. 2021). As a legume, it is also an important component of traditional cropping systems since rhizobium facilitation fixes atmospheric nitrogen and contributes to soil fertility improvement, particularly in smallholder farming systems where little or no fertilizer is used. Cowpea fits well in a variety of cropping systems and is grown as cover crop, mixed crop, catch crop and green manure crop. Cowpea also serves as an ideal crop for soil and water conservation because of its ability to grow fast and cover the soil surface quickly (Eswaran et al. 2007). Although cowpea is known to be drought tolerant when compared to other crops, the productivity of cowpea varieties is hampered by erratic rainfall, and many are sensible to high temperatures. However grain yield of this legume varies widely when grown at different location. Cowpea is extensively grown in India particularly in the states of Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu.

The productivity potential of cowpea in Tamil Nadu is low 265 kg/ha as compared to the national productivity. This clearly indicates the necessity to identify the reason for such a low productivity in India and particularly in Tamil Nadu. Three distinct botanical varieties of the cultivated cowpea are recognised (Faris, 1965). V.unguiculata var. unguiculata, the catjang cowpea is the primitive of all the varieties and predominance in Africa. The pods are 80 – 130 cm long and erect. V.unguiculata var. sinensis, the common cowpea has most of its form in Africa where the crop is more highly specialised. The pods are 200 – 300 m in length. V.unguiculata var. sesquipedalis, the yard long bean or asparagus bean is most widely grown in the Far East, mostly for its immature pods. The pod is 30 – 100 cm long. However, there is little justification in upgrading them to the specific rank since the three can be crossed freely and free gene flow is possible.

Pods have different colours but consumer's preference is for green pod colour for vegetable purpose. The principle flower colours in Cowpea are dark, pale, tinged or white. Flower colour and pod colour being less influenced by environmental variations are used as markers in the identification of species or varieties. Pigmentation is a common feature of cowpea and its presence is due to the anthocyanin pigment. This soluble compound imparts purple colour on the shoot, pods and petals of cowpea. Limited works have been carried out on the inheritance of flower colour and pod colour in cowpea, therefore, the present investigation was carried out.

DOI: **10.30726/esij/v9.i1.2022.91003**

ISSN 2394-7187(Online)
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2. Materials and Methods

Two true breeding genetically diverse lines of cowpea namely, ACM 05-02 (cream colour flower and green colour pod with purple tip) and ACM 05-07 (light purple colour flower and green colour pod) were developed from Agricultural College and Research Institute, Madurai, one national variety RC 101 (white colour flower and green colour pod) developed from Central Arid Zone Research Institute, Jodhpur and three local varieties namely, Vyjayanthi (purple colour flower and purple colour seed), Vellayani jyothica (pale yellow colour flower and green pod) and Ettumanoor local (cream with purple flower and green pod) were collected from Kerala were chosen for this study. Advanced lines and national variety were characterized by dwarf, early flowering with short pod and grain (*V. unguiculata subspecies sinensis)* types and local varieties were characterized by climber, late flowering with long pod and vegetable (*V. unguiculata subspecies sesquipedalis).* An investigation was carried out in F_1, F_2 and F_3 generations of four inter sub-specific crosses (RC101×Vyjayanthi, RC101× Vellayani jyothica, ACM 05-02×Ettumanoor local and ACM 05-07× Vyjayanthi) of cowpea. In these crosses RC 101, ACM 05-02 and ACM 05-07 were grain type parents and Vyjayanthi, Vellayani jyothica and Ettumanoor local were vegetable parents which are having long purple pods in the climbers. The cross combinations were effected, the hybrids F_1, F_2 and F_3 progenies were evaluated along with their parents. Four crosses for the study of flower colour and pod colour comprising F_1, F_2 and F_3 generations were developed. The materials were grown in Randomized Block Design with three replications during main rainy season at Agricultural College and Research Institute, Madurai with row to row spacing of 90 cm and plant to plant spacing of 20 cm. There were single row of the non-segregating generations (P1, P2 &F_1) and eight rows of F_2 and F_3 generations. Flower colour and pod colour of the individual plants were recorded from the all the five generations of the four crosses Chi-square test was applied to test goodness of the fit for observed segregation ratios.

Table 1. Parents involved in the four cross combinations

S. No	Parents	Source of origin
Vigna unguiculata subspecies. sinensis		
1	RC101	Central Arid Zone Research Institute, Jodhpur
2	ACM 05 02	Agricultural College and Research Institute, Madurai.
3	ACM 05 07	Agricultural College and Research Institute, Madurai.
Vigna unguiculata subspecies. sesquipedalis		
4	Vyjayanthi	Kerala Agricultural University, Thrissur, Kerala.
5	Vellayani jyothica	Kerala Agricultural University, Vellayani, Kerala.
6	Ettumanoor local	Kerala Agricultural University, Vellayani, Kerala.

3. Results and Discussion

3.1 Flower Colour

The F_1 s *viz.,* cross 1 (RC101 × Vyjayanthi) and cross 4 (ACM 05 07 × Vyjayanthi) had purple colour flower which indicated that purple colour flower is a dominant trait. The dominant nature of purple colour over white colour was confirmed by F_2 generations. There are two distinct classes i.e., purple and white in the F2 and F3 generations (Table 2). The pattern of segregation in F2 gave a good fit to 3 purple: 1 white flower colour (Table 1). This indicated that a single recessive gene pair conditioned white flower colour in RC 101 and ACM 05-07. This further confirmed the monogenic recessive nature of white colour flower in cowpea. Jindla and Singh (1970) and Hanchinal and Goud (1978) reported dominant nature of violet flower colour over very light violet colour, whereas Uguru (1995) observed partial dominance of purple petal colour over white petal colour in a cross of white and purple petal coloured parents.

Harland (1919) and Spillman and Sando (1930) suggested that the R factor is essential for expression of flower colour and rr for white flower colour. Based on the above studies, the gene symbols R and rr are assigned for purple and white flower, respectively.

Table 2. Mode of segregation for flower colour in Cowpea

Cross	Generation	No. of plants			Ratio	Chi square Value	P value
		Purple	White	Total			
RC101×Vyjayanthi	F_2	206	63	269	3:1	0.357	0.70-0.50
ACM 05-07× Vyjayanthi	F_2	199	72	271	3:1	0.356	0.70-0.50

3.2 Pod colour

The F_1 s *viz.,* cross 1 (RC101 × Vyjayanthi) and cross 4 (ACM 05 07 × Vyjayanthi) had light purple colour pod. This indicated that purple colour pod is partial dominant over green colour pod. F2 segregation gave a good fit to the expected ratio of 1 green: 2 light purple: 1 purple in both the crosses (Table 2). Singh 2002, noted the monogenic dominance of brownish straw colour of pods

DOI: 10.30726/esij/v9.i1.2022.91003

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

over straw coloured pods. Premsekar and Raman (1972) found that light green pods and are conditioned by a single gene in cowpea. However, Hanchinal and Goud (1978) reported that two genes are responsible for expression of green pod colour, whereas, Uguru (1995) observed that purple colour of pods is governed by two genes in cowpea.

Table 3. Mode of segregation for pod colour in Cowpea

Cross	Generation	No. of plants				Ratio	Chi square Value	P value
		Green	Light purple	Purple	Total			
RC101×Vyjayanthi	F_2	69	135	63	267	1:2:1	0.303	0.70-0.50
ACM 05-07× Vyjayanthi	F_2	52	105	49	206	1:2:1	0.165	0.70-0.50

3.3 Segregating pattern in F_3 generations

Morphological characteristic of parents and their crosses in F_3 generation details were given in table 4 and fig. 1. Cross RC101 x Vyjayanthi RC101 had Dwarf, early flowering plant type, white coloured flowered, Short, green colour pods and dull white colour and round, small sized seeds and Vyjayanthi had Climber, late flowering plant type, purple coloured flower, long and purple colour pods and purple oval, long sized seeds. Its F_3 progenies had Dwarf late, dwarf early, medium early, medium late, tall early and tall late plant type; White, white purple shade, light purple and purple coloured flowers, Short green, short purple, medium green, medium purple, long green and long purple type pods and white colour and oval small, white colour and oval medium, white colour and oval long, black colour and round small, black colour and round medium, black colour and oval long and purple with white colour and oval long seeds besides their parental type, colour, size and shape.

In cross RC101 × Vellayani Jyothica, involving the parents RC 101 nature has Dwarf, early flowering plant type, white coloured flowered, Short, green colour pods and dull white colour and round, small sized seeds and Vellayani Jyothica had Climber, late flowering plant type, Pale yellow coloured flowers, Long, Purple type pods and Purple with white mottled and oval long sized seeds and their F_3 progenies had Short early, short late, tall early and tall late type plants, White, pale yellow with purple shade, pale yellow coloured flowers, Short green, medium green and long green type pods and White oval small, white oval medium, white motteled black, white motteled black oval small, white motteled black oval medium and brown oval medium size seeds.

The cross ACM 05 02 × Ettumanoor local F_3 progenies had Medium early and short early type plants, Cream, cream with light purple shade and cream with dark purple shade coloured flowers, Medium green with purple tip and long green with purple tip type pods and Black motteled cream oval small, black motteled cream oval medium, black motteled cream oval long, brown oval medium and brown motteled cream oval medium sized seeds. But these both parents are different from their segregants like ACM 05 02 had Medium, early flowering plant type, Cream coloured flowers, Short and green with purple tip type pods and Pure white and round, medium sized seeds and Ettumanoor local had Climber, late flowering type plants, Cream with purple coloured flowers, Long, green pods and Dark purple and long, bold sized seeds.

While in cross ACM 05 07 x Vyjayanthi ACM 05 07 had Medium, early flowering type plants, Light purple coloured flowers, Medium, green type pods and cream coloured round, small sized seeds and Vyjayanthi had Climber, late flowering type plants, purple coloured flower, long and purple colour pods and purple and oval, long sized seeds. Its F_3 progenies had cream color and oval medium, cream colour and oval long, brown colour and oval small, brown colour and oval medium, shiny dark black colour and oval medium, dark black colour and oval medium, dark black colour and round medium and purple colour and oval medium besides their parental size and shape.

Table 4. Morphological characteristic of parents and their crosses in F_3 generation

Genotypes/ Crosses	Plant type	Flower colour (Standard petal)	Pod colour	Seed colour and size
RC 101	Dwarf, early flowering	White	Short, green	Dull white and round, small
ACM 05 02	Medium, early flowering	Cream	Short and green with purple tip	Pure white and round, medium
ACM 05 07	Medium, early flowering	Light purple	Medium, green	Cream and round, small
Vyjayanthi	Climber, late flowering	purple	Long, Purple	Purple and oval, long

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Vellayani Jyothica	Climber, late flowering	Pale yellow	Long, green	Purple with white mottled and oval long
Ettumanoor local	Climber, late flowering	Cream with purple	Long, green	Dark purple and long,bold
Cross 1 (RC101 × Vyjayanthi)	Dwarf late, dwarf early, medium early, medium late, tall early and tall late,	White, and purple	Short green, short purple, medium green, medium purple, long green and long purple	White oval medium, white oval long, black round small, black round medium, black oval long and purple with white oval long
Cross 2 (RC101 × Vellayani Jyothica)	Short early, short late, tall early and tall late	White, pale yellow with purple shade, pale yellow	Short green, medium green and long green	White oval small, white oval medium, white motteled black, white motteled black oval small, white motteled black oval medium and brown oval medium
Cross 3 (ACM 05 02 × Ettumanoor local)	Medium early and short early	Cream, cream with light purple shade and cream with dark purple shade.	Medium green with purple tip and long green with purple tip	Black motteled cream oval small, black motteled cream oval medium, black motteled cream oval long, brown oval medium and brown motteled cream oval medium
Cross 4 (ACM 05 07 × Vyjayanthi)	Medium early, medium late, tall early, tall late	white and purple	Small purple, medium purple, long purple, small green, medium green and long green	Cream oval medium, cream oval long, brown oval small, brown oval medium, dark black oval medium, dark black oval medium, dark black round medium and purple oval medium.

3.4 Independent Assortment

In F_2 generation of Cross RC101 × Vyjayanthi and Cross ACM 05 07 × Vyjayanthi , each of purple as well as white coloured flowers produced pods of all the three coloured pods *viz.,* purple, light purple and green coloured pods. F2 phenotypic ratio gave a good fit to 3 purple flower and purple pods; 6 purple flower and light purple pods; 3 purple flower and green pods; 1 white flower and purple pod; 2 white flower and light purple pod; 1 white flower and green pod which confirmed that flower colour and as well as pod colour are controlled by single gene and situated on separate chromosome.

4. Conclusion

Some of the F_3 segregants in all the crosses had besides their parental type, colour, size and shapes. It will be much useful for the plant breeders to develop different coloured and various sized new cowpea genotypes in future breeding programmes.The study provides understanding of the genetic basis of inheritance of flower colour in cowpea which can be useful in future breeding programmes.

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DOI: 10.30726/esij/v9.i1.2022.91003