https://doi.org/10.29321/MAJ.10.A04633

Inheritance of Characters in Safflower—*Carthamus tinctorius* L.

By M. VENKOBA RAO,
Agricultural Research Station, Hagari

Introduction The safflower is an oil-seed crop belonging to the natural order *Compositae*. This was once grown extensively in Bengal, United Provinces, the Punjab, Bombay and the Central Provinces for the extraction of an yellow dye, carthamin, from the florets of this plant, but with the introduction of synthetic dyes, this industry has ceased to exist, and the importance of this crop has very much dwindled. It is now grown merely for the sake of its oil. The seeds when crushed yield a clear straw-coloured oil which is largely used for culinary purposes. In the Madras Presidency this crop is cultivated chiefly in the black soils of the Ceded Districts, the largest area being in the Bellary district. Little known outside the Ceded Districts it does not find a place in the Season and Crop Report of this Province. This crop is sown in October--November and is harvested by February. It is usually sown as a mixture with coriander, sorghum or wheat. As a pure crop it is sown only along the borders of fields where its spiny bracts serve as a protection against cattle trespass.

The literature regarding this crop is rather scanty. The earliest reference is in the Commercial Products of India, Watt (1908), where a general account of this crop is given and the existence of two types of plants, the spinose and the spineless, is recognised. Howard *et al* (1915) published detailed descriptions of 34 types. Subsequently Sabnis and Phatak (1935) have made a classified list of 63 types, based on the flower colours and on the nature and shape of bracts. At the Agricultural Research Station, Hagari, selection work on this crop has been in progress for some time and the mode of inheritance of a few plant characters has also been studied incidentally. The results obtained are recorded in this paper.

Spinose and spineless types In safflower two distinct types, the spinose and the spineless can be distinguished. In the spinose type the tips and margins of the involucral bracts as well as those of the upper leaves become stiff and spiny, while in the spineless the bracts and leaves are devoid of any such outgrowths. The difference between the two types becomes very marked when the flower heads appear. With regard to the genetic behaviour of these two characters mention is made in the Scientific Reports of the Pusa Institute (1931 to 1934) that the spineless behaves as a recessive to its allelomorph spinose in a 1:15 ratio as a result of duplicate factors. The inheritance of these characters were studied at Hagari in a number of artificial crosses and it was found that the spinose type behaved as a simple dominant to the spineless type (Table I).

Bloomy and bloomless types Another differentiation of types has been made out from the presence or absence of heavy bloom on the inner

bracts of the involucre. This bloom gives a whitish appearance to the plants when the flower heads appear, while plants without such bloom appear green. An examination of the several types grown at this Station showed that bloom is present in all types, the density of the deposit alone being either heavy or sparse. Sabnis and Phatak (1935) in their classification of Indian safflowers describe these two types as "Inner bracts felted and white" and "Inner bracts smooth and green". This "felted and whitish appearance" is due to the heavy deposit of whitish, waxy and hairlike out growths on the surface of the involucral bracts. A study of the segregations for these two characters showed that the heavy bloom behaves as a simple dominant to sparse bloom (Table II).

TABLE I. Segregation for Spinose and Spineless bracts

Generation	Selection number	Character of selection	Behaviour of progeny Segregating for	
			Spinose	Spineless
Parents	C. T. 53 / C. T. 62		♂	♀
F. 1	Cross 28 & 29		Spiny	
F. 2	From cross 28 :—			
	C. T. 304 & 305	Spiny	63	24
	From cross 29 :—			
	C, T. 331 to C. T. 335	"	496	156
F. 3	From C. T. 304 ; —			
	C. T. 304/1, 3, 7, 9, 11	"	525	166
	" 304/2 & 8	"	Pure	"
	" 304/6 & 10	Spineless	"	Pure
	From C. T. 305 ;—			
	C. T. 305/1, 2, 4 to 5	Spiny	649	229
	" 305/5 & 8	Spineless	"	Pure
		Total	1733	575
		Expected (3:1)	1731	577

$X^2 = 0.0092$, P between 0·95 & 0·90.

TABLE II Segregation for Heavy Bloom and Sparse Bloom

Generation	Selection number	Character of Selection	Behaviour of progeny Segregating for	
			Heavy bloom	Sparse bloom
Parents	C. T. 53 / C. T. 62		♀	♂
F. 1	Cross 28 & 29		Heavy bloom	
F. 2	From cross 28 :—			
	C. T. 304 & 305	Heavy bloom	68	19
	From cross 29 :—			
	C. T. 331 to C. T. 335	"	494	158
F. 3	From C. T. 304 :—			
	C. T. 304/1, 3, 6, 9 to 11	"	648	221
	C. T. 304/4 & 8	"	Pure	
	C. T. 304/2, 7 & 8	Sparse bloom		Pure
	From C. T. 305 :—			
	C. T. 305/1, 2, 4 to 7	Heavy bloom	659	219
	C. T. 305/3 & 8	"	Pure	
		Total	1869	617
		Expected (3:1)	1864·5	621·5

$X^2 = 0.1303$, P between 0·8 & 0·7

Linkage relationship When the interactions between the two pairs of characters, spinose and spineless and heavy bloom and sparse bloom were studied, it was found that a linkage existed between the two sets of allelomorphs with a cross-over value of 13%±2%. Table III (a) and (b) give the relevant data, in the coupling and repulsion phases respectively.

TABLE III. Linkage between spininess and bloom

Generation	Selection number	Character of selection	Behaviour of progeny Segregating for			
			Spinose		Spineless	
			Heavy bloom	Sparse bloom	Heavy bloom	Sparse bloom
		(a) Coupling phase				
Parents	} C. T. 63 } C. T. 231		♂			♀
F. 1	Cross 9		F. 1			
F. 2	From cross 9 :—					
	C. T. 291	Spinose, heavy bloom	109	11	8	30
	Expected @ 13% Cross-over		110	9	9	30
	X^2=0·6547, P between 0·95 & 0·90					
		(b) Repulsion phase				
Parents	} C. T. 53 } C. T. 62					
F. 1	Cross 28 & 29		F. 1			
F. 2	From cross 28 :—					
	C. T. 304 & C. T. 305	Spinose, heavy bloom	45	18	23	1
	From cross 29 :—					
	C. T. 331 to 335	„	339	157	155	1
F. 3	From C. T. 304 :—					
	C. T. 304/1, 3, 9 & 11	„	291	144	136	2
	From C. T. 305 :—					
	C. T. 305/1, 2, 4 to 7	„	432	217	227	2
		Total	1107	536	541	6
	Expected @ 13% cross-over		1103	539	539	9
	X^2=1·0386, P between 0·8 and 0·7					

Normal and rosette types In the course of these studies one late type, C. T. 12, was isolated, which had numerous close-set radial leaves resulting in a rosette-like appearance. The plants of this type were similar to the erect and late types, Nos. 1, 2, 5 and 15 among the Pusa types (Howard *et al*, and Sabnis and Phatak). The genetic behaviour of this type of plant-habit was studied and the data are presented in Table IV. It would be seen that Rosette is a simple recessive to the normal type and is also inherited independently of spininess.

TABLE IV

Generation	Family number	Character of selection	Behaviour of progeny Segregating for			
			Spinose		Spineless	
			Normal	Rosette	Normal	Rosette
Parent	C. T. 12					♀
F. 1	Natural cross		F. 1			
F. 2	C. T. 81	Spinose, normal	199	59	56	21
F. 3	From C. T. 81—					
	C. T. 143 to C. T. 148	,,	795	290	272	104
		Total	994	349	328	125
		Expected (9 : 3 : 3 : 1)	1010·25	336·75	336·75	112·25
			X^2 = 2·3827, P between 0·5 and 0·			
	C. T. 150	Spinose, normal	Pure			
	C. T. 149	,,	106	34		
		Expected (3 : 1)	105	35		
			X^2 = 0·116, P between 0·8 and 0·			
	C. T. 152	Spinose, rosette		Pure		
	C. T. 151, 153 and 154	,,		222		66
		Expected (3 : 1)		216		72
				X^2 = 2·000, P between 0·2 and 0·1		
	C. T. 155 and 156	Spineless, normal			Pure	
	C. T. 157 and 158	,,			536	185
		Expected (3 : 1)			540·75	180·25
					X^2 = 0·5004, P between 0·5 and 0·3	
	C. T. 159 and 160	Spineless, rosette				Pure

Floret colours The flowers in *Carthamus tinctorius* are arranged in composite heads. The florets, which are all tubular in this genus, exhibit four different colours ranging from white to orange. The existence of such colour differences has been recorded by Howard, Howard and Khan (1915) and their description of the Pusa types is based mainly on these variations in flower colours. Sabnis and Phatak (1935) also, have taken the floret colour-groups as the basis for their classification of Indian safflowers.

The colour groups referred to above are as follows:—

(i) *Orange* Florets yellow when fresh, developing a reddish tint on fading and drying finally to orange. This is the commonest and most predominant type in the Bellary area. The flower buds are yellow, but these too, if injured develop a reddish colour at the tips.

(ii) *Red* Florets reddish orange while fresh and deep red on drying.

(iii) *Yellow* Florets yellow both when fresh and dry. Both the buds and florets resemble type (i) when fresh, but does not change colour on drying.

(iv) *White* Florets white, which when dry turn creamy white.

These four types have been described by Sabnis and Phatak as (i) florets yellow, turning red on fading, (ii) florets reddish orange, turning to deep red on fading, (iii) florets yellow turning to brownish yellow on fading and (iv) florets white.

These four types can easily be distinguished, the colours being quite stable and recognisable even long after the plants have matured and dried up. In the inheritance studies recorded below, orange, red, yellow and white refer to the colour of the dry florets.

Inheritance of floret colours Mention is made in the Scientific Reports of the Pusa Institute (1935-36) that orange and yellow are both dominant to white. At this station, numerous single-factor segregations for flower colours, have been recorded, from various natural and artificial crosses. These are summarised in Table V below.

TABLE V

Colour groups	No. of families Studied	Actual numbers	Expected numbers on 3:1 ratio	X^2	Probability
					P between
1. Yellow & white	4	477:152	472:157	0·2336	0·5 & 0·7
2. Red & white	10	1347:430	1333:444	0·6186	0·3 & 0·5
3. Red & yellow	5	418:130	411:137	0·4764	0·3 & 0·5
4. Orange & white	2	410:132	407:135	0·1206	0·7 & 0·8
5. Orange & yellow	7	778:253	773:258	0·0934	0·7 & 0·8
6. Orange & red	14	1753:579	1749:583	0·0092	0·9 & 0·95

It is seen from the table that (1) orange is dominant to red, yellow and white, (2) red is dominant to yellow and white and (3) yellow is dominant to white, each with a single factor difference. This indicates that three factors are necessary for the manifestation of the orange colour, two for the red and one for the yellow.

In table VI are given the two-factor segregations observed in the floret colours. It would be noted that all of them are modified 9:3:3:1 ratios where the last two groups get merged into one, due to the interaction of factors.

TABLE VI

Colour groups	Actual numbers	Expected numbers on 9:3:4 ratio	X^2 and probability		Remarks
				P between	
1. Red : yellow : white	98: 26: 38	91 : 30 : 41	1·3031	0·5 & 0·7	Artificial cross
2 Orange : yellow : white	93: 39: 44	99 : 33 : 44	1·4780	0·3 & 0·5	Do.
3. Orange : red : white	692:226:304	687 : 229 : 306	0·0888	0·95 & 0·98	Natural cross
4. Orange : red : yellow	281:113:127	293 : 98 : 130	2·8567	0·2 & 0·3	Artificial cross

TABLE VII Inheritance of Flower colours in Safflower

Generation	Selection Number	Parental constitution		Segregating for				X^2	Probability P between
		Phenotypic	Genetic	Orange	Red	Yellow	White		
Parents	C. T. 18	White	OORRyy				♀		
	C. T. 40	Yellow	oorrYY			♂			
F. 1	Cross I			Orange					
F. 2	C. T. 307, 308 and 309	Orange	OoRrYy	260	103	120	151		
	Expected on 27 : 9 : 12 : 16 ratio			268	89	119	158	2·7605	0·5 & 0·3
F. 3	Selections from C. T. 308								
	C. T. 308—1, 5, 11, 14, 16, 18, 19	Orange	OoRrYy	487	142	173	254		
	Expected on 27 : 9 : 12 : 16 ratio			446	148	198	264	7·496	0·1 & 0·05
	C. T. 308—3, 4, 7, 10	Orange	OORrYy	380		121	166		
	Expected on 9 : 3 : 4 ratio			375		125	167	0·2007	0·95 & 0·90
	C. T. 308—8, 13, 15, 17	Orange	OoRrYY	319	110	124			
	Expected on 9 : 3 : 4 ratio			311	104	138		1·9722	0·5 & 0·3
	C. T. 308—20	Orange	OoRRYy	30	10		16		
	Expected on 9 : 3 : 4 ratio			31·5	10·5		14	0·2381	0·9 & 0·8
	C. T. 308—2 9	Orange	OORRYy	232			69		
	Expected on 3 : 1 ratio			226			75	0·6921	0·5 & 0·3
	C. T. 308—6, 12	Orange	OORrYY	221		80			
	Expected on 3 : 1 ratio			226		75		0·3998	0·7 & 0·5
	C. T. 308—21, 24	Red	ooRrYy		179	55	92		
	Expected on 9 : 3 : 4 ratio				183	61	82	1·8971	0·5 & 0·3
	C. T. 308—22	Red	ooRrYY		122	44			
	Expected on 3 : 1 ratio				124	42		0·0201	0·9 & 0·8
	C. T. 308—25, 26, 27, 28	Yellow	{oorrYy / OOrrYy}			487	168		
	Expected on 3 : 1 ratio					491	164	0·1471	0·8 & 0·7

The above data (Table VI) suggests the following hypothesis. The basic colour of the florets is yellow and is due to a factor 'Y'. In the absence of this factor no colour can develop and the florets remain white. A supplementary factor 'R' acting in conjunction with 'Y' produces red colour. A third factor 'O' with 'R' produces the orange colour, but as 'R' itself requires the presence of Y for manifestation, the orange colour would contain all the three factors O, R and Y. Factor 'O' cannot develop the orange colour without 'R' nor can 'O' and 'R' produce any colour without the basic colour factor Y. On this hypothesis the genetic constitution of the four types of floret colours would be as follows—

Phenotype	*Genetic constitutions*
Orange	OO RR YY
Red	oo RR YY
Yellow	oo rr YY, OO rr YY
White	OORRyy, OOrryy, ooRRyy, oorryy

With the object of testing this hypothesis, a cross was made between C.T. 18 a white with the constitution OORRyy and a yellow (C. T. 40) of the constitution oorrYY. The behaviour of this cross was studied up to the third generation and it was found to substantiate the above hypothesis in all respects. The data are detailed in Table VII.

The inheritance of these floret colours was found to be independent of the nature of the bracts, (spiny or spineless), as seen from the data presented in Table VIII.

TABLE VIII

Generation.	Selection number	Nature of parent	Segregating for					
			Spiny			Spineless		
			Orange	Red	White	Orange	Red	White
F. 2	C. T. 34/1		Spiny natural cross from spineless white bulk lot C. T. 34.					
F. 3	C. T. 119	Spiny orange	14	3	6	3	2	2
F 4	*From C. T. 119*							
	C. T. 181	,,	100	32	43	33	15	15
	,, 182	,,	78	40	33	29	7	10
	,, 184	,,	101	50	42	32	12	18
	,, 189	,,	141	43	66	52	7	23
	Total of F. 3 & F. 4		434	148	190	149	43	68
	Expected on 27 : 9 : 12 : 9 : 3 : 4 ratio		435	145	194	145	48	65

$X^2 = 0{\cdot}9165$ P is between 0·98 and 0·95

Summary In safflower (*Carthamus tinctorius* L.) the mode of inheritance of a number of characters have been studied and recorded.

Spinose bracts behave as a simple dominant to spineless. Sparse bloom on the involucral bracts behaves as a simple recessive to heavy bloom. The two sets of allelomorphs were found to be linked with a

cross-over value of 13 %. Rosette-like arrangement of leaves was a simple recessive to the normal. This character was independent of spininess.

Four types of floret colours viz. orange, red, yellow and white have been observed. The genetic inter-relationship of these four colours are explained on a three factor hypothesis.

There is a basic factor 'Y' for colour, due to which the florets are yellow. In the absence of this factor no colour can develop and the florets are white A supplementary factor 'R' produces the red colour in the presence of 'Y'. A third factor 'O' develops the orange colour in conjunction with 'R' which in turn is dependant on 'Y', the basic colour factor, for its manifestation

The inheritance of these flower colours were found to be independent of the nature of bracts.

Literature cited

Howard, A., Howard, G. L. C. and Khan, A. R. (1915) *Mem. Dept. Agric. India Bot.* 7, 237—55.

Sabnis, T. S. and Phatak, M. G. (1935) *Indian J. Agric. Sci.* 5, 705—14.

Sci. Rep. Agric. Res. Inst. Pusa 1931 to 1936.

Watt, G. (1908) *Commercial Products of India.*

A Plea for Reviving the Omblachery Breed of Cattle in the Tanjore District

By R. SESHAYYA, M. A., B. L.,

Secretary, Tail-end Association and

Member, District Agricultural Association

Omblachery breed The district of Tanjore, familiarly known as the "granary of the South", is also reputed from time immemorial, for its sturdy cattle, in relation to its agricultural economy. The *ryots* of the district have been depending for long, for their agricultural operations on a well-suited local breed of cattle known as the "Omblachery breed", taking its name from a village called Omblachery, in the Taluk of Tiruturaipundi. The bullock of this breed is a sturdy worker, both at the wheels and at the plough. It is of medium size with a comparatively small head. Its complexion is, generally, bluish grey, and it has a white star on its fore-head. It has shining dark eyes and wears a few thick hairs, on its chin. Its tail is black above the thighs and ends with a lotus like brush of snow-white hair, soft and glossy like silk. Its hoofs are equally white and resemble ivory, in their finish. The pure bred pedigree sire is generally ferocious by nature. Owing to the large demand for this breed of cattle and due to lack of organised effort in breeding in the past decade, its population in the village of Omblachery has slowly dwindled. At present, the pure stock is very rare and outnumbered by those of mixed blood. The pure breed is known throughout the district, as the *jothi madu.*