



Inheritance of morphine in opium poppy (*P. somniferum* L.)

Sudhir Shukla and S. P. Singh

Department of Plant Breeding and Genetics, National Botanical Research Institute, Lucknow 226 001

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Abstract

Inheritance of morphine in opium poppy (*Papaver somniferum* L.) Vr. NBRI-1 and NBRI-2 was studied by selfing in seven successive generations. The morphine content over years ranged from 7.14 to 29.98 percent. Progenies with high morphine content segregated strongly and produced progenies with lower content, while selection in middle order produced high and intermediate progenies. Selection response was also high in progenies selected from middle range. The results suggest that high morphine content resulted due to certain epistatic combinations.

Key words: Inheritance, morphine, *Papaver somniferum*, selection differential, selection response.

Introduction

Development of new varieties with more yield is continuous process of plant breeding. The efforts to enhance the yield potential i.e. opium latex and seed along with its alkaloid content, is long being tried in opium poppy (*Papaver somniferum* L.). The morphine is the most important alkaloid among all the five major alkaloids of economic value found in the latex. The inheritance pattern of this alkaloid has been reported in intra varietal crosses of *P. somniferum* [1] and interspecific crosses of *P. somniferum* × *P. setigerum* [2, 3]. The present investigation was carried out to study the inheritance pattern of morphine in subsequent selected progenies of two opium poppy varieties viz. NBRI-1 and NBRI-2.

Materials and methods

From two varieties viz. NBRI-1 and NBRI-2 of opium poppy (*P. somniferum* L.) developed at National Botanical Research Institute, Lucknow, 15 and 20 plants were randomly selected for latex collection from NBRI-1 and NBRI-2 respectively and selfed during 1991-92. The latex was analyzed and 11 plant progenies in NBRI-1 and 10 in NBRI-2 were selected and their progenies were studied in subsequent years up till 1997-98. Total 272 plants in NBRI-1 and 193 plants in NBRI-2 (Table 1) were analyzed for morphine content

by colorimetric method [4]. The morphine percentage is given on the basis of dry opium mass. Statistical analysis for selection differential (ΔS) and selection response (ΔR) was done according to Singh and Chaudhary [5].

Results and discussion

The inheritance pattern of morphine in opium poppy (*P. somniferum* L.) vrs. NBRI-1 and NBRI-2 studied for 7 generations successively and their grouping in different classes and selection response are presented in Table 1 and 2 respectively. The fresh latex of opium is usually brown to red and morphine content in them ranges in different groups. The morphine percentage over 7 years varied from 7.14% (lower limit of 1997-98) to 29.88 (upper limit of 1996-97) in variety NBRI1, while it was 7.17% (lower limit of 1993-94) to 29.98% (upper limit of 1993-94) in NBRI-2.

Considering class interval, maximum number of progenies were found in group of 15-20 followed by 20-25 percent morphine (Table 1) but same progenies segregate in successive generations (years) producing genotypes of lower morphine content. This was also

Table 1. Variation in morphine % in opium poppy over years of vrs. NBRI-1 and NBRI-2 (in parenthesis)

Class interval (morphine %)	No. of plants selected over years						
	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	1997 -98
7-10	8(0)	4(1)	- (1)	2(0)	2(0)	1(0)	3(0)
10-15	8(6)	39(20)	14(1)	31(9)	1(0)	19(0)	18(0)
15-20	3(9)	13(24)	36(4)	27(8)	15(0)	23(5)	28(7)
20-25	0(6)	3(9)	15(12)	19(9)	8(1)	5(6)	9(8)
25-30	0(1)	0(12)	8(13)	6(9)	4(1)	1(2)	2(11)
Range	8.26	7.26	11.57	8.16	9.01	7.47	7.14
	-19.88	-23.66	-29.23	-29.20	-26.98	-29.88	-29.14
	(12.99	(9.21	(7.97	(12.72	(21.04	(17.52	(17.43
	-27.15)	-29.76)	-29.98)	-29.65)	-26.25)	-28.07)	-29.37)
Total plants	19(22)	59(66)	73(31)	85(35)	30(4)	49(13)	61(26)

Table 2a. Selection response of morphine over generations in opium poppy Vr. NBRI-1 (*P. somniferum* L.)

Selection Cycle/year	Selection differential (ΔS)			Selection response (ΔR)			Pedigree
	X ₀	X _s	ΔS	X _p	Plants/ Progeny	ΔR	
I cycle (1991-92)							
1.	11.2±0.73(8.3-16.0)	8.2	-3.0	12.9±1.44(10.1-17.3)	5	1.72	NB1-92-1
2.		14.7	3.5	14.2 ±0.33 (12.9-14.8)	5	2.93	NB1-92-5
3.		9.2	-2.1	12.4±1.57 (9.8-16.5)	5	1.14	NB1-92-6
4.		8.6	-2.7	15.2±2.03 (11.1-22.6)	5	3.97	NB1-92-16
5.		13.0	1.8	15.9±1.52(13.3-19.9)	4	4.68	NB1-92-7
6.		9.2	-2.1	13.5±0.89 (9.9-16.1)	6	2.24	NB1-92-8
7.		19.2	8.5	14.9±1.78 (9.3-23.7)	7	3.60	NB1-92-12
8.		14.9	3.6	15.2±1.24(12.2-18.5)	6	3.92	NB1-92-13
9.		8.6	-2.7	15.2±2.03(11.1-22.6)	5	3.97	NB1-92- 16
10.		15.7	4.4	3.1±1.24(10.5-17.2)	5	1.97	NB1-92-17
11.		16.0	4.8	16.8±1.80(7.9-22.9)	7	5.43	NB1-92-20
II cycle (1992-93)							
1.	12.9±1.44	17.26	4.26	24.4± 2.47(17.1-29.8)	5	11.38	NB1-92-1-93-3
2.	"	15.42	2.43	14.0±0.41(12.4-14.5)	5	1.04	NB1-92-1-93- 1
3.	" 14.2±0.33	14.20	-0.15	19.5±2.59(16.3- 22.3)	5	7.68	NB1-92-5-93-1
4.	"	14.43	0.23	20.2±2.49(14.5-27.3)	5	5.95	NB1-92-5- 93-3
5.	"	14.68	0.48	15.6±0.20(14.9-15.9)	5	1.48	NB1-92-5- 93-5
6.	15.9±1.52	16.69	0.74	18.3±0.66(17.4-19.6)	3	2.33	NB1-92-7-93-1
7.	"	13.95	-2.00	17.7±2.47(14.6-22.6)	3	1.80	NB1- 92-7-93-3
8.	13.5±0.89	14.60	1.09	16.7±1.91(11.6-24.5)	5	3.16	NB1-92.8-93-2
9.	:	14.31	0.80	16.3±1.28(12.7-20.9)	5	2.79	NB1-92-8- 93-3
10.	15.2±1.24	17.08	1.89	16.7±0.95(14.5-18.7)	5	1.48	NB1-92-13-93-1
11.	15.2±2.03	14.23	-1.01	20.2±1.64(17.5-26.5)	5	5.05	NB1-92-16-93-2
12.	13.1±1.24	14.53	1.47	16.8±1.12(13.7-19.6)	3	3.78	NB1-92-17-93-3
III cycle (1994-95)							
1.	24.4±2.47	17.11	-7.26	12.0±0.89(11.2-12.8)	2	-12.37	NB1-92-1-93-3-94-3
2.	19.5±2.59	22.29	2.78	16.8±1.95(14.7-20.7)	3	-2.88	NB1-92-5-93-1-94-3
3.	"	16.27	-3.27	17.4±0.96(15.5-18.6)	3	-4.53	NB1-92-5-93-1-94-5
4.	20.1±2.49	19.24	-0.91	18.8±1.17(15.8-23.5)	3	-1.37	NB1-92-5-93-3-94-3
5.	15.6±0.20	15.36	-0.24	20.0±1.99 (16.1-22.2)	3	4.45	NB1-92-5-93-5-94-1
6.	"	14.98	-0.62	14.6±1.38(11.9-16.6)	3	-1.00	NB1-92-5-93-5-94-2
7.	"	15.73	0.13	17.3±3.90(11.2-24.6)	3	1.73	NB1-92-5-93-5-94-4
8.	18.3±0.66	17.86	-0.32	22.3±4.11(15.1-29.2)	3	3.98	NB1-92-7-93-1-94-1
9.	17.7±2.47	15.99	-1.76	24.8±2.99(18.9-28.9)	3	7.07	NB1-92-7-93-3-94-3
10.	20.2±1.64	18.99	-1.24	25.2±1.56(22.4-27.8)	3	5.00	NB1-92-16-93-2-94-1
11.	"	20.29	0.06	18.7±1.17(16.5-20.4)	3	-1.48	NB1-9216-93-2-94-3
12.	"	17.53	-2.70	13.4±1.15)(11.4-15.4)	3	-6.84	NB1-92-16-93-2-94-5
13.	"	17.86	-2.37	19.3±0.75(18.4-19.9)	3	-0.95	NB1-92-16-93-2-94-2
IV cycle (1995-96)							
1.	18.8±1.17	17.05	-2.68	18.6±2.53(16.1-21.2)	2	-0.13	NB1-92-5-93-3-94-3-95-1
2.	17.3±3.90	16.21	-1.12	18.7±1.32(16.5-23.9)	5	1.42	NB1-92-5-93-5-94-4-95-1
3.	25.2±1.56	25.54	0.23	18.4±4.40(9.9-24.9)	5	-6.83	NB1-92-16-93-2-94-1-95-1
4.	"	23.38	-1.85	21.5±1.37 (17.2-25.2)	3	-4.73	NB1-92-16-93-2-94-1-95-2
5.	"	27.78	2.55	16.0±3.48 (12.5-19.5)	2	-9.23	NB1-92-16-93-2-94-1-95-3
6.	19.3±0.75	18.38	-0.90	19.5±1.30(18.4-22.3)	3	0.23	NB1-92-16-93-2-94-2-95-1
7.	"	19.97	0.69	22.8±1.48(16.3-26.9)	7	3.52	NB1-92-16-93-2-94-2-95-2

Table 2a. (Contd.)

Selection Cycle/year	Selection differential (ΔS)			Selection response (ΔR)			Pedigree
	X_0	X_s	ΔS	X_p	Plants/ Progeny	ΔR	
V cycle (1996-97)							
1.	18.6 \pm 2.53	21.18	2.53	17.0 \pm 0.22(13.7-21.2)	3	-1.61	NB1-92-5-93-3-94-3-95-1-96-1
2.	18.6 \pm 2.53	16.12	-2.53	13.1 \pm 0.64(11.8-15.4)	5	-5.52	NB1-92-5-93-3-94-3-95-1-96-2
3.	18.7 \pm 1.32	16.97	-1.78	12.29 \pm 1.47(7.47- 16.61)	5	-6.46	NB1-92-5-93-5-94-4-95-1-96-1
4.	21.5 \pm 1.37	19.91	-1.59	17.70 \pm 1.86(13.3-23.2)	5	-3.80	NB1-92-16-93-2-94-1-95-2-96-5
5.	19.5 \pm 1.30	22.28	2.77	18.49 \pm 1.09(15.9-21.3)	4	-1.02	NB1-92-16-93-2-94-2-95-1-96-3
6.	22.8 \pm 1.48	22.44	-0.36	18.41 \pm 0.55(16.8-19.1)	4	-4.39	NB1-92-16-93-2-94-2-95-2-96-2
7.	22.8 \pm 1.48	26.67	3.87	13.65 \pm 0.78(12.7-15.2)	3	-9.15	NB1-92-16-93-2-94-2-95-2-96-3
8.	22.8 \pm 1.48	23.83	1.03	15.65 \pm 1.17(14.5-16.8)	2	-7.15	NB1-92-16-93-2-94-2-95-2-96-4
VI cycle (1997-98)							
1.	17.0 \pm 0.22	21.24	4.20	20.46 \pm 1.73(17.34-25.55)	3	3.42	NB1-92-5-93-3-94-3-95-1-96-1-97-1
2.	17.0 \pm 0.22	16.17	-0.87	18.24 \pm 2.94(11.22- 24.46)	4	1.20	NB1-92-5-93-3-94-3-95-1-96-1-97-2
3.	13.1 \pm 0.64	15.45	2.32	17.43 \pm 1.39(12.27-19.04)	5	4.30	NB1-92-5-93-3-94-3-95-1-96-2-97-5
4.	12.3 \pm 1.47	12.67	0.38	13.84 \pm 1.38(11.02-17.57)	4	1.57	NB1-92-5-93-5-94-4-95-1-96-4-97-1
5.	12.3 \pm 1.47	16.61	4.32	11.59 \pm 0.67(9.70-12.83)	4	-0.70	NB1-92-5-93-5-94-4-95-1-96-4-97-3
6.	17.7 \pm 1.86	18.14	0.44	14.45 \pm 4.08(10.37-18.52)	2	-3.25	NB1-92-16-93-2-94-1-95-2-96-5-97-3
7.	18.5 \pm 1.09	15.96	-2.53	13.14 \pm 2.02(9.80- 16.79)	3	-5.35	NB1-92-16-93-2-94-2-95-1-96-3-97-1
8.	18.5 \pm 1.09	18.59	0.10	16.82 \pm 2.37(14.81-21.36)	3	-1.67	NB1-92-16-93-2-94-2-95-1-96-3-97-2
9.	18.5 \pm 1.09	18.13	-0.36	16.07 \pm 1.61(10.13- 18.70)	5	2.42	NB1-92-16-93-2-94-2-95-1-96-3-97-3
10.	18.5 \pm 1.09	21.26	2.77	18.58 \pm 0.67(17.29-21.13)	5	0.09	NB1-92-16-93-2-94-2-95-1-96-3-97-4
11.	18.4 \pm 0.55	19.12	0.71	20.46 \pm 2.78(15.82-28.53)	4	20.5	NB1-92-16-93-2-94-2-95-2-96-2-97-3
12.	13.6 \pm 0.78	15.20	1.55	21.30 \pm 1.66(19.68-22.93)	2	7.65	NB1-92-16-93-2-94-2-95-2-96-3-97-2
13.	15.6 \pm 1.17	16.83	1.18	18.97 \pm 2.82(16.15-21.80)	2	3.32	NB1-92-16-93-2-94-2-95-2-96-4-97-1

X_0 : Mean of base population; X_s : Mean of selected individual from base population; X_p : Mean of progenies of selected individual; ΔS : Selection differential; ΔR : Selection response.

Table 2b. Selection response of morphine over generations in opium poppy Vr NBRI-2

Selection Cycle/year	Selection differential(ΔS)			Selection response (ΔR)			Pedigree
	X_0	X_s	ΔS	X_p	Plants/ Progeny	ΔR	
I cycle (1991-92)							
1.	18.23 \pm 0.82 (12.99-27.15)	20.00	1.77	15.57 \pm 1.65(12.26-17.30)	3	-2.66	NB2-92-1
2.	"	21.36	3.00	15.23 \pm 0.92(12.52-19.43)	8	-3.00	NB2-92-2
3.	"	16.87	-1.49	14.85 \pm 1.27(10.64-22.31)	8	-3.38	NB2-92-3
4.	"	16.80	-1.56	17.28 \pm 1.62(13.09-22.35)	5	-2.61	NB2-92-4
5.	"	27.15	8.79	26.28 \pm 1.93(15.30-29.54)	7	7.45	NB2- 92-6
6.	"	25.00	6.64	18.41 \pm 1.85(12.86-20.58)	4	0.18	NB2- 92-7
7.	"	17.61	-0.64	17.31 \pm 1.63(13.43-23.15)	5	-0.86	NB2-92-8
8.	"	20.05	1.69	18.44 \pm 1.92(11.94-25.68)	8	0.23	NB-2- 92-9
9.	"	13.79	-4.57	20.80 \pm 3.43(17.88-27.65)	3	2.51	NB2-92-16
10.	"	12.99	-5.37	18.86 \pm 2.42(11.28-28.28)	7	0.58	NB2-92-20
11.	"	13.68	-4.68	18.16 \pm 1.33(15.99-19.88)	4	-0.07	NB2-92-22
II cycle (1992-93)							
1.	14.85 \pm 1.27	17.63	2.78	26.64 \pm 1.27(24.27-28.71)	2	11.79	NB2-92-3-93-5
2.	17.28 \pm 1.62	14.73	-0.89	25.71 \pm 1.47(24.24- 27.17)	2	10.09	NB2-92-4-93-4
3.	17.37 \pm 1.63	17.50	0.15	21.17 \pm 0.36(20.81-21.52)	2	3.80	NB2-92-8-93-4
4.	17.37 \pm 1.63	15.32	-2.05	19.48 \pm 0.94(18.54- 20.41)	2	2.17	NB2-92-8-93-7

Table 2b. Selection response of morphine over generations in opium poppy Vr NBRI-2

Selection Cycle/year	Selection differential (ΔS)			Selection response (ΔR)			Pedigree
	X_0	X_s	ΔS	X_p	Plants/Progeny	ΔR	
5.	18.44±1.92	13.86	-4.58	28.39	1	9.95	NB2-92-9-93-2
6.	20.80±3.43	17.88	-2.92	19.06±11.09(7.92-30.14)	2	-1.74	NB2-92-16-93-1
7.	20.80±3.43	16.90	-3.90	22.88±4.05(14.79-29.98)	4	2.08	NB2-92-16-93-2
8.	18.86±2.42	16.06	-2.80	25.34±1.55(22.58-27.92)	3	6.48	NB2-92-20-93-2
9.	18.16±1.33	15.79	-2.37	21.74±2.21(19.33-23.95)	2	1.17	NB2-92-22-93-4
III cycle (1993-94)							
1.	26.64±1.29	24.27	-2.37	27.19±0.77(26.45-27.95)	2	0.55	NB2-92-3-93-5-94-1
2.	25.71±1.47	24.24	-1.47	25.30±3.51(21.80-28.81)	2	-0.41	NB2-92-4-93-5-94-2
3.	21.17±0.36	20.81	-0.36	21.38±3.89(17.49-25.28)	2	0.21	NB2-92-8-93-4-94-1
4.	21-17±0.36	21.52	0.35	25.68±3.88(17.92-29.65)	3	4.51	NB2-92-8-93-4-94-2
5.	19.48±0.94	18.54	0.94	23.65±1.33(21.29-25.87)	3	4.17	NB2-92-8-93-7-94-1
I cycle (1994-95)							
1.	25.24	25.45	0.21	14.98±0.93(12.72-18.09)	5	-10.26	NB2-94-2
2.	25.24	23.33	-2.93	15.25±0.90(13.21-17.83)	5	-9.98	NB2-94-3
3.	25.24	26.19	0.95	19.56±2.72(12.87-27.37)	5	-5.68	NB2-94-4
II cycle (1995-96)							
1.	19.56±2.36	19.47	-0.09	22.74±1.18(21.04-26.25)	4	3.18	NB2-94-4-95-1
III cycle (1996-97)							
1.	22.74±1.18	21.97	-0.77	23.07±1.32(20.49-28.07)	5	0.33	NB2-94-4-95-1-96-1
2.	"	21.04	-1.70	19.66	1	-3.08	NB2-94-4-95-1-96-5
3.	"	21.68	-1.06	18.21±0.62(17.52-19.44)	3	-4.53	NB2-94-4-95-1-96-6
IV cycle (1997-98)							
1.	23.07±1.32	22.48	-0.59	19.92±1.45(18.00-22.80)	3	-3.08	NB2-94-4-95-1-96-1-97-1
2.	23.07±1.32	21.48	-1.59	28.03±0.71(26.62-29.09)	3	4.96	NB2-94-4-95-1-96-1-97-2
3.	23.07±19.66	19.66	0.00	26.78	1	7.12	NB2-94-4-95-1-96-2-97-1
4.	23.07±18.21	17.52	-0.69	24.22±2.23(19.98-28.25)	4	6.01	NB2-94-4-95-1-96-3-97-1

X_0 : Mean of base population; X_s : Selected individual from base population; X_p : Mean of progenies of selected individual; ΔS : Selection differential; ΔR : Selection response

supported by selection response (ΔR) (Table 2a, b). In general when medium morphine content progenies were selected, the selection gain was high, while it was very low in almost all the cases when selection was practiced for high morphine genotypes. This suggests that high morphine genotypes segregate strongly and produce poor progenies in following years. The plants selected from middle range generally have intermediate progenies. The suggested explanation is that the high morphine content is due to certain epistatic combinations, which are broken down in every generation and are produced a fresh again. The pattern of inheritance is comparable to that of Solasodine [6] in *S. khasinum* and Papaverine [7] in *P. somniferum*.

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