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IDENTIFICATION OF SUITABLE BIVOLTINE FOUNDATION CROSS FOR SUSTAINABLE BIVOLTINE SILKWORM SEED CROP IN TROPICS

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ABSTRACT

The success of rearing with presently available conventional bivoltine breeds are unpredictable in some of the seed crop seasons in West Bengal and similar regions of India because of prevailing of highly fluctuating adverse climatic conditions. Thus, it is very much essential to have a bivoltine breed, which can give stable cocoon crop under variable environments. As single bivoltine parent shown poor cocoon yield in those seasons, as an alternative, foundation crosses (FC) were tried. Out of nine FCs evaluated, D6 (P) N x SK4C shown higher cocoon yield of 12.8kg/10000 larvae with 91% pupation (average of three seasons) compared to 9.8kg cocoon yield/10000 larvae with 67% pupation in control, NB18 x P5. Thus the identified FC can be utilized as a male parent for preparation of three way cross, multi x bi hybrid for utilization in commercial crop.

INTRODUCTION

Sericulture, being rural based agro industry is suited for improving the social and economic conditions of rural poor. Indian Sericulture is mostly multivoltine oriented and more than 95% of the silk is produced by multivoltine x bivoltine hybrids. Eastern India, especially West Bengal, one of the major sericulture practicing states in India, experiences wide fluctuation in temperature, humidity and precipitation rate (Moorthy and Das, 2007). In general, the areas located in the plains of West Bengal are very hot and humid during summer and fairly cold and dry during the winter. These conditions affect both growth of mulberry and silkworm rearing. In the plains of West Bengal, rearing of seed and commercial crops is a round the year process, while in the hills of Darjeeling district, it is restricted to spring(Apr-May), summer (June-July) and autumn (Sep-Oct) seasons only. Five commercial crop silkworm rearing are carried out in a year out of which, multivoltine x bivoltine hybrids can successfully be reared during three seasons *i.e.*, Autumn (Oct-Nov), Spring (Feb-Mar) and Early summer (Mar-Apr) and in other seasons viz., Summer (June-July) and rainy (Aug-Sep), multivoltine x multivoltine hybrids are reared. Multivoltine x bivoltine hybrid yield more cocoon and fetch more prize as the silk reeled from multivoltine x bivoltine are qualitatively better than multivoltine x multivoltine. However for preparing multivoltine x bivoltine hybrid layings, bivoltine seed cocoons are required, but raising of bivoltine seed cocoons are difficult in tropical climate as they are susceptible to temperature and pathogens.

Especially, the seed crop of autumn (the major commercial crop when 30% dfls consumption annually) has to be conducted during Sept-Oct, when both temperature (>35ºC) and humidity (>90%) are high which threat rearing of bivoltine parent silkworms, resulting unsuccessful raising of bivoltine seed cocoon which in turn affects production of multi x bi silkworm eggs (Das *et al.*, 1994).

On the other hand foundation crosses may not be a true hybrid; however because of two (similar types of) parents involved they are tolerant to environmental condition and easy to rear than the single parent. Hence in this study, as an alternative to single bivoltine parent, bivoltine foundation crosses(FCs) are tried during different seed crops to find out suitable foundation cross (FC) which can give sustainable yield and can be used for multi x bi dfls production.

MATERIALS AND METHODS

Four bivoltine breeds spinning oval shape cocoon (CSN, CSC, SK3N, SK3C) and four spinning dumbbell shape cocoon [D6(P)N, SK4N, D6(P)C, SK4C] were used to prepare nine bivoltine foundation crosses viz., CSN x SK3N, CSN x SK3C, SK3C x SK3N, SK3C x CSC , SK3N x CSC (Oval- FC) , D6(P)N x SK4C , D6(P)N x SK4N , SK4C x SK4N and SK4C x D6(P)C (Dumbbell FC). These foundation crosses were evaluated during three seed crop seasons viz., Sep-Oct, Dec-Jan and Feb-Mar. for two years. Data on the economically important traits were collected from each seasons are pooled and analyzed. The ranking of the foundation crosses was done as per Mano's *et al.* (1993) evaluation index.

$$\text{Evaluation index} = \frac{A - B}{C} \times 10 + 50$$

Where, A = Value obtained for a trait in a breed /FC
(On mean value of the trait concerned in a breed)
B = Mean value of a trait of all the breeds/FCs
C = Standard deviation of a trait of all the beeds/FCs
10 = Standard unit
50 = Fixed value
The EI value fixed for the selection of FC is 50 and FC which scored above the limit is considered to possess greater economic value.

RESULTS

Performance of bivoltine foundation crosses in different seed crops

The analysis of the performance of the bivoltine foundation crosses reared during three seed crop seasons viz., Sep-Oct, Dec-Jan and Feb-Mar are shown in the Table 1, 2 and 3. In Sep-Oct (seed crop), D6 (P) N x SK4C ranked first with pupation % of 85.56 with cocoon yield of 11.31 kg/ 10,000Larvae and shell% of 18.75 compared to 12% pupation, 1.65 kg cocoon yield / 10,000Larvae and 17.60 % shell in the control breed,NB4D2 (Table 1).

During Dec-Jan (Seed crop) season also, D6(P)N x SK4C ranked first with pupation % of 95.44 with cocoon yield of 14.513kg/ 10,000larave and shell% of 20.68 against 77% pupation, 10.2 kg cocoon yield / 10,000larvae and 18.40 % shell in the control breed, NB4D2 (Table 2).
In Feb-Mar (Seed crop) season again D6(P)N x SK4C ranked first with pupation % of 92.50 with cocoon yield of 12.585kg / 10,000larvae and shell% of 21.05 against 73% pupation, 10.6 kg cocoon yield/ 10,000larvae and 19.11 % shell in the control breed, NB4D2 (Table 3).

Ranking of foundation crosses

As per evaluation index calculated for six traits for three seasons FCs viz., D6 (P) N x SK4C (61.38), SK3C x SK3N (59.81), D6(P)N x SK4N (55.08), SK4C X SK4N (54.08) and SK4C x D6(P)C (51.61), showed higher evaluation index values (above 50 EI value) and lower was obtained in NB4D2(34.0) followed by SK3C x CSC (44.63) and CSN x SK3N (44.83). As per high index values D6 (P) N x SK4C ranked first followed by SK3C x SK3N (Table 4).

DISCUSSION

It is well documented that F1 silkworm hybrids are superior to single parent in respect of many quantitative and qualitative characters (Gamo and Hirobayashi, 1983). However foundation crosses are not a true hybrid, since they are crossing between similar types of parents to avoid segregation in the commercial level. In this study two types of foundation crosses are made *i.e.,* oval FC (crossing between oval and oval cocoon with plain larvae) and dumbbell FC (crossing between dumbbell and dumbbell cocoon with marked larvae), so that no variation in cocoon shape occurred at F1. Results of the present study clearly indicated that foundation crosses are superior over single parent (NB4D2) in respect of cocoon yield and other economically important parameters. Out of nine new FCs evaluated, D6 (P) N x SK4C out yielded control (NB4D2) as well as other FCs in all seed crop seasons. The parents of these FCs are developed through introgression survival character from multivoltine breed (Moorthy *et al.*, 2007a, b) for improving survival, thus proving their capacity to tolerate the prevailing environmental impediments. This study also inferred that bivoltine FCs can be recommended instead of single bivoltine parent for bivoltine seed crop stabilization.

In silkworm, *Bombyx mori*, the silk yield is contributed by more than 21 traits (Thiagarajan *et al.*, 1993) and there exists an interrelationship between multiple traits in silkworm. Any effort to improve the yield requires consideration of cumulative effect of the major traits which influences the silk yield. It has been also established that selection pressure applied for one character results in correlated changes in other quantitative traits of economic importance. So in order to judge the superiority of the silkworm breed/ hybrid impartially, a common index method was found very much essential (Bhargava *et al.*, 1994). The evaluation index (E.I) method developed by Mano *et al.*, (1993) was found to be very useful in selecting potential parents/ hybrids in silkworm breeding programme. In this method characters are given equal weightage because in hybrids expression of traits will be uniform, in other words no variability within traits. Many workers used this E.I for selecting potential hybrid (Kumaresan *et al.*, 2000; Rao *et al.*, 2006; Moorthy *et al.*, 2007a; Rayar, 2007). The selection of the hybrids ultimately depends on the excellence and performance of hybrids in many individual

Table 1: Mean performance of bivoltine foundation crosses during Sep-Oct seed crop season

Foundation cross	Fecundity (no.)	Pupation %	Cocoon yield /10000 larvae(kg)	Cocoon wt (g)	Shell wt (g)	Shell%
D6(P)N x SK4C	456	85.56	13.476	1.575	0.325	20.63
SK3C x SK3N	468	85.00	13.260	1.560	0.315	20.19
D6(P)N x SK4N	440	87.67	13.501	1.540	0.310	20.13
SK4C X SK4N	451	86.06	12.720	1.478	0.295	19.96
SK4C x D6(P)C	469	73.78	10.551	1.430	0.279	19.51
CSN x SK3C	457	84.60	11.506	1.360	0.265	19.49
CSN x SK3N	422	75.67	10.669	1.410	0.255	18.09
SK3C x CSC	458	77.00	10.472	1.360	0.249	18.31
SK3N x CSC	464	74.00	9.916	1.340	0.235	17.54
NB4D2 (Control)	450	12.98	1.623	1.250	0.220	17.60
CD at 5%	15.2	8.56	1.032	0.044	0.011	0.72
CV%	8.45	4.26	6.455	1.897	2.533	2.328

Table 2: Mean performance of bivoltine foundation crosses during Dec-Jan seed crop season

Foundation cross	Fecundity (no.)	Pupation %	Cocoon yield /10000 larvae(kg)	Cocoon wt (g)	Shell wt (g)	Shell %
D6(P)N x SK4C	578	95.44	16.206	1.698	0.365	21.50
SK3C x SK3N	569	95.00	15.694	1.652	0.355	21.49
D6(P)N x SK4N	560	94.00	15.275	1.625	0.340	20.92
SK4C X SK4N	458	91.22	14.686	1.610	0.325	20.19
SK4C x D6(P)C	514	91.56	14.357	1.568	0.310	19.77
CSN x SK3C	489	88.78	13.637	1.536	0.300	19.53
CSN x SK3N	503	88.67	13.230	1.492	0.279	18.70
SK3C x CSC	507	91.44	13.177	1.441	0.264	18.32
SK3N x CSC	478	91.56	13.066	1.427	0.275	19.27
NB4D2 (Control)	539	77.33	10.440	1.350	0.249	18.44
CD at 5%	22.1	3.16	0.608	0.037	0.009	0.603
CV%	8.56	2.09	2.75	1.475	1.96	1.89

Table 3: Mean performance of bivoltine foundation crosses during Feb-Mar seed crop season

Foundation cross	Fecundity (no.)	Pupation %	Cocoon yield /10000 larvae(kg)	Cocoon wt (g)	Shell wt (g)	Shell%
D6(P)N x SK4C	546	92.50	15.818	1.710	0.374	21.87
SK3C x SK3N	536	91.56	15.382	1.680	0.365	21.73
D6(P)N x SK4N	504	78.49	13.076	1.666	0.37	22.21
SK4C X SK4N	526	89.56	14.733	1.645	0.365	22.19
SK4C x D6(P)C	512	85.87	14.040	1.635	0.34	20.80
CSN x SK3C	512	88.40	14.515	1.642	0.325	19.79
CSN x SK3N	508	84.67	13.505	1.595	0.308	19.31
SK3C x CSC	489	82.33	13.255	1.610	0.3	18.63
SK3N x CSC	464	90.25	14.115	1.564	0.315	20.14
NB4D2 (Control)	508	73.48	9.920	1.350	0.258	19.11
CD at 5%	18.1	2.84	0.542	0.0257	0.008	0.587
CV%	7.52	1.85	2.62	1.354	2.1	1.65

Table 4: Estimation of Evaluation index values for three seasons and ranking of foundation crosses

Foundation cross	Fecundity (no.)	Pupation %	Cocoon yield /10000 larvae(kg)	Cocoon wt (g)	Shell wt(g)	Shell%	Average	Rank
D6(P)N x SK4C	60.51	58.58	61.09	62.57	63.32	62.19	61.38	1
SK3C x SK3N	61.16	57.71	58.97	59.73	60.75	60.54	59.81	2
D6(P)N x SK4N	49.21	50.34	53.66	57.84	59.47	59.96	55.08	3
SK4C X SK4N	46.58	54.34	55.11	54.76	56.37	57.35	54.08	4
SK4C x D6(P)C	53.42	50.70	50.97	51.67	51.42	51.47	51.61	5
CSN x SK3C	48.53	51.91	51.41	48.76	47.95	48.27	49.47	6
SK3N x CSC	42.38	53.12	47.93	42.29	42.17	42.77	45.11	7
CSN x SK3N	40.84	48.47	47.73	47.44	43.75	40.71	44.83	8
SK3C x CSC	46.94	49.18	46.93	44.86	41.23	38.64	44.63	9
NB4D2 (Control)	50.42	25.65	26.20	30.08	33.57	38.11	34.00	10

traits. By considering the higher average EI value of all the traits, D6 (P) N x SK4C (EI value: 61.38) emerged as potential one.

CONCLUSION

Among the nine foundation crosses, D6 (P) N x SK4C found best considering its better performance in all the three seed crop seasons, especially the target seed crop Sep-Oct. Therefore it can be utilized as a male parent for preparation of three way cross, multi x bi hybrid for utilization in commercial crop.

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