Table 2. Coefficients of correlation among the pedicel length, fruit length, fruit diameter and fruit weight in the different genotypes of Chilli germplasm

Character	Pedicel length	Fruit length	Fruit diameter	Fruit weight
Pedicel length	1.000	0.526**	-0.297*	0.168ns
Fruit length		1.000	-0.308**	0.233**
Fruit diameter			1.000	0.621**
Fruit weight				1.000

** = significant at P = 0.01 * = significant at P = 0.05 ns = not significant

educed FD (r = -0.297 significant at P = 0.05) and t will not be effective in the improvement of dry fruit weight since its relation with PL is very negligible (r = 0.168, not significant) (Table 2). Selection based on longer PL and consequently decreased FD will be effective in breeding varieties with lesser diameter of the pedicel and consequently small diameter pedicel at the point of detachment to the stem facilitating easy harvest. The gene system that controls FD is the same as for PD (Setiamihardja and Knavel, 1990).

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FRUIT SEED WEIGHT AND SEED NUMBER AND THEIR RELATIONSHIP WITH OTHER CHARACTERS IN CHILLI

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ABSTRACT

Outstanding cultivars could be developed successfully and efficently by concentrating breeding on yield components than on yield itself. Two yield components namely fruit seed weight (FSWT) and number of seeds/fruit (FSN) were studied utilizing the diverse chilli germplasm maintained at Indian Institute of Horticultural Research, Bangalore. A fourfold variability was observed in each of FSWT and FSN and also in some other fruit characters. FSWT and FSN showed significant differences among the genotypes which included several high yielding cultivars popular in different States in India. The order of performance of the genotypes in respect of FSWT and FSN was similar. Positive correlation between FSWT and FSN was observed. Regression analysis indicated that FSWT was mainly dependent on FSN and FD positively and on FL (fruit length) and fruit length : fruit diameter ratio negatively. For obtaining higher fruit yield, genetic improvement in the characters namely FSN, FSWT, FD and fruit weight is to be aimed at.

KEY WORDS: Chilli, Genotypes, Fruit Seed Weight, Fruit Seed Number, Fruit Weight, Correlation, Regression

Capsicum breeders aim to increase fruit yield which is complex in nature and dependent on its co aracters Mean fruit wei ht (FWT and number of fruits/plant are the two major components of fruit yield/plant. Mehra and Peter 1980 and Sin h and Raj ut (1992) indicated that

selection for high yielding genotypes should be based on FWT. FWT is again made up of several parts namely number of seeds/fruit (FSN), fruit seed weight (FSWT), fruit pericarp weight (FPERWT), fruit pedicel weight (FPEDWT), pedicel length (PL), pedicel weight (FPEDWT), fruit length (FL), fruit diameter (FD), fruit size (FL X FD) and FL:FD ratio. Since FSWT and FSN are considered as important components, the genetic diversity of these traits have to be assessed among the genotypes of germplasm. Leng (1974) reported that heritabilities of yield components were mugh higher than the total yield and thus selection based on yield components would be more effective in breeding programmes. High heritability had been reported for the characters FSWT, FD, FL, FL X FD and number of fruits/plant by Chandra *et al.*, (1990) and Pawade *et al.*, (1993). Further, information on the relationship between yield and yield components will be helpful to form the basis of selection. Varieties with high FSWT and FSN are preferred not only to increase crop production but also to meet the needs of the seed industry and farmers. Very little information is available about FSWT and FSN and their association with FWT and other traits in chillies. The main objective of this study was i) to evaluate the chilli germplasm for FSWT and FSN; ii) to detect the possible associations of FSWT and FSN with FWT and other characters and iii) to estimate FSWT and FSN using other independent attributes by employing regression technique.

MATERIALS AND METHODS

The genetic materials consisted of 73 chilli genotypes including several high yielding varieties maintained at the Indian Institute of Horticultural Research, Bangalore were evaluated using randomized complete block design with three replications during 1980 *kharif* season. The plots were one row of 3.60 m long 50 cm apart. The distance between plants in the row was 30 cm. A basal dose of 20 t/ha FYM and N:P:K at 60, 80 and 50 kg/ha were incorporated before transplanting. The crop was also top dressed with 60 kg N/ha in two equal doses on 30th and 60th days after planting. Five plants were selected at random in each entry for recording observations. Number of fruits harvested over all the four pickings were counted and expressed as number of fruits/ plant (FN). Dry fruit yield/plant (FY) and finally dry fruit yield/ plot from all the four pickings were determined. From each genotype and replication, 10 red ripe fruits from the first picking were randomly selected and fruit length (FL) (distance from pedicel attachment to its apex), fruit diameter (FD) (measured at its maximum width) and pedicel length (PL)(distance between the points of attachment to the stem and the fruit) were measured. Fruit size (FLXFD) and fruit shape (FL/FD) were calculated. At the time of first harvest, 50 fruits were selected separately at random to record fruit dry weight (FWT), fruit seed weight (FSWT), fruit pericarp weight (FPERWT), fruit pedicel weight (FPEDWT) and number of seeds/fruit (FSN). One thousand seed weight (TSWT) was determined from 1000 seeds selected randomly from each plot. The statistical analysis was limited to the mean data for each variable and genotype in each replication. ANOVA was conducted to compare variable means of the 73 genotypes. Differences between means of genotypes were tested using least significant difference (1sd) at P = 0, 05. Genotypes were compared with the several high yielding cultivars and evaluated. Correlation analysis between FSWT and FSN and the inter-relationship among the variables were determined. The genotypes were then ranked based on the values of FSWT and FSN from highest to lowest to test whether the genotypes exhibit difference in the same order in respect of these two traits by applying the rank correlation test. Simple linear regression analysis considering FSWT as dependent variable (Y) and other characters as independent variable (Xs) was carried out separately. The coefficient of linear determination (R^2) was also calculated for each linear regression model. Correlation. rank correlation and regression analysis were carried out using the procedures of Steel and Torrie (1980).

RESULTS AND DISCUSSION

The performance of the genotypes in respect of different characters are shown in Table 1. Wide range of variation in all the traits were observed indicating the existence of genetic variation in the genotypes. A four fold range of variation in each of FWT, FSWT and FSN were observed and these results are in agreement with the findings of Sahoo

Table 1. Mean values for different parameters in the 73 chilli genotypes evaluated (arranged in the order from heavy to low of fruit seed weight)

Name of the genotype	FSWT	FSN	FL	FD	PL	FN
Gowribidnur (l)	0.6980	132.5	4.80	1.04	2.64	72.21
Guntur chilli	0.5894	98.2	10.85	1.32	3.44	30.29
JCA-154	0.5844	122.3	5.72	2.43	2.88	33.58
Byadgeri (l)	0.5316	110.5	5.80	1.04	3.30	56.44
Devdurg (l)	0.4754	75.7	6.53	1.21	3.40	18.42
JCA-232	0.4626	90.4	11.02	1.36	3.36	34.56
JCA-20	0.4538	75.1	10.42	1.55	3.04	27.32
Sardhana (l)	0.4534	95.7	4.73	1.73	2.80	37.24
Ronyal	0.4228	90.3	6.72	1.44	3.18	45.34
Kashmir (l)	0.4196	87.4	6.74	1.49	2.65	22.71
Charlapelly	0.4190	72.6	8.02	1.07	2.99	38.16
JCA-31B	0.4150	89.2	8.71	1.66	3.15	44.44
Ronyal (l)	0.4138	93.6	7.59	1.43	3.03	54.75
Red local (B)	0.4086	57.9	8.38	0.98	3.10	49.97
IHR-529	0.4056	84.3	5.86	1.44	2.48	39.99
Guntur chilli	0.4036	74.5	7.40	0.97	2.64	48.26
Kortical	0.3964	109.0	13.20	0.78	4.00	36.15
G5	0.3896	72.3	4.38	1.73	2.45	44.72
Ducale	0.3870	109.0	8.61	1.83	2.56	18.25
K2	0.3840	67.3	7.36	1.11	2.64	71.01
IHR-525	0.3780	84.9	8.81	1.35	2.87	51.68
IHR-531	0.3614	84.8	10.37	1.45	2.91	33.33
IHR-271	0.3596	81.5	12.02	1.33	2.88	21.83
Gowribidnur	0.3580	81.5	4.50	1.19	2.81	81.61
Arun (l)	0.3566	59.5	8.67	1.30	2.85	41.90
CO1	0.3490	73.5	7.96	1.17	3.35	48.83
Vijayawada (l)	0.3468	70.1	6.69	1.25	2.91	32.07
Musalwadi	0.3446	66.0	7.17	1.21	2.80	61.76
V.Kolar red	0.3422	73.6	4.71	1.23	2.89	47.31
Attapadi	0.3404	58.0	8.33	1.22	2.56	24.93
PM217(F)	0.3354	43.7	7.51	1.96	1.96	14.39
CA 960	0.3344	49.6	8.41	1.26	2.88	28.49
Mulato Rogue	0.3292	68.3	8.80	1.26	3.07	36.12
Raichur chilli	0.3274	50.5	7.85	1.29	3.24	47.91
Exambo	0.3238	60.2	11.39	1.09	2.99	50.35
Sardhana	0.3170	81.1	8.03	1.55	2.86	23.67
Daligai chilli	0.3148	57.1	5.17	1.10	2.69	76.58
Pant C-1	0.3116	68.6	6.32	1.20	3.15	79.90
IHR-263	0.3084	61.2	7.54	1.19	3.45	45.70
IHR-264	0.3070	52.9	7.14	1.19	2.35	39.82
IHR-270	0.2948	63.9	11.79	1.42	2.13	16.28
Anal	0.2888	53.7	7.58	1.25	3.37	46.94
Kalyanpur red	0.2804	42.3	10.09	1.05	4.35	39.18
G4	0.2790	45.0	7.94	1.11	3.14	59.68
Gowribidnur (l)	0.2786	52.9	8.57	1.02	3.20	60.23
Meerut (local)	0.2770	66.0	10.20	1.17	2.97	56.86
Kurnool chilli	0.2734	59.3	7.37	1.01	3.07	63.40

Table 1. Contd.,

Name of the genotype	FSWT	FSN	FL	FD	PL	FN
Anekal local	0.2686	55.4	4.86	1.02	2.44	106.59
IHR-268	0.2634	62.4	7.09	1.21	2.59	40.67
Kalyanpur	0.2536	42.9	8.29	1.14	2.80	82.30
IHR-268	0.2360	61.6	3.13	1.30	2.29	45.05
Shankeshwar	0.2354	50.2	13.74	1.06	3.37	38.53
Assam local	0.2300	56.1	3.84	1.31	3.88	28.80
Salem local	0.2266	43.7	6.26	1.19	2.28	69.61
Bellari khaddi	0.2240	49.6	12.70	1.08	3.39	44.24
Habbegudi	0.2232	48.7	4.53	1.08	2.33	126.26
IHR-45	0.2222	51.0	2.99	1.16	5.47	53.28
Varanasi local	0.2084	53.2	6.49	0.87	2.68	90.81
Kortical local	0.2076	48.2	13.18	0.79	3.75	42.10
Belgaum local	0.2070	48.9	14.60	0.92	3.71	27.75
DH-7-6-5	0.2062	47.4	14.73	1.01	3.92	44.12
Pusa Jawala	0.2012	47.0	12.25	1.07	3.24	44.99
IHR-302	0.2008	49.8	13.23	1.05	3.38	31.04
Kalyanpurchaman	0.1990	41.3	9.90	1.15	2.74	25.43
IHR-266	0.1964	45.9	7.06	1.06	2.51	44.19
Arun	0.1886	39.2	8.21	1.36	2.73	35.73
DH-7-6-12	0.1880	41.0	10.64	0.88	3.00	60.32
Byadegi	0.1776	51.6	13.64	0.99	3.57	28.66
Pinocchiopepper	0.1748	43.4	7.05	1.47	2.69	8.67
DH-7-6-6	0.1728	45.8	13.24	0.65	2.93	46.33
Sardanalocal4	0.1670	48.6	9.22	0.88	2.62	43.98
Santaka	0.1494	36.9	5.96	0.85	3.07	46.94
IHR-265	0.1474	31.5	8.18	1.13	2.65	48.09
lsd (P=0.05)	0.1082	20.6	1.27	0.28	0.44	26.02
Overall mean	0.3179	64.9	8.38	1.22	2.95	46.01
SEm	0.3190	2.5	0.34	0.03	0.06	2.43

FSWT = fruit seed weight (g); FD = fruit diameter (cm); FSN = number of seeds/fruit; PL = pedicel length (cm); FL = fruit length (cm); FN = number of fruits/plant

et al.,(1990). One can increase fruit yield by increasing FSWT or FSN or both.

Evaluation of genotypes for FSWT and FSN

Anova showed differences at P = 0.01 in these characters as well as other characters (Table 1) showing genetic variability. FSWT ranged from 0.6980 g to 0.1474 g. Based on lsd (P=0.05), the genotypes were classified into five distinct groups (A,B,C,D and E) in respect of FSWT. In group A, only one entry (entry 46) (Gowribidnur local) recorded the highest FSWT (0.6980 g). In group B, there were 3 entries (entry nos. 67,88 and 47) (Guntur chilli, JCA-154 and Byadgeri local respectively) recorded FSWT ranging from 0.5984 g to 0.5316 g. In groups C, there were 17 genotypes which recorded FSWT ranging from 0.4754 g to 0.3780 g. In groups D and E, there were 29 and 23 genotypes which gave 0.3614 g to 0.2536 g and 0.2360 g to 0.1474 g respectively. The outstanding genotype in group A i.e., entry 46 was recommended for breeding programmes to increase FSWT while aiming for the evoultion of high yielding cultivars and also for further improvement of yield in the already existing high yielding varieties namely K 2, G 4, G 5, pant C-1 CA-960 , CO 1, JCA 154 and Pusa Jwala. Further, Sahoo *et al.*, (1990) and Pawade *et al.*, (1993) reported high heritability for FSWT in their studies and hence there is great scope for improvement of this character through selection.

Table 2. Correlation coefficients among fruit seed weight and number of seeds/fruit and other characters in 73 genotypes of chilli

Trait	Y	X1	X2	X3	X4	X5	X6	X7
Y	1.0000							
X1	0.8790**	1.0000						
X2	-0.2580**	-0.2153**	1.0000					
X3	0.4614**	0.4545**	-0.3280**	1.0000				
X4	0.0640ns	0.0726ns	0.7451**	0.3270**	1.0000			
X5	-0.3833**	0.3078**	0.8753**	-0.6282	0.4070	1.0000		
X6	0.0124ns	0.0357ns	0.5196**	-0.2966**	0.2721**	0.5274**	1.0000	
X7	0.1150ns	0.1386ns	-0.3388**	-0.4020**	0.5126**	0.0487ns	0.1700na	1.000
FWT	0.6995**	0.6216**	0.2330**	0.6639**	0.5147**	0.2289*	0.1680ns	0.4544**

Y = Fruit seed weight (FSWT); X1 = Number of seeds/fruit (FSN); X2 = Fruit length (FL); X3 = Fruit diameter (FD); X4 = Fruit size (FL x FD); X5 = Fruit shape (FL/FD); X6 = Pedicel length (PL); X7 = Number of fruits/plant; FWT = Weight of the fruit; ns = not significant; * = significant at P = 0.05; ** = significant at P = 0.01

FSN ranged from 31.5 (entry 25) to 132.5 (entry 46) with overall mean of 69.9 ± 2.49 and cv of 32.8%. Based on lsd (P = 0.05), the genotypes were grouped into 5 (A, B, C, D and E) as in the case of FSWT. There were 2, 8, 17, 31 an 15 entries and with range values from 132.5 to 122.3, 110.5 to 90.3, 89.2 to 68.6, 68.3 to 48.2, and 47.4 to 31.5 respectively. The two entries in A (46 and 88) and 8 entries in B (47, 44, 6, 67, 48 41, 63 and 42) recorded significantly increased FSN than the high yielding varieties namely pant C-1, CO 1, G 5, K 2, Musalwadi, Byadagi, Shankeshwar, CA 960, Pusa Jwala and G 4 indicating their choice in breeding programmes to increase FSN in the existing popular high yielding varieties mentioned and also in the evolution of high yielding varieties in future plans. Sahoo *et al.*, (1990) reported high heritability (91.90 %) and genetic advance (29.23). The differences among the genotypes were due to genetic factors (Singh *et al.*, 1983 ; Awasthi *et al.*, 1976). The genotypes in mean FSWT also differed as in mean FSN in the same sequence, as rank correlation between the two rankings given to the genotypes in respect of FSWT and FSN was highly significant. A similar result has been reported by Almekinders *et al.*, (1995) in respect of berry weight and seed number in potato.

Correlation analysis

FSWT was significantly positively correlated with FSN (r = 0.8790) and FD (r = 0.4614) and negatively with FL : FD ratio (r =- 0.3833). FSN also exhibited a similar trend in the relationship with the above traits. These results show that the breeding efforts to increase whether FSWT or FSN or both would result in increased FWT and consequently fruit yield potential of new cultivars. Though FL was positively correlated with FWT (r=0.2330), it showed negative association with FSWT (r=-0.2580)as well as with FSN (r=-0.2153) and hence high FSWT or FSN could not be obtained by increasing FL. Khurana *et al.*, (1993) also reported significant positive correlation (r=0.5132) between FWT and FL. Fruit size (FLxFD), PL and FN were not correlated with either FSWT or FSN showing that they were independent traits. Correlation of FWT with FD has been reported by Sarma and Roy (1995). PL was associated with FL (r=0.5196) which result corraborated with Setiamihardja and Knave (1990) who also observed that PL and FL were genetic characters. The negative association of FSWT as well as FSN with FL and FL:FD ratio is undesirable and is an impediment to chilli breeding programmes when one wants to have long slender varieties with high FSWT or FSN. FWT and FSWT showed positive correlation (r=0.6995) which result is in close agreement with the findings of Mehra and Peter (1980).

Regression analysis

The regression equation between FSWT and other plant characters and the regression equation between FSN and FSWT are given in Table 3.

Table 3. Regression equations for fruit seed weight (FSWT) and several other characters and the regression equation for fruit seed number (FSN) and fruit seed weight (FSWT) and R^2 values in chilli

Regression equation	R^2 (%)
$Y = 0.0230 + 0.0045\ X_1^{**}$	77.26
$Y = 0.3979 - 0.0098\ X_2^{*}$	6.65
$Y = 0.0976 + 0.1805\ X_3^{**}$	21.29
$Y = 0.2974 + 0.0021\ X_4^{ns}$	0.48
$Y = 0.4004 - 0.0114\ X_5^{**}$	14.69
$Y = 0.3093 + 0.0029\ X_6^{ns}$	0.02
$Y = 0.3460 - 0.006\ X_7^{ns}$	0.01
$Y = 0.328 + 0.3745\ X_8^{**}$	48.93
$Y1 = 10.8494 + 169.9485\ X$	77.26

Y = Fruit seed weight (g) (FSWT); X_1 = Number of seeds/fruit (FSN); X_2 = Fruit length (cm) (FL); X_3 = Fruit diameter (cm) (FD); X_4 = Fruit size (sq.cm) (FL x FD); X_5 = Fruit shape (FL : FD); X_5 = Pedicel length (cm) (PL); X_7 = Number of fruits/plant (FN); X_8 = Fruit weight g (FWT); Y_1 = Number of seeds/fruit (FSN); X = Fruit seed weight (gm) (FSWT); ** = Significant at P = 0.01; * = Significant at P = 0.05; ns = not significant

Results of linear regression of i) FSWT on each of FWT, FSN, FL, FD, FL x FD, FL:FD ratio, PL and FN and ii)FSN on FSWT were studied by examining the significance of the regression components. The increase in FSWT was found to be the function of increased FWT,FSN and FD. Maximum variation in FSWT was attributed due to FSN followed by FWT as revealed by the coefficient of determination (R^2) values of 0.7726 and 0.3745 respectively. The significant regression coefficient between FSWT and FSN suggested that FSN had a direct influence on FSWT. The effect of characters namely fruit size (FLXFD), pedicle length (PL) and number of fruits/plant on FSWT was negligible as they showed non-significant correlation and regression coefficients. The negative relationship of FSWT with FL and FL:FD ratio indicated that the higher the FSWT the higher the reduction in FL and FL: FD ratio. These results indicate that future genetic improvement programmes aimed to increase FSWT of chilli should increase further FWT, FSN and FD and reduce FL and FL : Fd ratio.

Variability in all the plant attributes was identified among the several chilli entries investigated in the present study. Fourfold variability was recorded in each of the character namely FWT, FSN and and FSWT. Genotypes recorded significantly greater values in FSN and FSWT than the popular high yielding varieties under cultivation in the different States in India were identified. FSWT showed significant positive correlation with FWT, FSN, FD and FL : FD and negative correlation with FL. The major components which caused variation in FSWT were found. The results showed that FSWT in chilli could be increased by developing suitable breeding programmes using the superior genotypes identified and the information obtained from correlation and regression studies.

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