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Analysis of Genetic Variability for Nutritional Quality Traits in Hot Pepper (*Capsicum annuum* L.)

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Variability and association analysis were studied among 42 genotypes of hot pepper (*Capsicum annuum* L.) comprising exotic (Taiwan), landrace and open-pollinated varieties for some important nutritional quality traits. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits under study and difference between GCV and PCV was not high, indicating that these quality traits were not much influenced by the environmental factors. Heritability ranged from 38.8% (manganese μg g^{-1}) to 99.9% (capsaicin %). High heritability and high genetic advance were observed for ascorbic acid, total phenols, iron (Fe) and beta carotene content in fruits indicating involvement of additive gene action. Association analysis exhibited both positive and negative correlations among the traits under study.

Key Words: Hot pepper, Variability, Correlation, Nutritional quality

Introduction

Hot pepper (*Capsicum annuum* L.) is an important vegetable as well as spice crop, not only because of its economic importance, but also for the nutritional value of its fruits, mainly due to the fact that they are an excellent source of natural red pigment capsanthin and antioxidant compounds (Howard *et al.*, 2000). It is an excellent source of vital micronutrients such as vitamin C and vitamin E (Minguez-Mosquera and Hornero-Mendez, 1994; Daood *et al.*, 1996; Gnayfeed *et al.*, 2001). The important states growing hot pepper are Andhra Pradesh, Orissa, Maharashtra, West Bengal, Karnataka, Rajasthan and Tamil Nadu. Total world production of hot pepper has been estimated to be 14–15 million t per year (Weiss, 2002). Capsaicinoids (heat principle), have aroused great interest lately owing to their biological and therapeutic importance (Surh and Lee, 1996; Szolcsanyi, 2004). Capsaicinoids are alkaloids specific for *Capsicum* sp. A wide spectrum of antioxidant compounds are present in pepper fruits. It includes antioxidant vitamins (Vitamin E, C and β-carotene), phenolic compounds, carotenoides and xanthophylls. One of the important antioxidant is phenolic compounds, which occurs in peppers in connection with sugars (Materska *et al.*, 2003 a, b). The level of antioxidants differs between accessions, generally hot peppers are a better source of them than the sweet ones (Daood *et al.*, 1996; Gnayfeed *et al.*, 2001). Phenolic compounds retard or inhibit lipid autoxidation by acting as radical scavengers (Namiki, 1990) and consequently, are essential antioxidants that protect against propagation of the oxidative chain. Another important antioxidant-vitamin C, an important compound of pepper fruits, chelates heavy metal ions (Namiki, 1990), reacts with singlet oxygen and other free radicals, and suppresses per oxidation, reducing the risk of arteriosclerosis, cardiovascular diseases, and some forms of cancer (Harris, 1996). Carotenoid pigment, vitamin E, vitamin C are located in the pericarp of pepper fruit, whereas, capsaicinoids are distributed in different parts. Genetic variability, especially for quality in given sets of germplasm has not been studied much. Study related to pepper as functional food or as a source of micronutrient are not meager, but, systematic screening study for the quality evaluation of hot pepper and use of the information for the development of better varieties is lacking. Hence, the present study was undertaken to analyze the extent of variability in respect of nutritional quality present in available germplasm of hot pepper to breed better quality hot pepper varieties.

Materials and Methods

The present experiment was conducted in VPKAS, Almora at experimental farm, Hawalbagh (29º36' N, 79º40' E and 1250 m asl). Forty two lines of hot pepper (exotic, local and open pollinated popular varieties) were grown in the field under completely Randomized Block Design with three replications in *kharif* season (June-September) 2007. The crop was raised as per the recommended package of practices. Peppers were harvested at green mature stage. Three replicates of 42 genotypes were analyzed for different functional (β-carotene, ascorbic acid, total phenolics and capsaicin) and nutritional attributes (phosphorous, potassium, zinc,

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copper, iron and manganese). The detailed information regarding source of chilli lines is mentioned in Table 1.

Chemical Analysis

Determination of Ascorbic Acid Content

L-ascorbic acid (LAA) was estimated extracted and quantified by HPLC as described by Abdulnabi *et al.* (1997) with minor modifications. The sample (10 g) was homogenized with solution (10 ml) containing meta-phosphoric acid (0.3 M) and acetic acid (1.4 M) for 15 minutes at room temperature. The mixture was filtered through Whatman No. 4 to obtain clear extract. All samples were extracted in triplicate. Mobile phase was Acetonitrile: Methanol: Tetrahyrofuran (45:50:5; v/v/v) at a flow rate of 1.0 ml min^{-1} and detected at 254 nm.

Determination of β-Carotene Content

β-Carotene in the pepper samples was according to Ismail and Fun (2003) with minor modifications. The β-carotene standard ($E_{1cm}^{1\%}$ = 2560 in hexane) was obtained from Sigma Chemical Co. (St. Louis, MO). Pepper samples (10 g) were extracted with 40 ml ethanol (99.8%) and 10 ml 100 % (w/v) potassium hydroxide and homogenized for three minutes. The mixture was saponified by heating for 30 min. Then, the mixture was partitioned thrice in n-hexane, followed by washing with distilled water and then passed through sodium sulfate. Hexane was removed under reduced pressure at 45°C using rotary evaporator. The standards and pepper isolates were dissolved in 10 ml of hexane prior to HPLC analysis. A mobile phase ran at 0.8 ml min^{-1} and consisted of water containing 0.01% formic acid: Acetonitrile (95:5 v/v). β-Carotene was detected at 450 nm using a UV-Vis detector. The column was equilibrated to the original mobile phase concentration prior to the next sample injection.

Determination of Total Phenolics Content

Total phenolic content of the MeOH extracts was determined by the Folin-Ciocalteu assay and catechol was used as standard (Singleton and Rossi, 1965). Sample (500 mg) was weighed into 50 ml plastic extraction tubes and vortexed with 25 ml extraction solvent (80% ethanol). The sample with the extraction solvent was than heated at 60°C (water bath) for 1 h, allowed to cool to room temperature, and homogenized for 30 s with a sonicator. Two hundred fifty microlitres (three replicates) were introduced into screw cap test tubes; 1.0 ml of Folin-Ciocalteu's reagent and 1.0 ml of sodium carbonate (7.5%) were added. The tubes were vortexed and heated for 15 minutes at 45°C. The absorption at 765 nm was measured (Model U 2001, Hitachi UV/Vis spectrophotometer) and the total phenolic content was expressed as catechol equivalents in mg per 100 g dry material.

Determination of Capsaicin Content

Capsaicin content was determined using spectro-photometer. Sample (500 mg) was weighed into 50 ml plastic extraction tubes and extracted with 10 ml extraction solvent (acetone) for 3 h. Then, the sample with the extraction solvent was centrifuged and 1.0 ml extract was

Table 1. List of hot pepper lines analyzed for genetic variability

Accession No.	Code of lines	No. of lines	Source
ICPN 10 # 1	VLC-16-I-1, VLC-16-I-2, VLC-16-II-1,VLC-16-II-3	4	AVRDC through NBPGR
ICPN 10 # 3	VLC-18-I-1, VLC-18-I-2	2	AVRDC through NBPGR
ICPN 10 # 5	VLC-20-I-2, VLC-20-II-1	2	AVRDC through NBPGR
ICPN 10 # 6	VLC-21-II-3-1, VLC-21-II-3-2	2	AVRDC through NBPGR
ICPN 10 # 7	VLC-22-I, VLC-22-I-2-1, VLC-22-I-2-2, VLC-22-IV-1, VLC-22-V-1-1, VLC-22-V-1-2, VLC-22-VII-1,	7	AVRDC through NBPGR
ICPN 10 # 8	VLC-23-I-1-1, VLC-23-II-2-1, VLC-23-II-2-2	3	AVRDC through NBPGR
ICPN 10 # 9	VLC-24-I-1	1	AVRDC through NBPGR
ICPN 10 # 10	VLC-25-1	1	AVRDC through NBPGR
ICPN 10 # 13	VLC-28-II-1, VLC-28-II-2, VLC-28-III-1	3	AVRDC through NBPGR
ICPN 10 # 14	VLC-29-1, VLC-29-II-1-1, VLC-29-II-1-2	3	AVRDC through NBPGR
ICPN 10 # 15	VLC-30-I-1, VLC-30-II-1,VLC-II-2	3	AVRDC through NBPGR
ICPN 10 # 16	VLC-31-I-1	1	AVRDC through NBPGR
ICPN 10 # 17	VLC-32-1, VLC-32-3, VLC-32-4	3	AVRDC through NBPGR
ICPN 10 # 19	VLC-34-2	1	AVRDC through NBPGR
Lakhori mirch	–	1	Salt, Distt. Almora, Uttarakhand
Janjeera mirch	–	1	Salt, Distt. Almora, Uttarakhand
Berry mirch	–	1	Salt, Distt. Almora, Uttarakhand
Lal mirch	–	1	Salt, Distt. Almora, Uttarakhand
Pusa Sadabahar	–	1	Released variety from IARI
Pusa Jwala	–	1	Released variety from IARI

taken in a beaker and evaporated. The residue was dissolved in 0.4% sodium hydroxide solution (5 ml) and 3 ml 3% phosphomolibdic acid was added. The mixture was kept for 1 h and absorbance was taken at 650 nm after centrifugation. The capsaicin content was expressed as per cent dry material.

Determination of Nutritional Attributes

Peppers were analyzed for nutrient parameters after di-acid digestion (HNO_3: $HClO_4$; 10:4 v/v). The K content was determined by flame photometry, while Fe, Zn, Cu and Mn contents were analyzed by using an atomic absorption spectrophotometer. Phosphorus (P) was estimated photometrically via development of phospho-molybdate complex (Taussky and Shorr, 1953).

Statistical Analysis

The genotypic and phenotypic coefficient of variation, heritability (broad sense) were calculated by standard statistical procedure given by Burton and De Vane (1953); Johnson *et al.* (1955). The genotypic and phenotypic correlation coefficient was calculated by a method described by Singh and Choudhary (1979).

Results and Discussion

Variation among 42 genotypes of hot pepper was found highly significant for the characters under study (Table 2). The estimates depicting the genetic variability including genotype range, mean genotypic and phenotypic variation (GCV andPCV), heritability (broad sense) and genetic advance are presented inTable 3.

Wide variation (0.20-0.36 mg 100 g^{-1}) was observed in β-carotene content in evaluated pepper lines, suggesting considerable levels of genetic diversity. The result was not consistent with the report by Gnayfeed *et al.* (2001), where it was reported that paprika red pepper contained 171-250 mg g^{-1} β-carotene, but similar to the report by Howard *et al.* (2000). The latter reported 337-800 mg 100 g^{-1} β-carotene in *Capsicum annuum* fresh fruit. Ascorbic acid content in pepper accessions ranged from 25-217 mg 100 g^{-1}, consistent with the report by Howard *et al.*, 2000 and Gnayfeed *et al.* (2001). Total phenolics ranged between 38.4-188.1 mg 100 g^{-1} catechol equivalent. Capsaicin content ranged between 0.08-0.67%, which is far below than the report by Contreras-Padilla and Yahla (1998). It was reported that paprika accession contained 383-1075 mg g^{-1} (Gnayfeed *et al.*, 2001) and 997-1240 mg g^{-1} (Ayuso *et al.*, 2008) dry matter capsaicinoid. Phosphorous and potassium content in pepper ranged between 0.33-0.59 and 2.9-6.7% (dry matter basis). It was reported that physiologically mature peppers were rich in mineral content than green one (Jadczak and Grzeszczuk, 2004). Iron and zinc content ranged from 146-317 mg g^{-1} and 11.4-32.6 mg g^{-1}, respectively (Table 3). The PCV was higher than GCV for all the traits under study and difference between GCV and PCV is not much except manganese contents (mg g^{-1}) in fruits indicating that these quality traits were not much influenced by the environmental factors. Similar findings were reported by Shirshat *et al.* (2007), that difference between PCV and GCV was less in case of ascorbic acid content in fruits (Table 3). The high heritability coupled with high genetic advance was recorded for ascorbic acid, total phenols, iron (Fe) and β- carotene contents in fruits indicating the involvement of additive gene action for expression of these traits. Johnson *et al.* (1955) suggested that traits with high heritability coupled with high genetic advance would respond to select better than those with high heritability and low genetic advance. Heritability is not an exact parameter because it could be high even when genetic

Table 2. Analysis of variance for quality attributes in forty-two genotypes of hot pepper

Traits	Mean Sum of Squares (d.f.)			CD (5%)
	Replication (02)	Genotypes (41)	Error (82)	
K	0.00055	1.7815**	0.0071	0.137
P	0.000003	0.011456**	0.000047	0.011
Zn	0.2729	51.937**	0.549	1.198
Cu	0.0213**	6.954**	0.0037	0.100
Fe	8.822	4429.450**	46.51	11.078
Mn	0.492	14.312**	4.925	3.604
β-carotene	0.0007	0.347**	0.0034	0.096
Ascorbic acid	52.66	6643.68**	33.88	9.455
Total Phenolics	279.50*	4532.57**	68.67	13.460
Capsaicin	0.0244**	0.045**	0.000019	0.007

**Significant at 1 per cent level *Significant at 5 per cent level

Table 3. Range, mean, variance, coefficient of variation, heritability and genetic advance for quality attributes of hot pepper

Traits	Units	Range	Mean	Variance		Coefficient of Variation (%)		Heritability in broad sense (%)	Genetic advance 5%
				Genotypic	Phenotypic	Genotypic	Phenotypic		
K	%	2.88-6.69	4.596	0.591	0.599	16.732	16.833	98.8	1.58
P	”	0.326-0.585	0.463	0.004	0.004	13.327	13.409	98.8	0.13
Zn	mg g^{-1}	11.4-32.60	19.827	17.131	17.675	20.875	21.204	96.9	8.39
Cu	”	3.93-9.067	7.214	2.317	2.321	21.101	21.118	99.8	3.13
Fe	”	146.10-316.8	193.94	1460.98	1507.49	19.709	20.020	96.9	77.52
Mn	”	11.80-22.90	17.63	3.129	8.054	10.033	16.098	38.8	2.2
β-carotene	mg 100 g^{-1}	0.20-0.36	0.275	0.115	0.118	12.316	12.501	97.0	0.69
Ascorbic acid	”	25.00-217.00	67.79	2203.27	2237.15	69.246	69.777	98.5	95.96
Total phenolics	”	38.41-188.10	94.63	1487.97	1556.64	40.761	41.691	95.6	77.69
Capsaicin	%	0.08-0.670	0.267	0.015	0.015	46.240	46.268	99.9	0.25

Table 4. Genotypic (r_g) phenotypic (r_p) correlation coefficient among different quality attributes of hot pepper

Traits		K	P	Zn	Cu	Fe	Mn	β-carotene	Ascorbic acid	Total Phenolics	Capsaicin
K	r_g	1.0	0.6573	0.2048	–0.1852	–0.0163	0.6126	–0.1165	0.0449	0.0208	–0.0591
	r_p	1.0	0.6506	0.1965	–0.1849	–0.0116	0.3834	–0.1132	0.0438	0.0209	–0.0583
P	r_g		1.0	0.0585	–0.0953	0.0748	0.5806	–0.0982	0.0920	0.0480	0.0248
	r_p		1.0	0.0635	–0.0944	0.0839	0.3199	–0.0890	0.0913	0.0442	0.0246
Zn	r_g			1.0	0.2141	0.2547	0.4551	0.0237	–0.0213	–0.0430	0.0053
	r_p			1.0	0.2092	0.2611	0.2999	0.0210	–0.0210	–0.0389	0.0050
Cu	r_g				1.0	0.2402	0.0767	0.2277	–0.3681	0.0793	0.2286
	r_p				1.0	0.2353	0.0377	0.2256	–0.3646	0.0788	0.2280
Fe	r_g					1.0	0.4285	0.1754	–0.1198	0.3304	0.1169
	r_p					1.0	0.2364	0.1799	–0.1163	0.3170	0.1155
Mn	r_g						1.0	–0.1355	–0.1374	–0.0415	0.1884
	r_p						1.0	–0.1320	–0.0830	–0.0011	0.1164
β–carotene	r_g							1.0	–0.3311	–0.1105	0.0541
	r_p							1.0	–0.3230	–0.1052	0.0531
Ascorbic acid	r_g								1.0	0.2316	–0.0685
	r_p								1.0	0.2243	–0.0679
Totat phenolics	r_g									1.0	0.1365
	r_p									1.0	0.1323
Capsaicin	r_g										1.0
	r_p										1.0

advance is very low (Table 3). However, expected genetic gain can be high only if the genetic variance is high (Allard, 1960). Burton and Devane (1953) suggested that GCV along with heritable estimates would give a better picture of the amount of progress expressed by phenotypic selection.

The assessment of genetic potentiality of important quality traits and their association is of paramount importance to carryout the effective selection of genotype with desired quality traits. Correlation coefficient of important quality traits were estimated at genotypic and phenotypic levels. In the present study, the genotypic correlation coefficients were higher in magnitude than their respective phenotypic ones and positive correlation was observed (β carotene with P, Zn, Fe, Mn, β carotene and total phenols; total phenols with P, Fe, and ascorbic acid; ascorbic acid with K and P; β carotene with Zn and Cu, ascorbic acid and lycopene) indicating that there is an inherent association among these traits (Table 4).

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Studies on Genetic Variability, Character Association and Path Coefficient Analysis in Sesame (*Sesamum indicum* L.)

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Eighty two genotypes of sesame (*Sesamum indicum* L.) were evaluated in Randomized Block Design during rainy season of 2006 at Agricultural Research Station, Mandor, Jodhpur to assess the variability and character association. The mean sum of squares were significant for all the characters studied except oil content, indicating the presence of variability. Characters like seed yield, primary branches per plant, capsules per plant and capsule bearing height exhibited high heritability coupled with high genetic advance revealing that these characters were controlled by additive gene action. Seed yield showed significant positive correlation with capsules per plant, oil content, test weight, capsule bearing height and primary branches per plant. The maximum positive direct effects on seed yield was observed by capsules per plant followed by test weight and plant height, while days to maturity, days to 50% flowering and capsule bearing height had negative effect. Thus, capsules per plant, test weight and plant height were the major components contributing to the seed yield in sesame.

Key Words: Sesame, Variability, Heritability, Correlation, Path coefficient

Introduction

Rajasthan is the major sesame growing state (314.9 thousand ha area) in India with a production of 126.9 thousand tonnes but the productivity (403 kg/ha) is low (Anonymous, 2007-08). In order to increase the potential of sesame genotypes for seed yield, an understanding of the relationship among different characters with seed yield and presence of variability is essential. Besides this, knowledge about the direct contribution of different characters to seed yield would be highly useful for formulating a selection criterion, which will combine high seed yield and other desirable traits such as oil content. Therefore, the present study was undertaken to know variability and characters association among sesame genotypes for seed yield with yield contributing characters.

Materials and Methods

The materials for present investigation comprised of 78 newly developed white seeded genotypes selected from F_6 generation of different crosses (Parents RT 3, RT 46, RT 73, RT 125, RT 127, RT 142, RT 156, RMT 34, RMT 40, RMT 50, RMT 117, RMT 123, TKG 20, TKG 55, ES 135, ES 187, GRT 8333, GRT 8368, JLT 8, TNAU 63, AT 8, C 6, TC 383, IS 158-2, IS 225-3 and IS 238) and four standard check varieties (RT 46, RT 54, RT 127 and TKG 22) of sesame (*Sesamum indicum* L.). A set of 82 entries/varieties of sesame was grown in Randomized Block Design with three replications during *kharif* 2006 at research farm of Agricultural Research Station, Mandor, Jodhpur. Each genotype was sown in five rows of 4 m length following crop geometry of 30 cm × 15 cm. The crop was raised under rainfed conditions and all agricultural operations were done as and when necessary. The data were recorded on five competitive plants taken from each replication for plant height (cm), capsule bearing height (cm), number of primary branches per plant and number of capsules per plant. Seed yield (kg/ha), test weight (g), oil content (%), days to 50% flowering and maturity were recorded considering whole plot. The data were subjected to analysis of variance following standard methods. Correlation coefficients were used to perform the path analysis of seed yield suggested by Dewey and Lu (1959) and the other genetic parameters such as variability, heritability and expected genetic advance as percent of mean were estimated using INDOSTAT software (Indostat Services, Hyderabad).

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all the characters except oil content, indicating the presence of variability. The range, mean, coefficient of variability, heritability in broad sense and genetic advance (as per cent of mean) for yield and its component characters are given in Table 1. Wide variability was observed for seed yield (250-891 kg/ha) and other characters also. The high magnitudes of phenotypic as well as genotypic coefficient of variation for seed yield, primary branches per plant and capsules per plant indicated the presence of ample amount of variation for these characters. The high heritability (75-95%) combined with high genetic advance as percent of

Table 1. Estimates of genetic parameters of seed yield and its component characters in sesame

Characters	Mean	Range		GCV	PCV	Heritability	GA as per cent
	Min.	Max.	(%)	(%)	(%)	of mean	
Seed yield (kg/ha)	571.0	250.0	891.0	25.4	26.0	95	50.9
Days to 50% flowering	42.0	38.0	45.0	3.2	3.6	82	6.0
Days to maturity	80.0	71.0	87.0	2.5	2.7	88	4.9
Plant height (cm)	127.0	95.0	145.0	5.4	6.2	75	9.7
Capsule bearing height (cm)	59.0	47.0	93.0	8.9	10.3	76	16.0
Primary branches/plant	2.9	1.0	4.4	18.7	20.4	84	35.4
No. of capsules/plant	45.0	28.0	62.0	13.9	15.2	84	26.2
Test weight (g)	2.66	2.44	2.95	3.7	4.1	83	7.0
Oil content (%)	45.7	38.4	49.2	1.9	3.9	22	1.8

GCV-Genotypic coefficient of variation, PCV-Phenotypic coefficient of variation, GA-Genetic advance

mean for seed yield, primary branches per plant, capsules per plant and capsule bearing height revealed that these characters were controlled by additive gene action, suggesting that selection for these traits would be effective for crop improvement. These results are in agreement with those reported by earlier workers (Solanki and Gupta, 2004; Babu *et al.,* 2004).

The estimates of correlation coefficients between seed yield and other yield contributing characters in all possible combinations are presented in Table 2. Relative higher magnitude of correlation coefficients indicated a strong inherent association among various characters. Therefore, selection on the basis of the phenotype would be effective. Seed yield was found to be significantly and positively correlated with number of capsules per plant (0.56), oil content (0.48), test weight (0.31), number of primary branches per plant (0.26) and capsule bearing height (0.23), while days to maturity were significantly and negatively correlated with the seed yield (-0.42), which was a good sign for escaping drought in high yielding genotypes of sesame. Similar results were reported by Osman Khidir and Osman (1970) for plant height, branches number, capsules number and 1000-seed weight. Among other characters number of capsules per plant had positive significant correlation with number of primary branches per plant (0.52) and capsule bearing height (0.45). Plant height also exhibited significant positive association with days to maturity (0.47), days to 50% flowering (0.43) and capsule bearing height (0.31). These results indicated that improvement in seed yield can be achieved by improving the characters like capsules per plant, test weight and primary branches per plant.

Dewey and Lu (1959) suggested that when more variables are considered in correlation matrix, path coefficient analysis becomes more useful in specifying the cause and also measures the relative importance of each character. The direct and indirect effects of various characters on seed yield are given in Table 3. Number of capsules per plant had the maximum direct effects (0.471) on seed yield followed by test weight (0.229) and plant height (0.051), while days to maturity (-0.330) showed maximum negative direct effect *i.e.* early maturing genotypes were also higher yielders.

Thus, it may be concluded from this study that number of capsules per plant, test weight, number of primary branches per plant and plant height are the most important components for determining seed yield, as they

Table 2. Correlation coefficients between seed yield and its component characters in sesame

Characters	Days to maturity	Plant height	Capsule bearing height	Primary branches/ plant	No. of capsules/ plant	Test weight	Oil content	Seed yield
Days to 50% flowering	0.328**	0.429**	–0.103	0.162	0.036	–0.265*	–0.045	–0.132
Days to maturity		0.479**	0.146	–0.301**	–0.273*	0.094	–0.112	–0.415**
Plant height			0.316**	–0.038	0.056	0.179	0.155	0.017
Capsule bearing height				–0.121	0.450**	0.253*	0.083	0.227*
Primary branches/plant					0.516**	–0.224*	0.234*	0.263*
No. of capsules/plant						0.098	0.167	0.561**
1000-seed weight							0.150	0.314**
Oil content								0.484**

*and ** significant at 5% and 1% level, respectively.

Table 3. Path coefficient analysis showing direct (diagonal) and indirect effects in sesame

Characters	Days to 50% flowering	Days to maturity	Plant height	Capsule bearing/ plant	Primary branches/ plant	No. of capsules	1000-seed weight	Oil content	Seed yield
Days to 50% flowering	**–0.029**	0.009	0.012	–0.003	0.005	0.001	–0.008	–0.001	–0.132
Days to maturity	–0.108	**–0.330**	–0.158	–0.048	0.099	0.090	–0.031	0.037	–0.415**
Plant height	0.022	0.025	**0.051**	0.016	–0.002	0.003	0.009	0.008	0.017
Capsule bearing height	0.005	–0.008	–0.017	**–0.053**	0.006	–0.024	–0.013	–0.004	0.227*
Primary branches/plant	–0.200	0.037	0.005	0.015	**–0.121**	–0.063	0.027	–0.028	0.263*
Capsules/plant	0.017	–0.129	0.026	0.212	0.243	**0.471**	0.046	0.078	0.561**
1000-seed weight	–0.061	0.022	0.041	0.058	–0.051	0.023	**0.229**	0.034	0.314**
Oil content	–0.016	–0.040	0.056	0.030	0.084	0.060	0.054	**0.360**	0.484**

Residual effect = 0.6321

recorded significant positive correlation coefficients and higher positive direct and indirect effects on seed yield.

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Heterosis over Superior Parents under Diallel Cross in Linseed/Flax (*Linum usitatissimum* L.)

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A heterozygous individual resulting from the cross of two unlike parents is a hybrid which is usually vigorous. This increased vigour is often referred as hybrid vigour or heterosis. In general, considerable amount of heterosis over superior parent was observed for almost all the characters. Forty crosses showed positive and significant heterosis for seed yield per plant and 13 crosses for fibre yield per plot while nine crosses showed heterosis in both seed yield per plant and fibre yield per plot.

Key Words: Heterosis, Seed yield, Fibre yield

Introduction

Linseed/Flax (*Linum usitatissimum* L.) is an oilseed crop grown in winter (*rabi*) season in India mainly for industrial oil purpose. Besides oil, linseed is an excellent fibre producing crop with immense medicinal properties. India is one of the major linseed growing countries but its utilization is confined to only industrial oil purpose. The importance of this crop needs great attention to popularize the diverse use of linseed for better reaps of harvest. It is a highly self-pollinated crop. The scope for exploitation of hybrid vigour in genetically diverse population depends on direction and magnitude of heterosis and type of gene action. Techniques of hand emasculation and crossing have been standardized in this crop and the studies on the extent of heterosis for yield and its components were carried out through diallel mating design.

Materials and Methods

Experimental materials comprised of ten varieties, namely, Shubhra, Garima, Shekhar, Janki, J-23, T-397, Gaurav, Belinca, Rasmi and Nagarkot. The above varieties crossed in diallel mating design (without reciprocal) thus 45 F_1 were produced which were advanced to get the sufficient seeds for F_2 generation, the 10 parents along with 45 F_1s and 45 F_2s were grown in a Randomized Block Design with three replications at Oilseeds farm, CSA University of Agriculture and Technology, Kalyanpur, Kanpur, during *Rabi* 2002-2003. In 5 x 2 sq m plot size, row-to-row and plant-to-plant distance were maintained at 45 cm and 30 cm, respectively. The crop protections and other cultural operation were carried out as required to raise a good crop. The data were recorded on 5 randomly selected plants on thirteen characters, namely, days to 50% flowering, plant height (cm), technical plant height (cm) days to maturity, stem diameter (mm), number of capsules/plant, number of tillers/plant, seed yield/plant (g), oil content (%), fibre length (cm), fibre strength (Tax), fibre fineness (g/Tax) and fibre yield/plot (kg). Magnitude of heterosis was calculated as per cent of F_1 performance in favorable direction over superior parent as suggested by Hays *et al.* (1955).

Results and Discussion

For all the characters under study, F_1 crosses varied in magnitude and direction of heterosis (Table 1). This can be ascribed to the presence of genetic diversity among parents for all characters. The main cause of heterosis is dominant effect. The negative heterosis, which is desirable for days to 50% flowering, plant height, technical plant height and days to maturity was common in most of the crosses. The high negative heterosis over superior parent was observed in T-397 x Nagarkot, J-23 x Nagarkot, T-397 x Guarav, Janki x Belinca, and T-397 x Rasmi for days to 50% flowering, T-397 x Gaurav, Shekhar x Janki, Garima x Belinca, Shekhar x Belinca, and Janki x Belinca for plant height, for techmichal plant height Garima x Rasmi, T-397 x Rasmi, J-23 x Nagarkot and Garima x Balinca. Likewise for days to maturity, T-397 x Nagarkot, Garima x Nagarkot and Shekher x Nagarkot were found to have negative heterosis over superior plants. These results are in conformity with the findings of Singh *et al.* (1981), Singh and Srivastava (1987), Thakur and Bacteria (1991) for plant height and days to maturity.

The range of heterosis over superior parents is given in Table 3. The results indicated that seed yield/plant, fibre yield, stem diameter, technical plant height and fibre

Table 1. Percent heterosis over superior parent for 13 characters of a 10 x 10 diallel crosses of Linseed/Flax

Cross	Days to 50% flowering	Plant height	Technical plant height	Days to maturity	Stem dia	Number of capsules/ plant	Number of tillers plant	Seed yield/ plant	Oil content	Fibre length	Fibre strength	Fibre fineness	Fibre yield/plot
Shubhra x Garima	6.36**	5.72**	28.94**	4.49**	–2.02**	–4.84	0.25	–11.95**	3.14**	14.55**	26.32**	7.01**	18.34**
Shubhra x Shekhar	–0.89	10.44**	25.17**	0.72	4.67**	6.57*	14.17**	–15.15**	5.73**	–9.12**	24.15**	10.85**	–2.70**
Shubhra x Janki	–11.20**	1.77	–0.83	–5.79**	23.96**	72.20**	15.73**	26.11**	3.07**	–14.26**	4.73**	14.12**	26.76**
Shubhra x J–23	7.83**	23.61**	22.55**	5.27**	8.11**	20.87**	16.99**	16.13**	0.98*	1.50	3.44**	15.30**	74.45**
Shubhra x T-397	3.69**	21.16**	29.41**	2.60*	50.56**	20.48**	50.00**	34.67**	6.64**	–3.90**	6.23**	3.55**	8.28**
Shubhra x Gaurav	2.71*	–8.87**	–22.60**	–1.66	35.35**	12.02**	29.71**	13.04**	6.26**	–11.32**	–5.90**	–19.19**	–15.22**
Shubhra x Belinca	–5.06**	–6.58**	–10.97**	–7.30**	4.81**	38.07**	–13.04**	34.05**	1.02**	–16.70**	–4.40**	–3.87**	–29.71**
Shubhra x Rasmi	–5.95**	–2.76	–15.75**	–3.53**	21.87**	–17.42**	21.66**	16.66**	8.75**	–26.81**	–6.03**	7.10**	–22.43**
Shubhra x Nagarkot	–15.22**	–13.36**	–16.73**	–9.53**	18.02**	37.79**	10.23**	77.49**	0.59	–24.18**	0.77	–2.41**	–29.87**
Garima x Shekhar	–3.35*	–3.67*	1.35	–2.31*	8.41**	–12.65**	–9.63**	–4.74**	5.50**	–23.24**	–2.58*	14.12**	–1.09**
Garima x Janki	–2.73	–6.28**	–9.00**	–4.40**	3.12**	17.84**	–3.93**	35.14**	2.77**	–25.84**	0.29	15.83**	24.66**
Garima x J-23	1.55	5.87**	9.47**	2.98**	–15.32**	–4.62	10.46**	17.63**	4.40**	–17.48**	8.26**	4.15**	22.36**
Garima x T-397	5.17**	2.37	–3.30	4.56**	6.74**	–18.53**	1.35**	13.71**	3.67**	–4.52**	3.34**	16.68**	–.032
Garima x Gaurav	–3.18*	–10.62**	–26.32**	–3.17**	–17.17**	8.59**	4.35**	1.07**	0.78*	–4.64**	1.81	–29.89**	–19.14**
Garima x Belinca	–13.14**	–21.49**	–38.05**	–8.44**	2.88**	34.86**	–7.61**	56.75**	–2.10**	–22.09**	7.45**	–17.44**	–39.81**
Garima x Rasmi	4.29**	–7.92**	–53.99**	–6.17**	–20.83**	2.97	16.98**	30.03**	3.62**	–42.12**	–11.61**	–11.93**	–49.07**
Garima x Nagarkot	–12.26**	–13.35**	–31.17**	–10.99**	–37.84**	74.92**	15.91**	103.96**	–2.79**	–28.87**	5.74**	–0.47**	–36.29**
Shekhar x Janki	–9.78**	–25.46**	–32.57**	–5.55**	–22.92**	22.97**	12.36**	40.14**	13.61**	–15.77**	34.10**	2.16**	–13.01**
Shekhar x J-23	2.91*	5.77**	–6.94**	6.39**	–24.32**	3.62	34.64**	30.70**	5.21**	7.33**	6.61**	0.55**	67.57**
Shekhar x T-397	1.29	–8.31**	–27.67**	1.11	–11.24**	–19.31**	8.78**	45.15**	–0.43	3.90**	18.84**	5.53**	1.94**
Shekhar x Gaurav	2.43	–14.44**	–8.75**	–0.46	–24.24**	–1.77	23.19**	16.83**	4.89**	21.05**	14.94**	–5.93**	27.58**
Shekhar x Belinca	–4.70**	–21.05**	–26.05**	–6.90**	–25.96**	11.48**	–20.65**	45.78**	–6.07**	10.99**	15.01**	–14.56**	–7.87**
Shekhar x Rasmi	–4.71**	–8.83**	–21.74**	–3.45**	–17.71**	0.08	23.66**	23.48**	4.07**	8.23**	–9.26**	–10.38**	–10.28**
Shekhar x Nagarkot	–11.19**	–16.91**	–33.42**	–10.45**	–28.83**	49.57**	–4.55**	56.91**	5.12**	–2.72*	10.59**	–7.48**	–23.90**
Janki x J-23	5.29**	–3.44*	–20.35**	4.95**	–15.32**	4.46	29.41**	17.91**	6.67**	–4.32**	10.19**	2.30**	62.16**
Janki x T-397	6.43**	–9.44**	–31.97**	3.02**	–13.48**	–13.77**	26.35**	27.55**	4.84**	–7.19*	25.23**	9.38**	1.29**
Janki x Gaurav	–3.87**	–11.88**	–1.93	–2.98**	–32.32**	5.94	29.71**	16.26**	1.10**	9.72**	23.86**	–21.54**	–6.15**
Janki x Belinca	–16.36**	–20.86**	–30.88**	–8.98**	–30.77**	42.30**	0.00	41.84**	1.56**	8.73**	9.82**	0.00	–25.62**
Janki x Rasmi	–6.99**	–7.89**	–33.14**	–2.31*	–30.21**	11.64**	9.63**	13.03**	–2.25**	–3.58**	13.62**	–8.83**	–21.50**
Janki x Nagarkot	–10.52**	–8.70**	–14.28**	–8.08**	–30.63**	60.90**	11.36**	45.51**	–8.88**	2.18	23.60**	11.84**	–24.20**
J-23 x T-397	0.83	–1.49	–23.65**	2.73**	2.25**	–10.19**	27.03**	12.46**	3.00**	11.70**	24.47**	–2.50**	–15.05**
J-23 x Gaurav	–5.57**	–19.48**	1.26	–1.87	–22.22**	55.89**	55.07**	36.89**	10.44**	37.59**	18.55**	–15.75**	–5.12**
J-23 x Belinca	–3.80*	–12.66**	–32.50**	–6.05**	–35.58**	50.51**	–1.09*	42.96**	–0.40	10.24**	16.59**	–12.81**	–13.35**
J-23 x Rasmi	–7.71**	–14.25	–32.52**	–2.24*	–19.79**	19.52**	45.72**	28.36**	–2.16**	10.02**	5.36**	–6.65**	–13.46**
J-23 x Nagarkot	–19.16**	–12.21**	–38.53**	–10.11**	–22.52**	56.42**	–1.70**	48.79**	7.82**	–12.31**	31.25**	–15.81**	–32.48**
T 397 x Gaurav	–17.72**	–34.31**	–28.33**	–4.49**	2.02**	50.34**	50.72**	34.24**	–6.16**	12.92**	11.69**	3.74**	–31.31**
T 397 x Belinca	–12.59**	–15.67**	–28.13**	–4.82**	–21.15**	30.94**	–11.41**	34.43**	4.56**	1.08	22.01**	–18.27**	–24.53**
T 397 x Rasmi	–16.24**	–17.43**	–44.28**	–3.57**	1.04**	–2.89	14.30**	7.87**	3.16**	–6.80**	0.83	–4.10**	–8.60**
T 397 x Nagarkot	–20.34**	–18.57**	–21.78**	–11.65**	–0.90**	80.84**	10.23**	66.57**	6.93**	–16.99**	23.72**	–14.41**	–42.70**
Gaurav x Belinca	–5.51**	–15.67**	–21.63**	0.83	21.15**	38.79**	–8.70**	38.27**	6.16**	8.80**	21.44**	–21.30**	–12.65**
Gaurav x Rasmi	4.79**	–16.78**	–21.28**	0.39	5.21**	–6.88**	12.97**	–2.30**	5.08**	29.59**	7.92**	–8.83**	7.10**
Gaurav x Nagarkot	–8.89**	–18.47**	–25.76**	0.46	–15.32**	75.05**	6.82**	51.30**	–0.81*	6.10**	36.22**	5.30**	–7.49**
Belinca x Rasmi	8.38**	5.81**	–8.38**	6.37**	25.00**	–18.86**	3.61**	–14.70**	6.74**	16.59**	19.31**	29.96**	33.51**
Belinca x Nagarkot	–1.97	5.67**	–5.14**	3.31**	21.62**	28.04**	3.41**	26.28**	2.93**	0.98	36.86**	–1.40**	11.46**
Rasmi x Nagarkot	–12.68**	–4.45**	–6.26**	–2.18*	–15.32**	61.22**	0.00	59.71**	2.36**	6.54**	23.85**	–9.35**	–27.93**

*Significant at 5% per cent level; **Significant at 1 per cent level

Table 2. Crosses showing maximum heterosis for 13 characters in Linseed/Flax

S.No.	Character	Cross	Heterosis (%)
1.	Days to 50% flowering	T-397 x Nagarkot	-20.34
		J-23 x Nagarkot	-19.16
		T-397 x Gaurav	-17.72
		Janki x Belinca	16.36
		T-397 x Rasmi	-16.24
2.	Plant height	T-397 x *Gaurav*	-34.31
		Shekhar x Janki	-25.46
		Garima x Belinca	-21.49
		Shekhar x Belinca	-21.05
		Janki x Belinca	-20.86
3.	Technical plant height	Garima x Rasmi	-53.99
		T-397 x Rasmi	-44.28
		J-23 x Nagarkot	-38.53
		Garima x Belinca	38.05
4.	Days to maturity	T-397 x Nagarkot	-11.65
		Garima x Nagarkot	-10.99
		Shekhar x Nagarkot	-10.45
5.	Stem diameter	Shubhra x T-397	50.56
		Shubhra x Gaurav	35.35
		Belinca x Rasmi	25.00
6.	Number of capsules/plant	T-397 x Nagarkot	80.84
		Gaurav x Nagarkot	75.05
		Garima x Nagarkot	74.92
7.	Number of tillers/plant	J-23 x Gaurav	55.07
		T-397 x Gaurav	50.72
		Shubhra x T-397	50.00
8.	Seed yield/plant	Garima x Nagarkot	103.96
		Shubhra x Nagarkot	77.49
		T-397 x Nagarkot	66.59
9.	Oil content	Shekhar x Janki	13.61
		J-23 x Gaurav	10.44
		Shubhra x Rasmi	8.75
10.	Fibre length	J-23 x Gaurav	37.59
		Gaurav x Rasmi	29.59
		Shekhar x Gaurav	21.05
11.	Fibre strength	Belinca x Nagarkot	36.46
		Gaurav x Nagarkot	36.22
		Shekhar x Janki	34.10
		J-23 x Nagarkot	31.25
12.	Fibre fineness	Belinca x Rasmi	29.96
		Gamma x Janki	15.83
		Garima x T-397	15.68
13.	Fibre yield/plot	Shubhra x J-23	74.45
		Shekhar x J-23	67.57
		Janki x J-23	62.16

Table 3. Range of heterosis for 13 characters in Linseed/Flax

S.No.	Character	Range in heterosis (%)
1.	Days to 50% flowering	-20.34 – 8.33
2.	Plant height	-34.31 – 23.61
3.	Technical plant height	-53.99 – 29.41
4.	Days to maturity	-11.65 – 6.39
5.	Stem diameter	-37.84 – 50.56
6.	Number of capsule/plant	-19.31 – 80.84
7.	Number of tillers/plant	-20.65 – 55.07
8.	Seed yield/plant	-15.15 –103.96
9.	Oil content	-8.88 – 13.61
10.	Fibre length	-42.12 – 37.59
11.	Fibre strength	-11.61 – 36.46
12.	Fibre fineness	-29.89 – 29.96
13.	Fibre yield/plot	-49.07 – 74.45

length, heterosis was maximum for seed yield/plant up to 103.96% as observed over superior parents.

Positive heterosis, which is desirable for stem diameter, number of capsules/plant, number of tillers/ plant, seed yield/plant, oil content, fibre length, fibre strength, fibre fineness and fibre yield. High positive heterosis over superior parents was observed and T-397 x Nagarkot for seed yield/plant, T-397 x Nagarkot, Gaurav x Nagarkot and Garima x Nagarkot for no. of capsules/ plant, Shubhra x J-23, Shekhar x J-23 and Janki x J-23 for fibre yield, Shubhra x T-397, Shubhra x Gaurav, T-397 x Gaurav and Shubhra x T-397 for no. of tillers/ plant. For oil content the crosses, Shekhar x Janki, J-23 x Gaurav and Shubhra x Rasmi showed low heterosis percentage over superior parents. The results were in agreement with those of Kansal and Gupta (1981) Singh *et al.* (1983), Dakhore *et al.* (1987) and Rao *et al.* (1987) for seed yield and number of capsules/plant.

Conclusion

The studies on diallel (10 x 10 parents) without reciprocal analysis were carried out in linseed during *rabi* (winter) season 2002-03 to work out in the extent of heterosis for yield and its contributing traits. Garima, T-397, Nagarkot, Shekhar and Shubhra were observed to be best performing

Table 4. Estimates of SCA effects for 13 different characters in a 10 x 10 diallel cross of Linseed/Flax

Cross	Days to 50% flowering F_1	Plant height F_1	Technical plant height F_1	Days to maturity F_1	Stem dia F_1	Number of capsules/ plant F_1	Number of tillers/ plant F_1	Seed yield/ plant F_1	Oil content F_1	Fibre length F_1	Fibre strength F_1	Fibre fineness F_1	Fibre yield/plot F_1
Shubhra x Garima	1.08	–3.06**	5.80**	3.72**	–0.64**	8.47**	0.43	–0.68**	0.96**	4.93**	0.03	0.19*	6.20**
Shubhra x Shekhar	–0.47	3.14**	2.77**	3.11**	–0.02	12.26**	0.73*	–0.65**	1.01**	–0.57	–0.03	–0.11	4.65**
Shubhra x Janki	–4.69**	2.79**	–0.07	–3.09**	0.36*	22.28**	0.35	0.30	–1.52**	0.41	–0.05	0.09	–1.83*
Shubhra x J-23	1.63	1.84	1.63	1.04	0.18	0.78	–0.53	–0.20	–1.78**	–0.13	0.25**	0.08	–1.15
Shubhra x T-397	1.27	2.76**	3.12*	–0.66	0.56**	20.19**	1.16**	0.86**	1.57**	–0.59	–0.13*	0.02	–1.84*
Shubhra x Gaurav	4.88**	3.55**	–8.77**	–0.87	0.53**	–14.10**	–0.15	–0.15	0.48	–2.38**	–0.16**	–0.16*	–2.70**
Shubhra x Belinca	2.73**	6.98**	6.82**	–3.41**	–0.44**	–5.71**	–0.74*	–0.09	–0.71**	–0.41	0.31**	–0.22**	–2.18**
Shubhra x Rasmi	–0.56	3.54**	2.88*	–1.88**	0.06	–25.09**	–0.05	0.11	1.47**	–2.88**	0.39**	–0.12	–0.16
Shubhra x Nagarkot	–3.32**	–3.73**	–0.03	–3.94**	0.31	–17.23**	–0.02	0.81**	–1.11**	–0.75	0.18**	–0.09	–1.97*
Garima x Shekhar	–1.30	–0.91	2.21	1.27	0.98**	–1.58	–0.34	–0.20	1.65**	–2.06**	0.17**	0.07	–1.61
Garima x Janki	4.37**	2.24	4.16**	1.05	0.51**	–8.73**	–0.41	0.50*	–0.89**	–1.47	0.11	0.23**	–2.55**
Garima x J-23	–2.00*	–2.99**	4.92**	0.41	0.13	–14.59**	–0.46	–0.36	0.35	–2.25**	0.02	–0.11	0.32
Garima x T-397	3.74**	–2.39*	0.88	4.04	0.08	–13.98**	–0.83**	–0.44*	1.06**	0.55	0.40**	0.10	–2.11**
Garima x Gaurav	0.56	7.43**	–3.05*	–0.74	–0.89*	–11.47**	–0.91**	–0.94**	–0.98**	0.40	–0.54**	–0.06	–0.26
Garima x Belinca	–4.25**	–3.82**	–5.53**	–2.88**	0.31	–1.72	0.01	0.48*	–1.27**	–0.83	–0.18**	–0.30**	1.62
Garima x Rasmi	2.34**	4.82**	–14.16**	–3.55**	–0.49**	–3.32**	0.13	0.52**	0.16	–5.91**	–0.20**	–0.43**	–1.52
Garima x Nagarkot	1.09	1.84	–1.79	–3.91**	0.94**	7.33**	0.73*	1.49**	–1.76**	–0.94	0.37**	–0.07	–0.36
Shekhar x Janki	–3.57**	–10.51**	–6.72**	–2.34**	–0.20	0.96	0.45	0.57**	2.90**	–3.67**	–0.26**	–0.36**	3.66**
Shekhar x J-23	–2.42*	–1.26	–1.53	2.86**	–0.08	–3.46**	0.67*	0.09	0.23	–2.05**	–0.06	–0.02	–1.73*
Shekhar x T-397	–0.81	–6.68**	–7.45**	–2.11**	–0.33	–10.48**	–0.57	0.99**	–1.12**	–2.28**	0.07	–0.09	–0.42
Shekhar x Gaurav	4.24**	5.59**	5.19**	1.21	0.50**	–14.21**	–0.14	–0.37	0.02	2.10**	0.58**	0.48**	1.72*
Shekhar x Belinca	2.91**	–1.55	2.39	–2.39**	–0.56**	–10.32**	–0.90**	–0.07	–3.38**	5.21**	–0.03	0.26**	2.21**
Shekhar x Rasmi	0.46	5.27**	5.74**	–1.37*	–0.27	–1.29	0.36	0.04	–0.11	3.96**	–0.11	0.04	–2.47**
Shekhar x Nagarkot	0.73	0.17	–4.20**	–5.36**	–0.48**	–1.20	–0.58*	–0.30	1.02**	2.86**	0.10	–0.01	–0.75
Janki x J-23	–0.37	–9.03**	–7.37**	1.23	0.40*	–0.51	0.27	–0.08	2.24**	–3.39**	–0.09	0.08	–1.20
Janki x T-397	3.43**	–9.71**	–10.11**	0.46	–0.26	–2.57*	0.16	0.54**	2.51**	3.36**	0.11	0.01	0.64
Janki x Gaurav	–1.38	5.64**	7.40**	–2.12**	–0.62**	–6.73**	0.02	0.04	0.11	0.22	–0.22**	0.07	3.85**
Janki x Belinca	–8.98**	–3.73**	–2.53*	–5.32**	–0.59**	8.93**	0.24	0.23	1.21**	5.22**	0.53**	0.04	0.33
Janki x Rasmi	–1.56	3.76**	–2.99*	–0.41	–0.52**	10.02**	–0.47	–0.02	–1.23**	1.38	–0.14*	–0.02	4.02**
Janki x Nagarkot	1.61	5.75**	6.94**	–1.61*	–0.40*	6.78**	0.22	–0.26	–3.29**	5.08**	0.84**	0.12	2.31**
J-23 x T-397	2.12*	–1.36	–5.13**	–1.46*	0.00	–4.13**	0.22	–0.12	0.54*	–0.97	–0.15*	–0.08	0.48
J-23 x Gaurav	0.18	2.23*	11.52**	0.78	–0.49**	21.98**	1.21**	1.11	2.66**	5.94**	0.17**	0.15*	–2.39**
J-23 x Belinca	7.14**	9.09**	–1.28**	0.41	–0.96**	8.24**	0.19	0.88	0.81**	5.01**	0.09	0.32**	2.34**
J-23 x Rasmi	0.86	1.71	–0.13	1.87**	–0.40*	11.29**	1.35**	0.82**	–2.40**	4.50**	0.06	0.18*	1.56
J-23 x Nagarkot	–4.34**	6.17**	–6.44**	2.86**	–0.31	–0.72	–1.52**	–0.03	2.34**	–0.04	–0.22**	–0.01	4.32**
T 397 x Gaurav	–8.82**	7.62**	–0.64	–1.76**	0.22	14.49**	1.27*8	0.68**	–4.36**	2.21**	0.88**	–0.26**	1.53
T 397 x Belinca	0.25	10.07**	5.27**	3.34**	–0.55**	–6.29**	–0.18	–0.23	0.92**	4.11**	–0.33**	0.06	4.98**
T 397 x Rasmi	–5.17**	3.07**	–4.42**	1.10	0.18	–10.33**	0.04	–0.46*	–0.61*	1.74*	–0.02	0.28**	1.10
T 397 x Nagarkot	–3.36**	4.29**	7.80**	–4.10**	0.40*	7.93**	0.44	0.27	1.63**	0.47	–0.34**	–0.22**	3.40**
Gaurav x Belinca	–1.63	–6.94**	–3.08*	4.16**	0.89**	10.19**	0.11	0.45*	2.71**	0.21	–0.86**	–0.08	1.22
Gaurav x Rasmi	5.92**	–13.35**	–2.70*	–0.98	0.28	–1.32	0.10	–0.40*	1.28**	5.85**	–0.59**	0.12	–0.22
Gaurav x Nagarkot	0.54	–12.63**	–7.94**	6.59**	–0.16	17.13**	0.36	0.29	–0.41	0.98	0.11	0.13	3.07**
Belinca x Rasmi	3.82**	–4.72**	–4.13**	2.88**	0.78**	–1.60	–0.32	–0.44*	1.44**	–1.71*	0.75**	0.22**	1.50
Belinca x Nagarkot	1.12	–1.43	–4.24**	6.59**	1.07**	2.46*	0.21	–0.01	0.62*	–4.01**	–0.26**	0.14	1.56
Rasmi x Nagarkot	–5.93**	–2.04	2.47*	3.18**	–0.07	11.25**	–0.04	0.52**	1.09**	0.54	–0.21**	–0.31	0.35
SE (S_{ij})+	0.968	1.066	1.246	0.648	0.171	1.172	0.295	0.197	0.268	0.764	0.0595	0.074	0.828
SE (S_{ii}-S_{ik})+	1.088	1.126	1.143	0.909	0.241	1.318	0.413	0.276	0.376	1.056	0.0834	0.104	1.065

*Significant at 5% per cent level; **Significant at 1 per cent level

parents for seed yield and earliness. Shubhra, Shekhar, Janki and J-23 were observed good parents for fibre yield but not for other fibre quality characters like fibre strength and fibre fineness. Appreciable heterosis were found over superior parents for all the characters of desirable directions. Parents Subhra, Janki, J-23 are observed to be

Table 5. Estimates of GCA effect of the parents for 13 different characters in F_1s of linseed/Flax

Crosses	Days to 50% flowering F_1	Plant height F_1	Technical plant height F_1	Days to maturity F_1	Stem diameter F_1	Number of capsules/ plant F_1	Number of tillers/ plant F_1	Seed yield/ plant F_1	Oil content F_1	Fibre length F_1	Fibre strength F_1	Fibre fineness F_1	Fibre yield/ plot F_1
Shubhra	–1.53*	0.43	1.34**	–1.72**	0.74**	11.48**	0.35**	0.15	0.82	–4.32	–2.27	–0.11	–0.11
Garima	–2.82**	–5.12**	–6.33**	–3.96**	–0.08	5.72**	–0.06	0.39	0.08	–5.56	–2.57	0.21	–0.28
Shekhar	–1.34*	–6.91**	–5.39**	–2.14**	–0.20*	1.42	0.05	0.55	0.53	–1.36	–0.92	–0.24	–0.06
Janki	–1.52*	–4.53**	–4.02**	–2.31**	–0.34**	–0.83	0.18*	0.11	–0.88	–2.08	–0.58	–0.16	–0.20
J–23	–4.64**	–8.35**	–6.48**	–3.68**	–0.14	4.40**	0.16*	0.00	0.32	–1.40	–0.59	–0.28	–0.26
T 397	–6.85**	–12.65**	–90.79**	–4.77**	–0.05	8.12**	–0.10	0.31	0.67	–3.34	–1.63	–0.10	–0.27
Gaurav	2.36**	4.38**	3.35**	2.84**	–0.02	–4.02**	–0.22**	–0.23	–0.46	8.31	1.96	0.29	0.17
Belinca	7.93**	16.59**	13.12**	7.35**	0.11	–13.14**	–0.27**	–0.79	0.04	6.64	8.64	0.38	0.57
Rasmi	3.75**	7.29**	5.68*	2.25**	–09.12	5.13**	–0.23**	–0.18	–0.66	3.79	1.45	–0.02	0.14
Nagarkot	4.65**	8.84**	8.52**	6.15**	0.10	–8.02**	0.14	–0.32	–0.47	4.42	1.53	0.45	0.30
$SE_{gi} \pm$	0.29	0.35	0.37	0.19	0.05	0.58	0.08	0.06	0.08	0.22	0.25	0.01	0.02
SE (gi-gj) $\pm$	0.49	0.52	0.55	0.28	0.08	0.86	0.13	0.09	0.11	0.33	0.37	0.03	0.03

*Significant at 5 per cent level; **Significant at 1 per cent level

good parents for fibre yield and oil content and Shubhra is good parent for seed yield, fibre yield and oil content, while Belinca, Rasmi, Gaurav, and Nagarkot good parents for fibre quality character.

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Diversity of Medicinal and Tuber Bearing Plants in Bastar Plateau of Chhattisgarh, India

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Based on extensive explorations and observations the diversity and performance studies of medicinally important and some rarely occurring tuber bearing plants were studied. Out of major forest and village areas of Bastar division explored, the forest and some protected areas *viz.* Abujhmarh, Kanger ghati, Bijapur forest, Bailadila hills, Binta forest, Bhejji forests, Mardoom forests, Dantewada forest, Bhopalpatnam forest, Sukma forest and Keskal-Kanker were observed with maximum diversity of medicinal plants and tubers. Among medicinal species, the maximum diversity of *Chlorophytum* sp. was observed in eastern and southern regions of Abujhmarh, some pockets of Machkot range, river valley of Bhopalpatnam, Barsur and Kotumsar cave forests of Bastar. Similarly, the *Gloriosa superba* L. was noted with maximum diversity in forests surrounding to Sukma, eastern Abujhmarh, Cheetapadar and Tiriya forests. However, the occurrence of some other important medicinal species, *viz., Dioscorea* sp., *Amorphophallus* sp., *Colocasia* sp. Jangli angoor/ Datte lata (*Ampelocissus arnottina* Pleach) and Dokar bela/ Duthila kanda (*Vitex* sp. wild) was recorded in all the forest areas of Bastar with maximum recorded diversity in the forests of Abujhmarh hills, Machkot, Gupteswar river forest, Binta forests, Sukma, Kanger Ghatti, Bhopalpatnam, Barsur and Dantewara. Ramdatoun (*Smilax macrophylla*) was recorded with moderate in occurrence but maximum occurrence in forests of Abujhmar, Machkot, Tiriya, Kotumsar and Barsur.

Considering the density and diversity of various medicinal species like *Gloriosa superba*, *Chlorophytum borivillianum*, *C. laxum*, *Aristolochia indica* L., *Dioscorea hispida* L., *D. rotundata* L., *Smilax macrophylla* L., *Andrographis paniculata*, *Rauvolfia serpentina* are endangered and recorded with only location specific diversity in Bastar. *Piper longum* L. noted to be endangered except in river valleys of Abujhmar, Tiriya and Gupteswar surroundings where it was observed upto considerable extent. Similarly, *Rauvolfia serpentina* was noted to some extent only in forests of Gupteswar surroundings, Chitapadar of Machkot and eastern Abujhmarh. Based on above findings both the *in situ* and *ex situ* conservation of endangered species was suggested.

Key Words: Diversity, Medicinal species, Bastar plateau, Chhattisgarh, Abujhmarh hills, Barsur

Introduction

The state of Chhattisgarh has an area of 13.51 mh divided into 18 districts and three agro-climatic zones. Out of which 5.96 mh (44% approx) is covered under dense forests especially in areas like Bastar plateau and Northern hills (62 and 47 per cent, respectively) of total area under forest. These forests includes Bastar, Dantewada of Bastar plateau, Koriya, Surguja, Jashpur of Northern hills. Korba, Achanakmar of Chhattisgarh plains possesses dense and virgin forests growing medicinal and medicinal tuber plant species under natural habitats.

Since, time immemorial plants and plant parts like roots, tubers, barks etc. are being used for various needs related to health and illnesses. Further, various medicinal system, *viz.*, *Ayurveda*, *Siddha*, modern medicines mainly use roots and tubers, corms and rhizomes, bulbs etc. Similarly, the traditional tribal medicine systems like areas of Bastar mainly use aerial and underground parts like roots, tubers, leaf, bark, apical meristem, flowers and fruits etc. for general treatment and especially roots for specific treatments. Similarly, worlds traditional medicine systems use root as a main component, therefore in modern system like *Ayurvedic*, *Siddha*, *Unani* etc. herbal roots and whole extract play a significant role in medicine industries. Presently, out of 1200 medicinal plant species recognized with stable and potent components for treatments, 680 are root medicinal species of which 180 are minor edible and wild tubers. *Dioscorea species*, *viz.*, *D. floribunda* and *D. maxicana* originated from Mexico are being exploited for contraceptive medicines. Since, both the wild as well as cultivated spices are being used for contraceptive medicines as major source of Diosgenin, their availability is endangered. It is observed that the birth rate of Bastar tribals living in dense forests is automatically controlled without using any means of birth control since *Dioscorea* tubers are included in their daily diet. The other important medicinal plants of key importance with special reference to the Chhattisgarh state are Kalihari (*Gloriosa superba)*, Sarpagandha (*Rauvolfia serpentina*), Satawar *(Asparagus recemosus)*, Safed mushli (*Chlorophytum* sp.), Bidari kand (*Puraria tuberosa*), Keu kand (*Costus speciosus*), Teekhur

(*Curcuma angustifolia*), Kali haldi (*Curcuma caesia*), Ama haldi (*Curcuma amada* Roxb.), Jangali piyaj [*Urginea indica* (Roxb.) Kunth.], Jangali suran (*Amorphophallus sp.*), Jangli arvi [*Colocasia esculenta* (Linn.) Schott.], Chitrak (*Plumbago ovata*,), Peepra and peepri mool (*Piper longum*), Kali mushli (*Curculigo orchioides*), Jangli lahsun, Bramhi, Kimanch (*Mucuna purieta*), Aak [*Calotropis gigantean* (Linn) R. Br.], Dhatura (*Datura innoxa*), Anant mool (*Hemidesmus indicus*), Iser mool (*Aristolochia indica*), Gorakhmundi (*Sphaeranthus indicus* L.), Kalmegh (*Andrographis paniculata*), Bada ghokhru, Mokoi, Bhilwa (*Semecarpus anacardium*), Dokar bela [*Ampelocissus latifolia* (Vahl.) Pleach], Giloe (*Tinospora cordifolia*), Biskhapra (*Aconitum heterophyllum* Wall. ex. Royle), Mahabala (*Sida acuta*), Motha, Jangli bhatta, Van Jeera, Goolar, Ghui, Drona puspi, Lajwanti, Ram datoun, Marod phalli (*Holicterus isora*), Nagbala (*Sida veronicifova*) and many other medicinal species were observed under natural forests habitat.

Bastar is considered to be a 'Hot-Spot' for most of the tropical and sub tropical medicinal and tuber bearing plants which are rarely available in other areas of the state as well as other states, especially Abhujhmarh hills, Kanger ghati, Binta and Mardoom forests, Bailadila forest, Barsur forest, Bhairamgarh, Pamed, Dantewara, Bhopalpattanam, Machkot forest, Darbha forest, Sukma, Kondagoan, Keskal forests are the places of maximum diversity of medicinal plants and tuber species. The status diversity of some elite and important species are given below based on information gathered from intensive explorations and observations carried out to these areas.

Keeping these facts in view the study on biodiversity of some important medicinal plants in tribal area of Bastar (Chhattisgarh) is conducted with the following objectives:

i. To study the diversity and status of medicinal and tuber plants species in Bastar
ii. To identify the location specific diversity/hot spots of important medicinal plants in Bastar
iii. To assess the endangered species among medicinal and medicinal tuber crops in Bastar.

Methodology

The above study was conducted on the basis of extensive and planned frequent explorations to the selective large areas throughout the growing seasons. However, the specific explorations of the target species of maximum diversity was also conducted during their germination to early growth period as well as at the time of flowering and maturity to assess their actual growth and yield performance under natural habitat. The periodic explorations were made to individual areas during the period from 1989 to 2002 to collect and register the elite germplasm of various tuber and medicinal species to conserve and assess their field performance under better agro-climatic managements. As an out come of this study about 150 accessions of medicinal and 90 accessions of medicinal tuber species have been already submitted in national gene banks. A total of 90 accessions were submitted at CTCRI, Srikariyam, Thiruvanathapuram, Kerala. A part of these is also being maintained and evaluated at College of Agriculture and Research Station, Jagdalpur. The first phase of study mainly concentrated on tuber species, after the ad-hoc projects 'Network Project on Tribal area crops and Collection, conservation and evaluation of locally available Tuber Crops for different topo-sequences of Chhattisgarh' the medicinal and medicinally important tuber species were also studied.

For this study, the whole area was divided into different target locations and further into segments considering their importance and availability of species as per survey for target species. Accordingly the explorations were planned to explore the status (Fig. 1) and availability of species (Fig. 2). Thus the final location and segments for explorations were identified in Table 1.

Results and Discussion

On the basis of extensive explorations, the observed diversity and status of medicinal plants is presented segment wise as follows:

1. *Abujhmarh Hills of Bastar*

The Abujhmarh hill is situated in south western and joins the boundaries of Maharashtra and Andhra Pradesh states. Abujhmar hill, hillocks of Bastar and parts of Dantewara is most protected and prohibited parts because the specific

Table 1. Locations and segments for exploration of medicinal plants in Bastar Plateau of Chhattisgarh

S.No.	Name of location studied	Number of segments
1	Abujhmarh Hills	07
2	Antagarh-Pakhanjore-Bhanupratappur	04
3	Kanger Ghati-Teerathgarh-Kotumsar	04
4	Dantewara and Bailadila Hilly areas	05
5	Barsur Bijapur and Bhopalpatnam areas	05
6	Machkot-Gupteswar-Tiriya	03
7	Chitrakot-Mardoom-Binta areas	04
8	Jagdalpur-Kondagoan forest areas	04
9	Pharasgoan-Keshkal-Kanker	03
10	Sukma-Konta areas	03

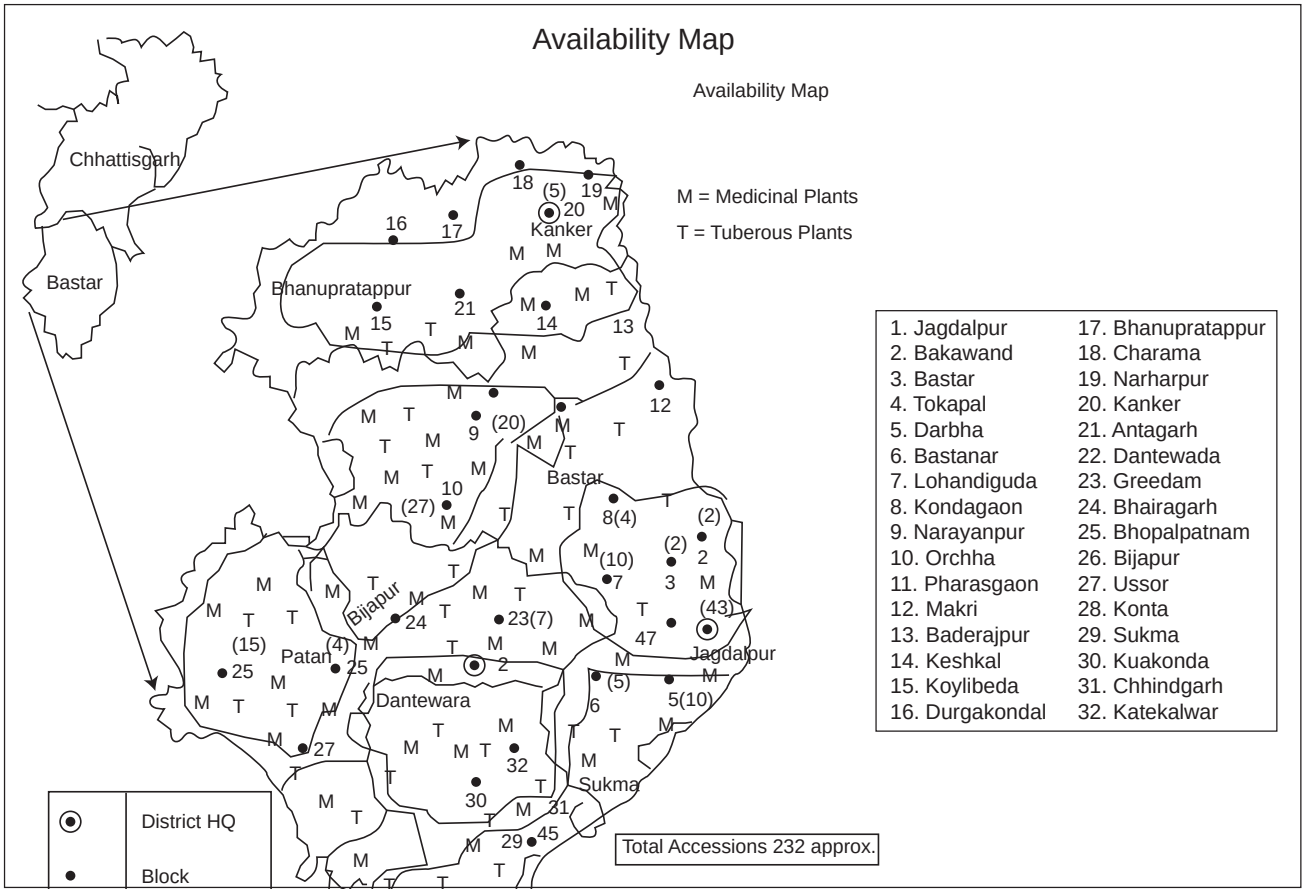


Fig. 1: Exploration map of medicinal plants at Bastar, Chhattisgarh

tribal race Abujhmaria, are native of this region but under full prohibition, since their main food source are roots, tubers, minor forest produces and hunting wild animals thus forest based economy prevails. Due to protection act operated in this area most of the rarely available endangered species of medicinal plants and tubers are available in abundance or up to the protectable scale. Tribal of this region are solely dependent on these species for various health illness and nourishments. Surveying or entering into this region by researchers/scientists or socialist etc requires the special permission by the district collector however, traders are strictly prohibited. Based on several intensive surveys/ explorations from 1989 to 2002, the general biodiversity of medicinal and tuber species is given in Table 2. It is evident from data that the medicinal floras are considerably or abundantly available in the region (Fig. 3) are *Chlorophytum* sp., *viz.*, *C. tubersum, C. arundinaceum, C. laxasum, C. borivillianum, Gloriosa superba, Disoscorea alata, D. bulbifera,* , *D. dumetorum, D. pentaphylla, D. trifoliata, D. esculenta, D. hispida, Curcuma angustifolia, Curcuma* sp. (Kalihaldi, ama haldi, jangli haldi), Ram dautoun (*Smilax macrophylla*), *Costus speciosus*, Jangli piyaj, Jangli lahsun, Jangli mirchi (wild chilli), Jangli suran (*Amorphophallus* sp.), Jangli arvi (*Colocasia* sp.), Chitrak (*Plumbago* sp.), Jatamansi (*Nardostachys grandiflora* DC), Bhui neem, Dholka kand, Anantmool, Bachh (*Acorus calmus* L.), jangli arand and Indrayan (*Citrullus colocinthis* Schrad) are also observed under Lanka and Kachhapal areas of Abujhmarh. Wild chillies resembling to Shimla mirch (sweet pepper) having wrinkled and uneven shape with light yellow colour and extreme pungency, small clove size and black round chilli all having excessive pungency is also observed in this area. Most of the important medicinal species have been observed in this location may be conserved through *in situ* conservation or making gene sanctuaries in these pockets.

2. Anthagarh-Pakhanjore-Bhanupratapur

The areas of Anthgarh include Anthgarh forest, Koilibeda, Pakhnjore and surroundings, Bande forest and adjoining forest areas of Bhanupratappur (Table 3). It has a typical

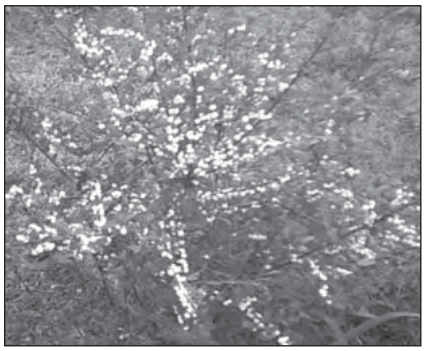
Selected plants from Cheetapadar collections

Dioscorea sinensis

Wild chili

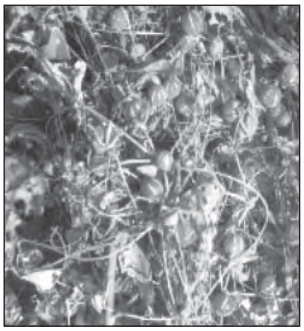
***Dioscorea* collections**

***Grewia tiliaefolia* Vahl.**

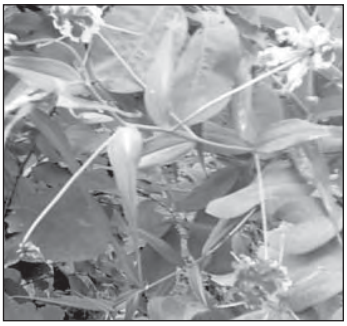


Fish Eye Plant (local name)

Hardjod



Brunopsis lacinasa



Gloriosa superba

Alpinia galanga

Dioscorea ovata

Tinospora cordifolia

Piper species

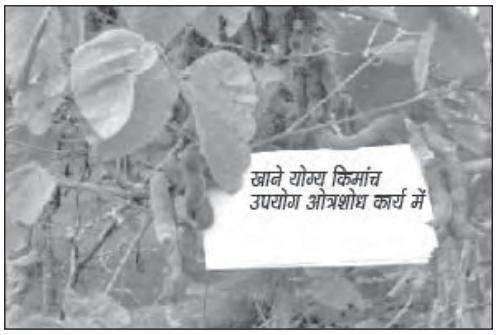
Fig. 2: Species diversity collected from Bastar plateau of Chhattisgarh

Martynia annua

Deekamali

***Cathrumthus* of Kondagaon**

***Dioscorea* of Kawalnar**



***Mucuna prurita* of Sukma**

***Clitoria ternatea* L. shrub**

Fig. 2 (Contd.): Species diversity collected from bastar Plateau of Chhattisgarh

flora comprising Sal trees, Dhawra, Arjun, Teak, Bamboo etc. Also the topography of this northern region is more plains than the hills. Hence, the location is rich in only medicinal weeds like Kalmegh, Gorakhmundi, Gumma, Bhaskatiya, Satyanasi, Indrayan (*Citrullus colocinthis* Schrad), Dudhi, Nagbel, Dokarbela, *Mucuna purita* and some tubers like *Dioscorea* sp., Jangli haldi, Jangli bhindi, *Costus speciosus*, wild *Amorphophallus*, Jangli *Colocassia* etc. Thus, this area can be considered as *in situ* diversity centre for *Colocasia*, *Zingiber* sp. and medicinal weeds. However the *Chlorophytum* sp. is rare in this area only *C. tuberosum* is found in some pockets. The typical species of *Dioscorea* like Sikka kanda (*D. rotundata*), Dori kand (*D. syanensis*), Surenda (*D. pentaphylla*) and Baichandi (*D. hispida*) are well represented in the area.

3. *Kanger Ghati-Teerathgarh-Kotumsar*

The areas of Kanger Ghati include Teerathgarh forest, Kotumsar, Kailasgupha, Darbha forest, Koling, Majhipal and adjoining forest areas (Table 3). It has a typical flora comprising Sal trees, Tendu, Dhawra, Arjun, Teak, Bija, bamboos and various ferns etc. Hence the zone is rich in medicinal climber medicinal tubers like *Dioscorea* species, Nagbel, Dokarbela (Dotho), wild grape or Datte lata (*Ampelocissus arnottina* Pleach) and also Brahmi, Mandukparni etc.The other medicinal species abundantly occurred are Jangali haldi, Jangali adark Jangli bhindi, Keu kand, Teekhur (*Curcuma angustifolia*), Indrayan (*Citrullus colocinthis* Schrad), Wild suran, Wild *Colocassia*, Bada Gunj (*Abrus precadiorius*) and Kimanch (*Mucuna purita*) etc. Thus this area can be considered as diversity for *Dioscorea*, *Amorphophallus*, *Colocassia*, *Curcuma* sp., *Zingiber* sp. hence, *in situ* conservation center may be adapted for their survival in this segment. However, the *Chlorophytum* sp. is rare in this area only *C. tuberosum* is abundantly occurred. The typical species of *Dioscorea* like Sikka kand (*D. rotundata*), Dori kand (*D. sinensis*), Surenda (*D. pentaphylla*), Targariya kand (*D. ovata*) and Baichandi (*D. hispida*) are observed in abundance. Wild *Dioscorea* germplasm, wild *Colocasia*, *Amorphophallus* (Gaint), bada gunj and mandukparni are important species in this area hence, may be conserved in this location.

4. *Machkot-Gupteswar-Tiriya*

The areas of Machkot range includes Kurandi forest, Cheetapaddar, Nangur, Gupteswar forest, Tiriya forest,

Table 2. Observed diversity and availability of medicinal plants in Abujhmarh-Hills, Chitrakot-Mardoom-Binta and Jagdalpur-Kondagoan forest areas of Bastar (Chhattisgarh)

S.No.	Vernacular name	Local name	Botanical name	Observed Diversity													
				Abujhmarh Hills							Jagdalpur-Kondagaon				Pharasgaon-Keskal-Kanker		
				1	2	3	4	5	6	7	1	2	3	4	1	2	3
1.	Ama haldi	Aami hardi	*Carcuma amada* Roxb.	–	+	+	++	++	++	+++	++	++	++	++	++	++	–
2.	Amaltas	Amaltas	*Cassia fistula* L.	–	+	+	–	–	+	+	+	++	++	++	++	++	+
3.	Aonla	Ounra	*Emblica officinalis*	–	+	++	++	+++	+	+++	+	++	+	++	++	+	+
4.	Anantamul	Sugandhi Jari	*Hemidesmus indicus*	++	++	++	++	++	++	+++	++	++	++	++	++	++	++
5.	Apamarg	Chirchira	*Achyranthus aspera*	++	++	++	++	++	+++	+++	+++	++	++	++	++	++	++
6.	Bach	Ghorbacchh	*Acorus calamus* L.	+	+	+	+	+	+	+	++	+	+	+	+	+	+
7.	Bada ritha	Ritha	*Sapindus aurifolius*	–	–	+	–	+	–	–	–	+	+	+	+	+	+
8.	Badi duddhi	Dudhiya	*Euphorbia hirta* L.	+++	+++	++	+++	+++	+++	+++	+++	++	++	+++	++	++	++
9.	Baghnakkha	Latkana	*Martynia annua*	++	++	+++	++	++	+++	+++	+++	++	++	++	++	++	++
10.	Baheda	Bahera	*Terminalia bellirica*	+	+	+	++	++	++	+++	–	+	+	+	+	+	–
11.	Bechandi	Kuliha kanda	*Dioscorea hispida*	+	+++	+++	+++	+++	+++	+++	+	+++	+	+	+++	+	+
12.	Bakayan	Bakien	*Malla azadaracht* L.	+	+	++	++	++	+	+	+	+	+	+	+	+	+
13.	Biskhapra Wall. ex. Royle	Bishkhapri	*Aconitum heterophyllum*	+++++	+++	+++	+++	+++	+++	++	++	++	+	+	++	+	
14.	Baramasi	Kandle Lata	*Ixora puriflora*	+++	+++	+++	++	++	+++	+++	+++	++	++	++	++	++	++
15.	Bariyara	Jharoo Lata	*Sida acuta*	++	+++	++	++	+++	++	+++	+++	++	++	++	++	++	++
16.	Bauchi	Bochi	*Psoralea corylifolia* L.	+	+	+	++	+	++	++	++	+	+	+	+	+	+
17.	Bel	Bel	*Aegle marmelos*	–	+	++	+	++	+	++	++	+	+	+	+	+	+
18.	Bhilwa	Bhirwan	*Semecarpus anacardium*	–	+	++	+++	++	+	++	+	++	+	+	++	+	+
19.	Bidari kand	Koua kand	*Puraria tuberosa*	++	++	++	++	++	+	+++	–	–	+	–	–	+	–
20.	Bilai kand	Bilaikand	*Ipomoea degitata*	++	+	++	+	++	++	+++	++	++	++	++	++	++	+
21.	Bramhi	Booti	*Bacopa monnieri*	–	+	++	+	++	+	++	+	+	+	–	+	+	+
22.	Chironji	Char-chironji	*Buchanania lanzan*	–	++	++	+++	+++	++	++	+	+	+	+	+	+	++
23.	Chitrak	Chitralata	*Plumbago ovata*	–	++	+	++	+++	++	+	+	+	+	–	+	+	+
24.	Dokarbela	Duthilakand (Vahl.) Pleach	*Ampelocissus latifolia*	+	++	+++	+++	++	+++	+++	+	++	+	++	++	+	+
25.	Giloe	Parhin	*Tinospora cordifolia*	+	++	++	+++	+++	+++	++	+	+	+	+	++	++	+
26.	Gorakhmundi	Mundi dara	*Sphaeranthus indicusi*	++	++	++	++	++	++	+++	+	++	+	+	++	+	++
27.	Gur sukri	Gur sakhari	*Grewia tiliaefolia* Vahl.	++	+++	+++	+++	+++	++	+++	+	++	+	++	+	++	+
28.	Hajardana	Bhui Aonla	*Phyllanthus niruri*	++	++	++	++	+++	++	+++	+++	++	++	+++	++	++	++
29.	Harad	Harra	*Terminalia chebula*	+	++	+++	+++	+++	+++	+++	+	++	++	++	++	++	+
30.	Hur hur	Hulhulia	*Cleome gynandra* L.	+	++	+	+	++	+	++	–	–	–	–	–	–	–
31.	Isser mool	Eswar mool	*Aristolochia indica*	–	–	+	++	–	+	+++	+	++	+	+	++	+	+
32.	Indrayan	Peeta Kachari Schrad	*Citrullus colocinthis*	+	++	+	+++	+	+++	+++	+	–	–	–		+	–
33.	Jangli angur	Datte lata Pleach.	*Ampelocissus arnottina*	+	++	++	+++	++	+	++	–	+	–	–	–	+	–
34.	Jangali arvi	Dhabbe kochai	*Colocasia indica* L.	++	+++	+++	+++	+++	+++	+++	+	+	+	++	+	+	++
35.	Jangali adrak	Baila Adrak	*Alpinia calcarata*	+	+	++	+++	++	++	+++	–	–	–	–	–	–	+
36.	Jangli bhindi		*Abelmoschus* sp.	+	++	++	+++	+++	+++	++	+	++	+	+	++	+	+
37.	Jangli bhatta	Jangli bagan	*Solanum melongena* var. *incanum* L.	+	++	++	+	++	+	++	+	–	–	–	–	+	–
38.	Jangli dhania	Padri Dera	–	+	+	+	++	+	+	+	+	–	+	+	–	+	+
39.	Jangli haldi	Hardi	*Curcuma aromatica* Salisb	+	+	++	+++	++	+++	+++	+	+	–	+	+	–	+
40.	Jangli pyaj	Gondla	*Urginea indica* (Roxb.) Kunth														
41.	Jangli suran	Barhakanda	*Amorphophallus* sp.	+	++	+++	+++	+++	+++	+++	+	++	+	+	++	+	+
42.	Kachnar	Kachnar	*Bauhinia purpuria*	–	+	–	–	–	–	+	+	+	+	+	+	+	+
43.	Kala dhatura	Dhatoor	*Datura innoxa*	+	+	++	++	++	++	++	–	–	–	+	–	–	–
44.	Kali haldi	Kaliyakand	*Curcuma caesia*	–	+	+	++	+	++	+	–	–	–	–	–	–	–
45.	Kali mushli	Musri lata	*Datura innoxa*	++	++	++	+++	+++	+++	+++	+	++	++	+	++	++	++
46.	Kalihari phool	Ghorandi	*Gloriosa superba*	+	+	+	++	+++	++	++	+	+	+	+	+	+	+
47.	Kalmegh	Bhuineem	*Andrographis paniculata*	+	+	++	+++	+++	+++	+++	++	+	–	++	+	–	+
48.	Karanj	Karanji	*Pongamia pinnata*	–	+	+	++	++	+	++	++	++	+	++	++	+	+
49.	Karukand	Peeta kanda	*Dioscorea dumetorum*	++	+++	+++	+++	+++	+++	+++	++	+++	+	++	+++	+	+
50.	Kekar	Keekar	*Garuga pinnata*	–	–	++	+++	++	–	++	–	+	+	+	+	+	+

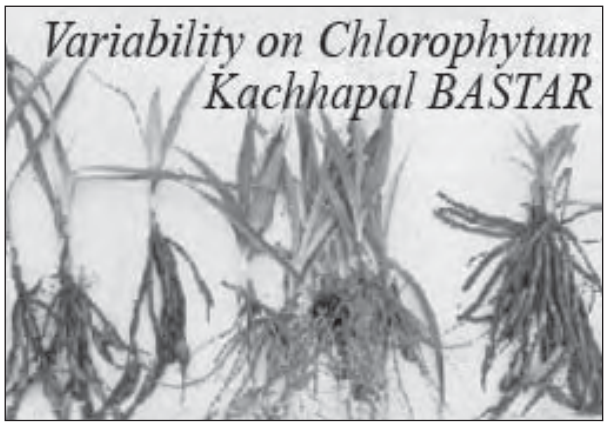
Contd.

Table 2. Contd.

S.No.	Vernacular name	Local name	Botanical name	Observed Diversity													
				Abujhmarh Hills							Jagdalpur-Kondagaon				Pharasgaon-Keskal-Kanker		
				1	2	3	4	5	6	7	1	2	3	4	1	2	3
51.	Keu kand	Keu	*Castus speciosus*	+	++	+++	++	+++	+++	+++	+	+	+	++	+	+	+
52.	Kimach	Kounch	*Mucuna prurita* Hook.	++	++	+++	+++	++	+++	+++	+	++	++	+	++	++	++
53.	Kulloo tree	Gurloo	*Sterculia urens*	–	+	++	++	++	–	++	–	+	–	+	+	–	–
54.	Kusum	Kosum	*Schleichera oleosa*	–	–	+	+	+	–	+	+	+	+	+	+	+	+
55.	Lajwanti	Lajni Lata	*Mimosa pudica*	++	+++	+++	++	++	++	+++	++	+++	+++	++	+++	+++	++
56.	Lal gunj	Gunj beej	*Abrus precadiorius*	+	+	++	++	++	+++	++	–	+	–	+	+	–	+
57.	Lemon grass	Chay lata	*Cimbopogon citrates*	+	+	++	+	+	++	++	++	+	+	+	+	+	+
58.	Lal Indrayan	Peeta kachri	*Trichosanthes tricuspidata* Lour fl Coch.	–	+	++	++	++	+	++	–	–	–	+	–	+	–
59.	Madar	Phundhar	*Calotropis gigantia*	++	++	+++	+++	++	+++	+++	+++	+++	++	++	+++	++	++
60.	Mahul	Mouha	*Madhuca longifolia* var. *latifolia* (Roxb) Cher	+	++	+++	+++	+++	+++	+++	+++	+++	++	++	+++	++	++
61.	Marodphalli	Maror phali	*Holicterus isora*	+	+	++	+	+	++	++	–	–	–	–	–	–	–
62.	Munga	Munga	*Moringa oleifera* Lam.	+	++	++	++	+++	++	+++	+++	++	++	++	++	++	++
63.	Nagbala	Palcha	*Sida veronicifova*	++	++	++	++	++	+++	+++	+	++	+	++	++	+	+
64.	Nagbel	Cheri singghi	*Cryptolapis buchananii* R. Rs.	++	++	+++	+++	++	+++	+++	–	++	++	++	++	++	+
65.	Neem	Neem	*Azadirachta indica*	+	+	+	++	+	+	++	++	++	+	+	++	+	++
66.	Nirgundi	Surteli	*Vitex negundo*	+	+	++	++	++	+++	++	+++	–	+	+	+		
67.	Palas	Choola	*Butea monosperma*	+	++	+++	+++	+++	++	+++	+	++	++	++	++	++	++
68.	Peet papra	Peet pakra	*Fumaria parviflora*	+	++	+++	++	+++	+++	+++	+	+	+	++	+	+	+
69.	Pipramool	Peepri jari	*Piper longum*	+	+	+	+	++	++	+	+	+	–	–	+	–	+
70.	Ramdaton	Potar	*Smilax macrophylla*	+	++	+++	+++	++	+++	++	+	+	+	+	+	+	+
71.	Ramphal	Ramphal	*Annona reticulata*	–	–	+	–	–	+	+	+	+	+	+	+	+	–
72.	Rasna jari	Rasna Booti	*Sapindus mukorossi*	–	+	+	+++	++	+	–	–	–	–	–	–	–	–
73.	Ratanjot	Ranijara	*Jatropa cordifolia*	++	+	++	++	+	++	++	++	+	++	+++	+	++	++
74.	Rosagrass	Pamarosa	*Cymbopogon martini*	+	++	++	++	++	++	++	+	+	+	+	+	+	+
75.	Sadabahar	Sadasuhagin	*Cathranthus roseus*	+	++	+	+	+	++	++	+	+	++	++	+	++	++
76.	Safed mushli	Mutri lata	*Chlorophytum arundinaceum*	+	++	++	+++	++	+++	+++	+	+	–	–	+	–	–
77.	Safed mushli	Mutri lata	*Chlorophytum laxum*	+	++	++	+++	+++	+++	+++	–	+	–	–	+	–	–
78.	Safed mushli	Mutri lata	*Chlorophytum tuberosum*	+	++	+++	+++	+++	+++	+++	+	++	+	+	++	+	+
79.	Safed mushli	Mutri lata	*Chlorophytum borivillianum*	–	–	+	+	+	++*	++*	–	++	–	–	++	–	–
80.	Sarifa	Seetaphal	*Annona squamosa* L.	+	++	++	++	++	+	+++	+++	++	++	++	++	++	++
81.	Sarpagandha	Kukdichhendi	*Rauvolfia serpentina* L.	–	+	+	++	+	–	+	–	–	–	+	–	–	–
82.	Satawar	Satawari	*Asparagus racemosus*	+	++	++	+++	+++	+++	+++	+	+	+	++	+	+	+
83.	Semal	Semal kand	*Bombax ceiba* L.	+	+	++	++	++	+	++	+	+	++	++	+	++	+
84.	Shivlinggi	Khutla (Linn)	*Brynopsis lacinosa*	+	++	++	+++	++	+++	+++	+++	++	++	++	++	++	++
85.	Surenda	Suarkand	*Dioscorea pantaphylla*	+	++	+++	+++	+++	+++	+++	+	+++	+	++	+++	+	+
86.	Targariyakand	Dorikanda	*Dioscorea sinensis* L.	+	+++	+++	+++	+++	+++	+++	+	+++	+	+	+++	+	+
87.	Teekhur	Teekhur	*Curcuma angustifolia*	+	+++	+++	+++	+++	+++	+++	++	+++	++	++	+++	++	++
88.	Tendu	Tendu	*Diospyros Montana* Roxb.	+	++	+++	+++	+++	++	+++	++	++	++	++	++	++	+
89.	Vaibidang	Bidang Burm. f.	*Embelia ribes*	+	++	+	++	++	+	+	+	–	–	–	–	–	–
90.	Van Tulsi	Moura lata	*Ocimum gratissimum*	+++	++	+++	++	++	+++	+++	+++	++	+++	+++	++	+++	++
91.	Wild fig	Tando	*Ficus benjamina*	+	++	+++	+++	+++	++	++	+	+	++	+	+	+	+
92.	Wood apple	Ghuee	*Feronia limonia*	–	+	++	+++	++	–	++	–	–	–	–	–	–	–

+ = Available in rare extent; ++ = Available in considerable extent; +++ = Available in abundant and - = Not available

- Abujhmarh hills: 1. Benoor forest, Narayanpur, Taroki and surrounding forests of Narayanpur, Brihibeda, Ranibeda and surrounding forests, 2. Sonpur, Sahnarghati, Kundla and intirior forests of medicinal importance, 3. Garpa, Paralkot, Gumnar and on way and interior forests from kundla to Garpa, 4. Kundla to Kuthul, Kacchapal and on way forest areas, 5. Akkabeda, Marka and on way forest and villages to Narayanpur, 6. Garhbengal, Dharaghati forest and Chotedongar forest areas, 7. Orchha forests, Aderghati adjoining river valley, forest areas and Dodamarka forests.
- Jagdalpur-Kondagoan: 1. Jagdalpur, Asna, Bastar and surrounding forests, 2. Bhanpuri, Baniyagoan and interior forests of medicinal importance, 3. Kondagoan and on way interior forests from Baniyagoan, 4. Makri, Riverbanks and on way forest areas from Kondagoan.
- Pharasgoan-Keshkal-Kanker: 1. Pharasgoan and on way forest to Keshkal, 2. Keshkal and sourrounding forest villages and 3. Kanker and surrounding forests, river banks.

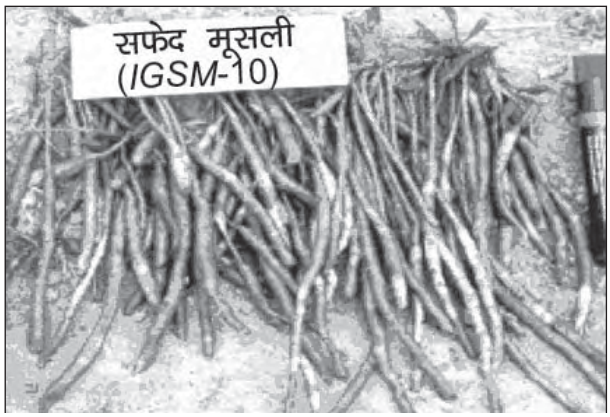


Chlorophytum **species abundantly observed at Abujhmarh**

Chlorophytum **tuberisation observed highest at Abujhmarh**

Chlorophytum **of East Abujhmarh**

Chlorophytum **of Dharaghati, Abujhmarh**

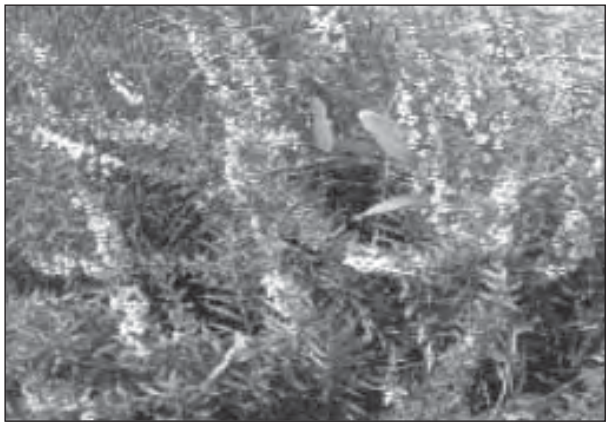


Selected accession of ***Chlorophytum*** **from Abujhmarh**

Selected plants from Abujhmarh collections

Fig. 3 : Medicinal floras abundantly available in the region

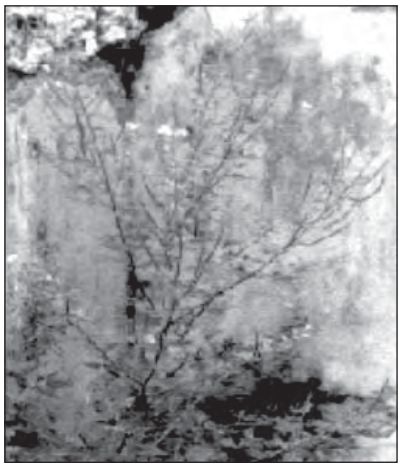
***Dioscorea* tubers of Abujhmarh collection**



Petrol plant (local name) of West Abujhmarh

Various medicinal plant species of Abujhmarh

Rasna booti, East Abujhmarh



***Cleome gynandra* East Abujhmarh**

***Solanum melongena* East Abujhmarh**

***Solanum nigrum* East Abujhmarh**

Fig. 3 (Contd.): Medicinal floras abundantly available in the region

Table 3. Observed diversity and availability of medicinal plants in Kanger ghati, Machkot-Tiriya, Chitrakot-Mardoom and adjoining forest areas of Bastar (Chhattisgarh)

S. No.	Vernacular name	Local name	Botanical name	Observed Diversity														
				Kanger Ghati-Teerathgarh Kotumsar				Machkot-Gupteswar Tiriya			Chitrakot Mardroom Binta				Antagarh Pakhanjore Bhanuprtappur			
				1	2	3	4	1	2	3	1	2	3	4	1	2	3	4
1.	Ama haldi	Aami hardi	*Carcuma amada* Roxb.	-	+	+	++	++	++	+++	+	+	++	++	+	-	+	-
2.	Amaltas	Amaltas	*Cassia fistula* L.	-	+	+	-	-	+	+	+	+	+	+	+	++	+	+
3.	Ambla	Ounra	*Emblica officinalis* L.	-	+	++	++	+++	+	+++	+	+	++	+	+	+	+	+
4.	Anantamul	Sugandhi jari	*Hemidesmus indicus* L.	+++	++	++	++	++	++	+++	1	2	3	4	++	++	++	+
5.	Apamarg	Chirchira	*Achyranthus aspera* L.	++	++	++	++	++	+++	+++	+	++	+++	+++	++	++	++	+
6.	Bach	Ghorbacchh	*Acorus calamus* L.	+	+	+	+	+	+	+	++	+	+	+	–	+	+	
7.	Bada ritha	Ritha	*Sapindus aurifolius*	–	–	+	–	+	–	–	–	+	+	++	+	–	+	
8.	Badi duddhi	Dudhiya	*Euphorbia hitra* L.	+++	+++	++	+++	+++	+++	+++	+	++	+	–	++	++	++	
9.	Baghnakkha	Latkana	*Martynia annua* L.	++	++	+++	++	++	+++	+++	+++	+++	++	+++	+++	++	++	
10.	Baheda	Bahera	*Terminalia bellirica*	+	+	+	++	++	++	+++	+++	++	++	+++	+	–	+	
11.	Baichandi	Bechandi	*Dioscorea hispidaI* L.	+	+++	+++	+++	+++	+++	+++	+	++	+++	++	++	++	+	
12.	Bakayan	Bakien	*Malla azadaracht* L.	+	+	++	++	++	+	+	+	+	++	+++	+	+	+	
13.	Banarandi	Rani jara	*Jatropha curcas* L.	+	++	+++	+++	++	+	++	+	+	+	++	++	++	+		
14.	Baramasi	Kandle lata	*Ikora puriflora*	+++	+++	+++	++	++	+++	+++	+	+	++	+++	++	++	++	
15.	Bariyara	Jharoo lata	*Sidacuta*	++	+++	++	++	+++	++	+++	+	++	+++	++	++	++	++	
16.	Bauchi	Bochi	*Psoralea ncordifolia*	+	+	+	++	+	++	++	+++	++	++	++	+	+	+	
17.	Bel	Bel	*Aegle marmelos* L.	–	+	++	+	++	+	++	+	++	++	++	+	+	+	
18.	Bhilwa	Bhirwan	*Semecarpus anacardium* L.	–	+	++	+++	++	+	++	+	+	++	+	+	+	+	
19.	Bidari kand	Koua kand	*Puraria tuberosa*	++	++	++	++	++	+	+++	+++	++	++	++	–	–	–	
20.	Bilai kand	Biliekanda	*Ipomoea degitata*	++	+	++	+	++	++	+++	–	–	+	+	+	–	+	
21.	Biskhapra	Bishkhapri Wall. ex. Royle	*Aconitum heterophyllum*	++	+++	+++	+	++	+	+++	+++	+++	+++	+++	++	+	++	+
22.	Bramhi	Booti	*Bacopa monnieri* L.	–	+	++	+	++	+	++	++	+	+	+	–	+	+	
23.	Chironji	Char-chironji	*Buchanania lanzan*	–	++	++	+++	+++	++	++	+	++	++	+++	+	+	+	
24.	Chitrak	Chitralata	*Plumbago ovata*,	–	++	+	++	+++	++	+	–	–	–	+	–	–	+	
25.	Dokarbela	Duthilakand (Vahl.) Pleach	*Ampelocissus latifolia*	+	++	+++	+++	++	+++	+++	+++	+++	+++	++	++	+	+	
26.	Giloe	Parhin	*Tinospora cordifolia*	++	++	–	–	–	–	++	+++	+	++	++	–	–	+	+
27.	Gorakhmundi	Mundi dara	*Sphaeranthus indicusi*	++	++	++	++	++	++	+++	++	+	+	++	++	+	+	
28.	Gur sukri	Gursakhari	*Grewia tiliaefolia* Vahl.	++	+	++	+	++	+++	+++	++	++	++	+	++	+	–	–
29.	Hajardana	Bhui aonla	*Phyllanthus niruri*	++	++	++	++	+++	++	+++	+	+	+	+	++	++	++	
30.	Harad	Harra	*Terminalia chebula* (Retz.)	+	++	+++	+++	+++	+++	+++	–	+	+	++	+	+	++	
31.	Hur hur	Hulhulia	*Cleome gynandra* L.	+	++	+	+	++	+	++	+++	+++	+++	++	+	+	+	
32.	Isser mool	Eswar mool	*Aristolochia indica*	–	–	+	++	–	+	+++	+	+	++	++	+	+	–	
33.	Indrayan	Peeta kachari	*Citrullus colocinthis* Schrad	–	++	++	–	+	–	+++	–	–	++	+	–	–	–	–
34.	Jangali arvi	Dhabbe kochai	*Curcuma aromatica*	++	+++	+++	+++	+++	+++	+++	–	–	+	++	++	+++	+	
35.	Jangali adrak	Baila adrak	*Zingiber roseum*	+	+	++	+++	++	++	+++	+	–	+	++	–	++	+	
36.	Jangli bhindi	Bheri	*Abelmoschus* sp.	+	++	++	+++	+++	+++	++	++	++	++	++	+	++	+	
37.	Jangli dhania	Parli lata		+	+	+	++	+	+	+	+++	++	+++	+++	–	–	+	
38.	Jangli haldi	Hardi	*Curcuma aromatica* Salisb	+	+	++	+++	++	+++	+++	++	++	++	++	+	+	–	
39.	Jangli pyaj	Gondla (Roxb.) Kunth	*Urginea indica*	+	++	+	+	+	+	++	++	++	++	+++	+	+	+	+
40.	Jangli suran	Barhakanda	*Amorphophallus* sp.	+	++	+++	+++	+++	+++	+++	+	++	++	++	+	+	+	
41.	Kachnar	Kachnar	*Bauhinia purpuria* L.	–	+	–	–	–	–	+	–	–	+	+	+	+	+	
42.	Kala dhatura	Dhatoor	*Datura innoxa*	+	+	++	++	++	++	++	++	++	+++	+++	+	–	–	
43.	Kali haidi	Kaliyakand	*Curcuma caesia*	-	+	+	++	+	++	+	+	+	++	++	–	–	–	
44.	Kali mushli	Musri lata	*Datura innoxa*	++	++	++	+++	+++	+++	+++	–	–	+	–	+	++	+	
45.	Kalihari	Ghorandilata	*Gloriosa superba*	+	+	+	++	+++	++	++	+	+	++	++	–	–	+	
46.	Kalmegh	Bhuineem	*Andrographis paniculata*	+	+	++	+++	+++	+++	+++	–	+	+	+	+	–	+	
47.	Karanj	Karanji	*Pongamia pinnata* L.	–	+	+	++	++	+	++	–	+	+	++	++	++	+	
48.	Karukand	Peeta kanda	*Dioscorea dumetorum* L.	++	+++	+++	+++	+++	+++	+++	+	++	+++	++	++	++	+	
49.	Kekar	Keekar	*Garuga pinnata* (Roxb.)	–	–	++	+++	++	–	++	++	++	+	+	+	+	+	
50.	Keu kand	Keu	*Castus speciosus*	+	++	+++	++	+++	+++	+++	+	+	+	++	+	+	+	
51.	Kimach	Kounch	*Mucuna prurita* Hook.	++	++	+++	+++	++	+++	+++	+++	++	++	++	++	++	++	
52.	Kulloo tree	Gurloo	*Sterculia urens* (Roxb.)	–	+	++	++	++	–	++	–	+	+	++	–	+	+	
53.	Kusum	Kosum	*Schleichera oleosa* (Lour)	–	–	+	+	+	–	+	–	+	++	+	+	+	+	
54.	Lajwanti	Lajni lata	*Mimosa pudica* L.	++	+++	+++	++	++	++	+++	+	++	+++	+++	++	++	++	

Contd.

Table 3. Contd.

S. No.	Vernacular name	Local name	Botanical name	Observed Diversity: Kanger Ghati-Teerathgarh Kotumsar 1	2	3	4	Machkot-Gupteswar Tiriya 1	2	3	Chitrakot Mardroom Binta 1	2	3	4	Antagarh Pakhanjore Bhanuprtappur 1	2	3	4
55.	Lal gunj	Gunj beej	*Abrus precadiorius*	+	+	++	++	++	+++	++	++	++	+++	++	–	–	+	
56.	Lal Indrayan	Peeta kachri Lour fl Coch	*Trichosanthes tricuspidata*	+	++	–	+	–	–	++	++	+	++	++	–	–	+	–
57.	Lemon grass	Chay lata	*Cimbopogon citrates*	+	+	++	+	+	++	++	++	+	++	++	++	+	+	
58.	Madar	Phundhar	*Calotropis gigantia*	++	++	+++	+++	++	+++	+++	++	+	+	+	++	++	++	
59.	Mahul	Mouha	*Madhuka longifolia*	+	++	+++	+++	+++	+++	+++	+	+	+	+	++	++	++	
60.	Marodphalli	Maror phali	*Holicterus isora*	+	+	++	+	+	++	++	+++	++	+++	+++	–	–	–	
61.	Munga	Munga	*Moringa oleifera* Lam.	+	++	++	++	+++	++	+++	–	–	+	+	+	++	++	
62.	Nagbala	Palcha	*Sida veronicifova*	++	++	++	++	++	+++	+++	–	+	+	+	+	++	+	
63.	Nagbel	Cheri singhi	*Cryptolapis buchananii* R. Rs.	++	++	+++	+++	++	+++	+++	++	++	++	++	+	++	++	
64.	Neem	Leem	*Azadirachta indica*	+	+	+	++	+	+	++	++	++	++	++	++	++	+	
65.	Nirgundi	Surteli	*Vitex negundo*	+	+	++	++	++	+++	++	++	++	+++	++	+	+	+	
66.	Palas	Choola	*Butea monosperma* (Lamk)	+	++	+++	+++	+++	++	+++	+	+	+	+	+	++	++	
67.	Peet papra	Peet pakra	*Fumaria parviflora*	+	++	+++	++	+++	+++	+++	+	–	–	–	++	+	+	
68.	Pipramool	Peepri jari	*Piper longum*	+	+	+	+	++	++	+	+	+	++	+	+	+	+	
69.	Ramdaton	Potar	*Smilax macrophylla*	+	++	+++	+++	++	+++	++	–	+	++	++	++	+	++	
70.	Ramphal	Ramphal	*Annona reticulata* L.	–	–	+	–	–	+	+	++	++	+	+	–	+	–	
71.	Rasna jari	Rasna booti	*Sapindus mukorossi*	–	+	+	+++	++	+	–	+	+	+++	+++	–	–	+	
72.	Ratanjot	Ranijara-	*Jatropha curcas* L.	++	+	++	++	+	++	++	+	+	++	+	++	+	++	
73.	Rosagrass	Pamarosa	*Cymbopogon martini*	+	++	++	++	++	++	++	–	–	–	–	+	+	+	
74.	Sadabahar	Sadasuhagin	*Cathranthus roseous*	+	++	+	+	+	++	++	+	+	+	++	+	+	+	
75.	Safed mushli	Mutri lata	*Chlorophytum arundinaceum*	+	++	++	+++	++	+++	+++	+	+	++	+++	+	–	–	
76.	Safed mushli	Mutri lata	*Chlorophytum laxum*	+	++	++	+++	+++	+++	+++	–	–	+	–	–	–	–	
77.	Safed mushli	Mutri lata	*Chlorophytum tuberosum*	+	++	+++	+++	+++	+++	+++	–	–	+	–	+	+	+	
78.	Safed mushli	Mutri lata	*Chlorophytum borivillianum*	–	–	+	+	+	++*	++*	+	+	+	+	–	–	–	
79.	Sarifa	Seetaphal	*Annona squamosa* L.	+	++	++	++	++	+	+++	–	+	++	++	++	++	++	
80.	Sarpagandha	Kukdichhendi	*Rauvolfia serpentina* L.	–	+	+	++	+	–	+	–	–	–	–	–	+	–	
81.	Satawar	Satawari	*Asparagus racemosus*	+	++	++	+++	+++	+++	+++	++	++	++	+++	+	+	+	
82.	Semal	Semal Kand	*Bombax ceiba* L.	+	+	++	++	++	+	++	+	+	++	++	+	+	+	
83.	Shivlinggi	Khutla	*Brynopsis lacinosa* (Linn)	+	++	++	+++	++	+++	+++					++	++	++	
84.	Surenda	Suarkand	*Dioscorea pantaphylla*	+	++	+++	+++	+++	+++	+++	+	++	+++	++	++	++	+	
85.	Targariya kand	Dorikanda	*Dioscorea sinensis* L.	+	+++	+++	+++	+++	+++	+++	+	++	+++	++	++	++	+	
86.	Teekhur	Teekhur	*Curcuma angustifolia*	+	+++	+++	+++	+++	+++	+++	+	–	+	–	++	++	++	
87.	Tendu	Tendu	*Diospyros Montana Roxb.*	+	++	+++	+++	+++	++	+++	–	+	+	+	++	+	+	
89.	Vaibidang	Bidang	*Embelia ribes* Burm. f.	+	++	+	++	++	+	+	++	+++	+++	+++	+	–	–	
90.	Van tulsi	Moura lata	*Ocimum gratissimum*	+++	++	+++	++	++	+++	+++	–	–	+	+	++	++	++	
91.	Wild fig	Tando	*Ficus benjamina*	++	+	+++	+	++	++	++	+++	+	+++	+	+	+	+	
92.	Wood apple	Ghuee	*Feronia limonia*	+	+	–	–								–	–	+	

+ = Available in rare extent; ++ = Available in considerable extent; +++ = Available in abundant, and – = Not available

- Kanger Ghati-Teerathgarh-Kotamsar: 1. Neganar, Teerathgarh forest, Niyanar and forests surrounding to villages, 2. Kotumsar Cave, Kailash Cave, Majhipal forest, Molipadr and surroundings, 3. Darbha ghati, Koling forest areas and river valley and 4. Darbha and on way forests upto Bastanar
- Chitrakot-Mardoom-Binta: 1. Karanji, Potanar, Chitrdhara and surrounding forests, 2. Lohandiguda, Chitrakot and interior forests of medicinal importance, 3. Mardoom, Binta and on way interior forests from Mardoom to Binta and 4. Binta and on way forest areas from Binta to Barsur.
- Machkot-Gupteswar-Tiriya: 1. Machkot, Cheetapadar, Kurandi, 2. Gumiyapal, Tiriya and on way forests of medicinal importance and 3. Gupteswar river valley and forest areas of Bastar and part of adjoining Orissa.
- Antagarh-Pakhanjore-Bande: 1. Antagarh and Koilibera, 2. Pakhanjore and surrounding forest and villages, 3. Bande and surroundings and 4. Bhanupratapur and surroundings.

Niyanar and river valley adjoining to this pocket having only Sal, Tendu, Palas and some other trees (Table 3). The important diversity noted on this area are wild *Amorphophallus*, Peepra mool (*Piper longum* L.), *Chlorophytum tuberosum*, *Chlorophytum arundinaceum*, *Dioscorea* sp., Lal Gunj (*Abrous precatorius*) etc. However, occurrence of *Rauvolfia serpentina*, *Plumbago zylenica*, *Jatropha curcas*, wild *Colocasia* and other herbs of shed loving nature are also noted. The *Rauvolfia* and wild suran have sturdy and excellent plant type in this region. *Piper longum* L., Sarpgandha, wild suran, kalihari was abundantly observed in Gupteswar and river valleys of this place hence, they may be conserved under *in situ* in these pockets.

5. *Dantewara and Bailadila Hills*

This area includes the forests and villages of Dantewara, Bailadila hillocks, Balood, Kawalnar forest (Table 4). The Flora of this zone is rich in most of medicinal herbs especially tubers. The typical tuber species are *Costus speciosus*, *Dioscorea esculenta*, *D. alata*, Jata Mansi (*Nardostichus grandiflora* DC), Wild & edible Kimanch (*Mucuna purita* L.), Kali Haldi (*Curcuma caesia* Roxb.), black fruited Benjamin fig (*Ficus benjamina* L), Peepra mool (*Piper longum* L.), Giloy (*Tinospora cordifolia* L.), Teekhur (*Curcuma angustifolia* Roxb.), Safed musli (*Chlorophytum arundinaceum* L.), Aonla, Baila adrak (*Alpinia galanga*), Patal Kumhra, Kalmegh (*Andrographis paniculata* L.) are the species available in abundance. Beside these some herbal plants like Ananta mool (*Hemidesmus indicus*), Gorakhmundi (*Spillanthus indicus*), Bhui Aonla (*Phyllanthus niruri*) and Badi duddhi (*Euphorbia hirta*) are also observed in abundance. Hence, efforts should be concentrated for their *in situ* conservation in this area.

6. *Barsur-Bijapur-Bhopalpatnam*

This region includes the most typical forests like Barsur hillocks, Tular cave and surrounding forests areas, Pamed Sanctuary, Bhopalpatnam Forest and river banks of Indrawati River, Mahanadi river, Tarlaguda, Bhadra Kali *etc.* having dense forest dominating by Sal, Tendu, Beeja, Sihari plant, Bamboo plants *etc.* are the flora of this location. The medicinal species abundantly observed (Table 4) in this area (Fig. 4) are Kalihari (*Gloriosa superba* L.), various *Dioscorea* sp., *viz.*, Dori kanda, Targariya, Kuliha kanda, Sikka Kanda, Wild suran, Safed mushli (*C. laxum, C. arundinaceum*), Bhilwa trees (*Semecarpus anacardium* L.), Ram datoun (*Smilax macrophylla*), Ratanjot, Dokar bella, wood apple, *Asparagus sp.*, Mainhar, Teekhur, Jangli adrak, Jangli haldi, Kali mushli, white gunj, *Rasna jari* (Local name),

***Chlorophytum* selection of Tular cave forest**

***Chlorophytum* selected from Bhopalpatnam**

***Chlorophytum* selected plants from Barsur collections**

Fig. 4: Medicinal plants abundantly observed in Barsur-Bijapur-Bhopalpatnam region

Table 4. Observed diversity and availability of medicinal plants in Dantewara-Bailadila-Barsur-Bhopalpatnam forests of Bastar (Chhattisgarh)

S. No.	Vernacular name	Local name	Botanical name	Dantewara-Bailadila forests					Barsur-Bijapur Bhopalpatnam					Sukma-Konta Forests		
				1	2	3	4	5	1	2	3	4	5	1	2	3
01	Ama haldi	Aami hardi	*Curcuma amada* Roxb.	+	+	+	–	+	++	++	++	++	+	–	++	+
02	Amaltas		*Cassia fistula* L.	++	++	+++	++	+++	++	++	+++	++	+++	++	++	++
03	Ambla	Ounra	*Emblica officinalis* L.	++	++	++	+	++	++	++	++	++	++	+	+	++
04	Anantamul	Sugandhi jari	*Hemidesmus indicus* L.	++	++	++	+	++	+++	++	+++	++	++	++	++	++
05	Apamarg	Chirchira	*Achyranthus aspera* L.	+++	++	++	++	+++	+++	++	+++	++	+++	++	++	++
06	Bach	Ghorbacchh	*Acorus calamus* L.	+	+	+	–	+	++	++	+	++	+	+	+	–
07	Bada ritha	Ritha	*Sapindus aurifolius* (Vahl.)	+	+	+	+	+	++	+	+	+	+	+	+	+
08	Badi duddhi	Dudhiya	*Euphorbia hitra* L.	++	+++	++	++	++	+++	+++	++	++	++	++	++	++
09	Baghnakkha	Latkana	*Martynia annua* L.	++	+++	++	++	+++	+++	+++	+++	+++	+++	++	+++	++
10	Baheda	Bahera	*Terminalia bellirica* (Roxb.)	+	++	++	+	++	++	++	++	++	++	+	++	+
11	Baichandi	Kuliha kanda	*Dioscorea hispidaI* L.	++	+++	++	++	+++	+++	+++	+++	+++	+++	++	+++	+++
12	Bakayan	Bakien	*Malla azadaracht* L.	+	+	+	+	+	++	++	+	++	+	+	+	+
13	Banarandi	Rani jara	*Jatropha curcas* L.	++	++	++	++	++	++	++	++	++	++	++	++	++
14	Baramasi	Kandle lata	*Ikora puriflora*	+++	+++	+++	++	++	+++	++	+++	++	++	++	++	++
15	Bariyara	Jharoo lata	*Sida acuta*	++	+++	+++	+++	+++	+++	+++	+++	++	+++	+++	+++	++
16	Bauchi	Bochi	*Psoralea cordifolia*	++	++	+	+	++	++	++	++	+++	++	–	+	+
17	Bel	Bel	*Aegle marmelos* L.	+	++	+	+	++	++	++	++	+	++	++	++	++
18	Bhilwa	Bhirwan	*Semecarpus anacardium* L.	++	++	+++	++	++	++	+++	++	++	++	+	++	+
19	Bidari kand	Koua kand	*Puraria tuberosa*	++	++	+++	++	++	+++	+++	++	++	++	+	++	+
20	Bilai kand	Bilaikand	*Ipomoea degitata*	++	+++	+++	+	++	+++	+++	+++	++	++	+	+	+
21	Biskhapra	Bishkhapri Wall. ex. Royle	*Aconitum heterophyllum*	+++	+++	+++	+++	++	+++	+++	+++	++	+++	+	+	+++
22	Bramhi	Booti	*Bacopa monnieri* L.	+	++	+	–	++	+++	++	++	++	++	–	+	–
23	Chironji	Char-chironji	*Buchanania lanzan*	++	++	++	++	++	++	++	++	++	++	+	++	+
24	Chitrak	Chitralata	*Plumbago ovata,*	+	+	+	+	++	++	++	++	+	++	+	++	++
25	Dokarbela	Duthilakand (Vahl.) Pleach	*Ampelocissus latifolia*	+++	+++	+++	++	+++	+++	+++	+++	+++	+++	++	+++	++
26	Giloe	Parhin	*Tinospora cordifolia*	+	++	+	++	+	++	++	++	++	+++	+	+++	+
27	Gorakhmundi	Mundi dara	*Sphaeranthus indicusi*	++	++	++	++	++	++	+++	++	+++	++	++	++	++
28	Gur sukri	Gursakhari	*Grewia tiliaefolia* Vahl.	++	++	++	+	+	+++	+++	++	+	+++	++	+	+
29	Hajardana	Bhui aonla	*Phyllanthus niruri*	++	++	++	++	++	+++	++	+++	++	++	++	++	++
30	Harad	Harra (Retz.)	*Terminalia chebula*	++	+++	++	++	+++	+++	++	+++	++	+++	++	++	+
31	Hur hur	Hulhulia	*Cleome gynandra* L.	+	++	+	+	++	+	+++	++	++	++	–	+	+
32	Isser mool	Eswar mool	*Aristolochia indica*	+	+	+	+	+	++	++	+	–	+	+	+	+
33	Indrayan	Peeta kachari	*Citrullus colocinthis* Schrad	–	++	++	+	+++	++	++	+++	++	+++	–	+	–
34	Jangali Arvi	Dhabbe kochai	*Curcuma aromatica*	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	++	+++	+
35	Jangali adrak	Baila adrak	*Zingiber roseum*	++	+++	+++	++	++	+++	+++	++	++	++	++	++	+
36	Jangli bhindi		*Abelmoschus* sp.	+++	+++	++	++	++	++	+++	++	++	++	++	++	++
37	Jangli dhania	Nepali dhaniya		+	+	+	–	–	–	–	–	+	–	–	–	–
38	Jangli haldi	Hardi	*Curcuma aromatica* Salisb.	+	++	+++	++	++	+++	+++	+++	++	++	++	+++	++
39	Jangli pyaj	Gondla	*Urginea indica* (Roxb.) Kunth.													
40	Jangli suran	Barhakanda	*Amorphophallus* sp.	++	+++	+++	++	+++	+++	+++	+++	++	+++	++	+++	++
41	Kachnar	Kachnar	*Bauhinia purpuria* L.	++	++	++	++	++	++	++	++	++	++	+	++	+
42	Kala dhatura	Dhatoor	*Datura innoxa*	++	+++	++	++	++	++	++	++	+	++	+	++	+
43	Kali haidi	Kaliyakand	*Curcuma caesia*	–	+	–	–	+	+	+	+	–	+	–	+	+
44	Kali mushli	Musri lata	*Datura innoxa*	++	++	++	+++	+++	+++	+++	+++	++	+++	++	+++	+
45	Kalihari	Ghorandi phool	*Gloriosa superba*	++	++	++	+	+	++	++	++	+	+	++	+++	–
46	Kalmegh	Bhuineem	*Andrographis paniculata*	++	+++	++	++	+++	+++	+++	++	++	+++	++	+++	++
47	Karanj	Karanji	*Pongamia pinnata* L.	+	+	+	+	++	++	++	++	++	++	+	++	+
48	Karukand	Peeta kanda	*Dioscorea dumetorum* L.	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
49	Kekar	Keekar	*Garuga pinnata* (Roxb.)	++	++	++	++	++	++	++	++	++	++	+	++	+
50	Keu kand	Keu	*Castus speciosus*	++	+++	++	++	++	+++	++	+++	++	++	++	++	++
51	Kimach	Kounch	*Mucuna prurita* Hook.	++	+++	++	++	+++	+++	+++	+++	++	+++	++	+++	++
52	Kulloo tree	Gurloo	*Sterculia urens* (Roxb.)	+	+	+	+	+	++	++	++	++	+	+	+	+
53	Kusum	Kosum	*Schleichera oleosa* (Lour)	+	+	+	+	+	++	+	+	+	+	+	+	+
54	Lajwanti	Lajni lata	*Mimosa pudica* L.	++	++	++	++	++	++	+++	++	++	++	++	++	++
55	Lal gunj	Gunj beej	*Abrus precadiorius*	+	++	++	++	++	++	++	++	++	++	++	++	+
56	Lal indrayan	Peeta kachri Lour fl Coch.	*Trichosanthes tricuspidata*	+	++	+++	–	+	+++	+++	+++	+	+++	–	+	+

Contd.

Table 4. Contd.

S. No.	Vernacular Name	Local Name	Botanical Name	Dantewara-Bailadila forests					Barsur-Bijapur Bhopalpatnam					Sukma-Konta Forests		
				1	2	3	4	5	1	2	3	4	5	1	2	3
57	Lemon grass	Chay lata	*Cimbopogon citrates*	+	+	+	+	+	+	+	++	+	+	+	+	+
58	Madar	Phundhar	*Calotropis gigantia*	+++	+++	+++	++	+++	+++	+++	+++	++	+++	+++	+++	++
59	Mahul	Mouha	*Madhuka longifolia* var. *latifolia*	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	++	++	++
60	Marodphalli	Maror phali	*Holicterus isora*	–	–	+	–	+	+++	++	++	++	+	+	+	+
61	Munga	Munga	*Moringa oleifera* Lam.	++	++	++	++	++	++	++	++	++	++	++	++	++
62	Nagbala	Paalcha	*Sida veronicifova*	++	++	++	++	++	++	++	++	++	++	++	++	++
63	Nagbel	Cheri singghi R. Rs.	*Cryptolapis buchananii*	++	+++	+++	+++	++	+++	+++	+++	++	++	++	+++	++
64	Neem	Neem A. Juss.	*Azadirachta indica*	++	++	++	++	++	++	+	++	+	++	++	++	++
65	Nirgundi	Surteli	*Vitex negundo*	+	++	++	+	++	++	++	+++	++	++	+	++	++
66	Palas	Choola	*Butea monosperma* Lamk.	++	+++	+++	++	+++	+++	+++	+++	+++	+++	++	+++	++
67	Peet papra	Peet pakra	*Fumaria parviflora* Lamk.	++	+++	+++	++	++	++	+++	+++	++	++	++	++	+
68	Pipramool	Peepri jari	*Piper longum*	–	+	–	–	+	++	++	++	+	+	+	+	–
69	Ramdaton	Potar	*Smilax macrophylla*	++	++	++	++	++	+++	+++	+++	++	++	++	+++	+
70	Ramphal	Ramphal	*Annona reticulata* L.	–	–	–	–	–	+	–	–	–	–	–	–	–
71	Rasna jari	Rasna booti	*Sapindus mukorossi*	–	–	–	–	+	+	+	+	–	+	–	+	–
72	Ratanjot	Ranijara-	*Jatropha curcas* L.	++	++	++	+	++	++	+++	++	++	++	+	++	+
73	Rosagrass	Pamarosa	*Cymbopogon martini*	+	+	+	+	+	+	++	+	+	+	+	+	+
74	Sadabahar	Sadasuhagin	*Cathranthus roseus*	+	++	++	++	+	+	++	+	+	+	+	+	+
75	Safed mushli	Mutri lata	*Chlorophytum arundinaceum*	+	+	+	+	+	+	+	+	+	+	+	+	+
76	Safed mushli	Mutri lata	*Chlorophytum laxum*	+	+	+	+	+	++	+	+	+	+	+	+	+
77	Safed mushli	Mutri lata	*Chlorophytum tuberosum*	+	++	++	+	++	+++	++	+	++	++	+	++	+
78	Safed mushli	Mutri lata	*Chlorophytum borivillianum*	–	–	+	–	–	–	–	–	–	–	–	–	–
79	Sarifa	Seetaphal	*Annona squamosa* L.	+	+	+	+	+	++	++	++	+	+	+	+	+
80	Sarpagandha	Kukdichhendi	*Rauvolfia serpentina* L.	+	+	+	–	+	+	+	++	+	+	+	+	+
81	Satawar	Satawari/ Jogilatti	*Asparagus racemosus*	++	+++	+++	++	+++	+++	+++	++	++	+++	++	+++	++
82	Semal	Semal kand	*Bombax ceiba* L.	++	++	++	++	++	++	++	++	++	++	++	++	++
83	Shivlinggi	Khutla	*Brynopsis lacinosa (*Linn)	++	+++	++	+++	++	+++	+++	++	+++	++	++	+++	+
84	Surenda	Suarkand	*Dioscorea pantaphylla*	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	++	+++	++
85	Targariyakand	Dorikanda	*Dioscorea sinensis* L.	++	+++	+++	++	+++	+++	+++	+++	+++	+++	++	+++	++
86	Teekhur	Teekhur	*Curcuma angustifolia*	+++	+++	++	++	+++	+++	+++	+++	+++	+++	+++	+++	++
87	Tendu	Tendu	*Diospyros Montana* Roxb.	++	++	++	++	+++	+++	+++	+++	+++	+++	++	+++	++
88	Vaibidang	Bidang	*Embelia ribes* Burm. f.	+	+	+	+	+	+	+	+	–	+	+	+	+
89	Van tulsi	Moura lata	*Ocimum gratissimum*	+++	+++	+++	++	+++	+++	+++	+++	+++	+++	++	+++	++
90	Wild fig	Tando	*Ficus benjamina*	++	+	+++	+	++	++	++	+++	+	+++	+	+	+
91	Wood apple	Ghuee	*Feronia limonia*	–	+	++	+	++	++	++	++	–	–	–	+	–

+ = Available in rare extent; ++ = Available in considerable extent; +++ = Available in abundant and - = Not available

- Dantewara and surrounding forest: 1. Kalepal upto Geedam and forests surrounding to villages and interiors, 2. Dantewara and river valley of Dankni and Shankani and surroundings forests, 3. Kawalnar and on way forest surroundings, 4. Nakulnar, Kuakonda, Jeerampal, Katkalyan, 5. Bailadila, Bacheli-Kirandul.
- Barsur-Bijapur-Bhopalpatnam: 1. Barsur, Chindnar, Bodhghat river valley and surrounding forests, 2. Tular cave, Garma and interior forests of medicinal importance, 3. Bijapur, Pamed, Nimed, Bhairamgarh and on way forests of medicinal importance, 4. Sangampalli, Maded, Sankanpalli and some interior hilloks of medicinal importance, 5. Bhopalpatnam, Bhadrkali, Tarlaguda, River valley and interior forest areas.
- Sukma-Konta and onway forests: 1. Bastanar, Chindgarh, Pakela, Rokel and on way forests, 2. Sukma, Gadiras, Jeerampal and interior forests of medicinal importance, 3. Sasharam, Penta, Ischar, Konta

Marod phalli (*Holicterus isora*), Gullu tree (*Sterculia urens* (Roxb.)) etc. Beside these, various orchids, bramhi, ferns and mosses are also available in riverbanks and most forests of Bastanar surroundings. The species *C. borivillanum* was also observed in some pockets of this area viz. on way riverbanks towards Tular cave and intirior river banks and forests of Bodhghat project. A rarely occurring species, locally known as *Ramakanda* was also noticed in forest of this location. Marod phalli (*Holicterus isora*), *Dioscorea* species are elite germplasm of this location. Hence they may be conserved under *in situ* in this location.

7. *Sukma-Konta Region*

This region includes forest and forest villages of Sukma, Chhindgarh, Gadiras and forests on way to Konta have been intensively surveyed and observed for the diversity present. The typical features of this area are dry and hot climate forests rich with Tendu, Sal, Palas, Arjuna and Teak trees in abundance. Among medicinal flora *Puraria*

tuberosa (locally called *Patal Kumhra*), *Dioscorea* species, *Tinospora cordifolia*, *Chlorophytum* sp., Kimanch yellow and Red fruit type (*Macuna puriata* L.) and white and red gunj (*Abrous precatorius*), Kalmegh, *Asparagus* sp., Nagbel, Nagbala etc. are in abundance. It was also observed that most of the edible and wild legumes are in abundance in this location. Wild chilies of upside bearing resembling to shimla mirch, small yellow in colour but having extremely high pungency was also seen in this area. *Tinospora cordifolia*, *Puraria tuberosa*, *Gloriosa superba* and *Abrous precatorius* may be conserved under *in situ* considering suitability of climate for these .

8. *Jagdalpur-Kondagaon*

The surveyed areas of this region include Bakawand, Bhond, Bhanpuri, Baniyagaon, Masora, Benoor and some other small interior forest villages on way to Kondagoan. The medicinal species available are *Asparagus* sp., *Amorphophallus* sp., *Cucurliago orchiodes*, Dokarbela and Ramdatoun. The typical strain of Safed musli (*Chlorophytum borivillianum*) having leaves dark green colour on upper surface and pinkish blue on lower surface is observed in interior forests near Baniyagoan which is never seen in any place of Chhattisgarh. The taste of tuber is very sweet and sticky but thin and medium in length. This elite strain of safed mushli should be studied and conserved in its existing place. The typical strain of reddish brown *Mucuna prurita* is also recorded in this region. The other herb, shrub and tree medicinal plants are noted similar to other areas but in less to moderate in occurrence.

9. *Chitrakote-Mardoom-Binta*

This includes areas of Chitradhara, Karanji, Lohandiguda, Chitrakot forest and surroundings, Mardoom and surrounding forests, Binta and Bhejji forests etc. These areas are dominated by most of the climbers like *Disoscorea alala*, *D. bulbifera*, *D. syanensis*, *D. dumetorum*, *D. pentaphylla*, *D. trifoliata*, *D. esculenta*, *D. hispida*, Ram datoun, dokarbela, Nagbel and herbs and Shrubs, *viz.*, Bhui neem, Wild brinjal (*Solanum* sp.), Vaybidang, Peng beej, *Asparagus* sp., wild arvi (*Colocasia* sp.), Wild suran (*Amorphophallus companulatus* and *A. poinifolious* L.), Anantmool, Buchh, jangli arand, Semal Kand, Baghnakkha (*Martynia annua* L.) etc. are noted in abundance. Among location specific species peng beej, white and red gunj, *Asparagus* having extra white tubers, wild bel (*Aegle marmelos* Wild.), Bada Surenda and edible sweet arvi are also noted in this region. Wild bel, peng beej, baghnakkha, kalmegh, various *Dioscorea*, wild brinjal etc. are noted specific to this location and hence, can be conserved in this area.

10. *Pharasgaon-Keskal-Kanker*

This includes forest areas of Pharasgaon, on way forest to Keshkal, Keshkal forest and surrounding forest villages, Kanker forest areas and river banks etc. These areas are dominated by most of the climbers like *Dioscorea* sp., *Tinospora cordifolia*, Ram datoun, dokarbela, Nagbel and herbs and shrubs, *viz.*, *Asparagus* sp., *Jatropa curcas*, wild and cultivated arvi (*Colocasia* sp.), Wild suran (*Amorphophallus companulatus* L.), Semal Kand, Baghnakkha (*Martynia annua*), *Piper longum* etc. are noted in considerable extent, though this location couldn't be extensively surveyed except some areas. Lemon grass and Pamarosa are also noticed in abundance in this area.

Conclusion

Based on overall observation and findings some of the species like *Piper longam*, Rasna Jari, *Gloriosa superba*, *Tinospora cordifolia*, Gunj, Sarpagandha etc. are found to be location specific hence, they can be conserved under *in situ* in those areas to maintain their existence and quality. However, some rarely existing species should be conserved under both the *ex situ* as well as *in situ* condition to sustain their existence. The rarely occurring species are already discussed in text. Thus gene sanctuaries for various species, *viz.*, *Chlorophytum* sp., *Gloriosa superba*, Wild Capsicum, Wild onion, *Dioscorea* sp., *Plumbago*, Jatamasi, Jangli arand, *Colocasia*, *Curcuma* sp., Rasna booti, *Satawar (Asparagous recemosus)* can be made in Abujhmarh; Barsur forest and river valleys for *Chlorophytum*, *Dioscorea* sp., Kachari kand, *Colocasia*, *Amorphophallus*, Marodphalli locally known as *Ainthee*; Machkot forests for conservation of *Rauvolfia serpentina*, *Asparagus*, *Piper longum* etc.; Dantewara-Bailadila forest can be chosen for conservation of *Dioscorea*, Bilai kand, Bidari kand, Jangli Haldi, Ram datoun etc. and Sukma forest may be utilized for Giloy, Gunj, Kalihari, Kalmegh, *Dioscorea* etc.

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Studies on Genetic Variability and Path Analysis for Quality Characters in Rapeseed-Mustard *(Brassica* species)

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A two-year study was carried out during rabi 2003-04 and 2004-05 with 40 varieties of rapeseed-mustard to assess the nature of variability and association for fatty acid profile, oil, protein and glucosinolate content. Analysis of variance indicated significant differences for all the quality characters investigated. The environmental effects were significant for erucic, oleic acid, glucosinolate and protein content and the influence of environmental factors appeared to be less on other characters. The genotype x environment interactions were non-significant for all the characters, hence the data were pooled over the years and discussed on the basis of mean of two years. The coefficients of variation at phenotypic level varied from 4% for protein content to 50.9% for oleic acid. The genotypic coefficients of variability were high for oleic, palmitic + stearic, erucic and linolenic acid. Protein and oil content had the least genotypic variation (GCV: 2.6-2.7%). The heritability in broad-sense was relatively high for oleic (61.5%) and erucic acid (56.3%). The high heritability was associated with high genetic advance only for oleic acid suggesting the role of additive gene action in the inheritance of this character. Erucic acid was negatively and significantly correlated with the rest of the fatty acids except linolenic acid. It had positive association with glucosinolate content (r =0.331). Glucosinolate content had negative and significant correlations with oleic (r =-0.536) and eicosenoic acid (r =-0.260). The negative association of palmitic + stearic, oleic, linoleic, linolenic and eicosenoic with erucic acid was the result of their high to moderate negative direct effects. Although glucosinolate content had very low direct effect (-0.051) on erucic acid but its positive association was the result of its strong positive indirect effect via oleic acid (0.435), which was partially neutralized by negative indirect effects (-0.112) via linolenic acid. The implications of these results in the quality-breeding programme were discussed in this paper.

Key Words: *Brassica* species, Path analysis, Correlation coefficients, Fatty acid profile, Glucosinolate content, Rapeseed-mustard

Introduction

Rapeseed-mustard is extensively grown in India and the major source of edible oil. Oil quality is determined by fatty acid profile, whereas, level of glucosinolates predicts the quality of seed meal. In the present era of health consciousness, the quality of oil remains a cause of concern among consumers and hence its improvement gained the paramount importance among the breeding objectives in recent years. The success of any crop improvement programme relies upon the extent of variability for a character to be improved. Correlation studies among various characters help breeders to formulate the appropriate breeding strategy to improve a number of characters simultaneously. Path analysis provides an insight into the causes of correlations between two characters. Such information for oil and seed meal quality characters is limited in the rapeseed-mustard varieties grown in India. Therefore, the present investigation attempts to assess the extent of genetic variation and nature of associations among quality characters in rapeseed-mustard. Further, the correlation coefficients of erucic acid with other characters were partitioned in to direct and indirect effects by path analysis to precisely elucidate the nature of association.

Materials and Methods

The experimental material consisted of 40 released varieties of rapeseed mustard (Indian mustard 25; gobhi sarson 4; toria 6; yellow sarson 2; karan rai 2 and taramira 1). These were grown in Randomized Complete Block design during 2003-04 and 2004-05 rabi seasons with two replications in 5-row plot of 5 m length, keeping 45 cm row–to-row and 15 cm plant-to-plant spacing. The experiment was conducted at 80:40:40 kg/ha of $N:P_2O_5:K_2O$. Half the dose of nitrogen and full doses of P_2O_5 and K_2O were applied basally at the time of sowing and the remaining dose of nitrogen was top dressed after first irrigation (35 days after sowing). The crop was also irrigated at 60 days after sowing. The observations were recorded on composite sample from central three rows. The oil and protein content were analyzed using NIR (Dicky John Insta Lab 600). Fatty acid profile was analyzed by gas liquid chromatograph (Nucon Model 5765) using SP 2300 + 2310 SS columns. Hyola PAC 401, a double low hybrid of gobhi sarson (*Brassica napus*) and Varuna a non-canola variety of Indian mustard (*Brassica juncea*) were used as checks. The detailed method for fatty acid analysis has been described earlier (Chauhan *et al*., 2002a). ELISA reader at 405 nm analyzed

the glucosinolate content of the seeds following tetrachloropalladate method (Kumar *et al*., 2004). The mean values were used for analysis of variance using multiple Randomized Complete Block Design by indostat software. The genotypic (GCV) and phenotypic coefficients of variation (PCV), heritability in broad-sense and genetic advance were calculated by the formulae given by Johnson *et al*. (1955). The genotypic and phenotypic correlations were calculated as per the method of Al-Jibouri *et al.* (1958). Path coefficient analysis was done according to the method of Dewey and Lu (1959).

Results and Discussion

Analysis of variance indicated significant differences for all the quality characters investigated. The environmental effects were significant for erucic, oleic acid, glucosinolate and protein content but the environment influence was less on the other characters. The interactions between genotype x environment were non-significant for all the characters, hence the data were pooled over the years and discussed on the basis of mean of two years. All the genotypes showed same pattern of variability for both years for linoleic, linolenic, eicosenoic acid and oil content. Erucic acid ranged from 30.7% (PC 5) to 52.2% (Neelam) and glucosinolate content from 90.7 (RH 8812) to 106.6 m moles/g defatted seed meal (GM 1). The range for linolenic acid was 5.7% (RH 30) to 19.6% (Varuna). The range for palmitic + stearic and oleic acid was 2.3 % (Bhawani)-6.0 % (RH 8812) and 8.9% (JT 1)-22.7% (RH 30), respectively. Linoleic acid was the highest in Basanti (25.7%). In general, all the characters had higher magnitude of PCV than GCV (Table 1) indicating that environment influenced the expression of these characters but to a varying extent. However, the trend of PCV and GCV was similar. The coefficients of variation at phenotypic and genotypic level varied from 4% (protein content) to 50.9% (oleic acid) and 2.6% (oil content) to 39.9% (oleic acid), respectively. The genotypic coefficients of variation were high for oleic, palmitic + stearic, erucic and linolenic acid, which provide good opportunity for selection for desirable level of these fatty acids. Protein and oil content had the least variation (Table 1). Heritability values ranged from 11.9% (linoleic acid) to 61.5% (oleic acid). The heritability was relatively high for oleic (61.5%) and erucic acid (56.3%). The characters like linolenic acid, oil and protein content showed moderate heritability while, rest of the characters showed low heritability. However, in earlier studies (Chauhan *et al.*, 2002a, b) high heritability estimates were reported for erucic, oleic and linoleic acid. The high genetic advance was observed only for oleic acid (64.5%) while the other characters showed low to moderate genetic advance. The high heritability was associated with high genetic advance only for oleic acid suggesting the role of additive gene action in the inheritance of this character. The results were in agreement with earlier reports (Chauhan *et al*., 2002 b). The extent of variation for oil, protein and glucosinolate content was found to be low, accompanied by low to moderate estimates of heritability and low genetic advance indicating thereby the chances of improvement of these characters by simple selection are limited.

Correlations

Phenotypic level:Erucic acid is an undesirable fatty acid found in rapeseed-mustard oil of prevalent Indian cultivars. It had negative and significant relationships with most of the other fatty acids but showed positively significant correlation with linolenic acid and glucosinolate content (Table 2). The results implied that an increase in the level of other fatty acids, particularly that of oleic acid, which had the highest negative direct

Table 1. Mean, standard error, range, coefficients of phenotypic (PCV) and genotypic variance (GCV), heritability in broad-sense (h^2) and genetic advance for quality characters in rapeseed-mustard

Characters	Mean ± SEm	Range	PCV (%)	GCV (%)	h^2 (%)	Genetic advance (%)
Palmitic + stearic acid (%)	3.6 ± 0.6	2.3-6.0	36.4	16.9	21.6	16.2
Oleic acid (%)	15.8 ± 2.5	8.9-22.7	50.9	39.9	61.5	64.5
Linoleic acid (%)	19.6 ± 2.0	14.3-25.7	22.1	7.6	11.9	5.4
Linolenic acid (%)	13.4 ± 1.5	5.7-19.6	27.6	15.9	33.0	18.8
Eicosenoic acid (%)	7.0 ± 1.2	4.6-10.4	35.8	12.6	12.4	9.2
Erucic acid (%)	40.3 ± 2.9	30.7-52.2	21.7	16.3	56.3	25.1
Oil content (%)	39.1 ± 0.7	35.7-41.6	4.6	2.6	32.2	3.0
Protein content (%)	19.7 ± 0.3	18.5-21.2	4.0	2.7	46.0	3.8
Glucosinolate content (m moles/g defatted seed meal)	99.3 ± 4.5	90.7-106.6	10.7	5.6	27.5	6.0

effect (Table 3), would result in the reduction of erucic acid content. The negative relationships of erucic with oleic and linoleic acid have been reported earlier also (Zhou and Liu, 1987; Singh *et al.*, 2001; Chauhan *et al.*, 2002a; Meena, 2006]. Increase in the level of oleic acid might also result in the high protein content as both characters were positively correlated and reduction in the glucosinolate content because of negative relationship between oleic acid and glucosinolate (Table 2). Glucosinolate content had negative and significant correlations with oleic and eicosenoic acid while, linolenic and erucic acid showed positively significant correlation with glucosinolate content.

Genotypic level: Erucic acid showed moderately high positive correlation with linolenic acid. Oleic acid had negative association with linolenic, erucic acid and oil content while positively related with linoleic, palmitic + stearic, eicosenoic and protein content (Table 2). Glucosinolate content was negatively correlated with most of the characters except linolenic (r=0.890) and erucic acid (r=0.450). On the basis of present investigation, it would be appropriate to enhance the level of oleic acid, which had high extent of variability and negative relationship with erucic acid through hybridization among varieties/donors having high level of oleic acid and low erucic acid as well as low glucosinolate content. However, the pattern of correlations between erucic acid and other quality characters were similar at both genotypic and phenotypic levels except linoleic acid with eicosenoic and glucosinolate content; oleic, linoleic and eicosenoic acid with oil content (Table 2). These results indicated that environment played an important role in the expression of these relationships.

Path Analysis

Phenotypiclevel: Correlation coefficients only describe the nature and magnitude of association between any two variables but path analysis enables interpretation of cause and effect relationship. Therefore, correlation coefficients of erucic acid (dependent variable) with other quality characters (independent variables) were partitioned into direct and indirect effects. The negative association of palmitic + stearic, oleic, linoleic, eicosenoic acid and protein content with erucic acid was the result of their high to moderate negative direct effect. Palmitic + stearic acid had negative direct effect (-0.127) on erucic acid. The indirect effects via linoleic, linolenic acid and glucosinolate content were positive, however, the correlation coefficients remained negative and significant (-0.208) due to major negative indirect effect via oleic acid (Table 3). Oleic acid had the highest direct negative effect (-0.812) on erucic acid and also had major positive indirect effect via linoleic acid. The indirect effects via other characters were low, hence the correlation between oleic and erucic acid remained negative but significant. Linoleic acid also had major negative direct effect (-0.318) though it had been diluted by positive indirect effects via palmitic + stearic, linolenic, eicosenoic and oil content, however, due to negative indirect effects via oleic acid, protein and glucosinolate content the correlation coefficient remained significant and negative. Mainly positive indirect effects via oleic, eicosenoic acid and protein content had nullified the direct negative effect of

Table 2. Correlation coefficients at phenotypic (P) and genotypic (G) levels among quality characters

Characters		Oleic acid	Linolenic acid	Linolenic acid	Eicosenoic acid	Erucic acid	Oil content	Protein content	Glucosinolate content
Palmitic + Stearic acid	P	0.184*	–0.146	–0.208**	0.165*	–0.208*	–0.111	0.195*	–0.096
	G	0.539	–0.065	–0.319	0.821	–0.546	–0.556	0.715	–0.277
Oleic acid	P		0.0001	–0.646**	0.453**	–0.678**	0.039	0.201*	–0.536**
	G		0.426	–0.929	1.105	–0.766	–0.127	0.287	–0.708
Linoleic acid	P			–0.084	–0.287**	–0.193*	0.084	0.018	0.056
	G			–0.664	0.436	–0.319	0.099	0.306	–1.105
Linolenic acid	P				–0.303**	0.265**	–0.030	–0.258**	0.293**
	G				–0.687	0.600	0.280	–0.596	0.890
Eicosenoic acid	P					–0.407**	0.041	–0.001	–0.260**
	G					–0.936	–0.129	–0.113	–0.587
Erucic acid	P						0.068	–0.153	0.331**
	G						0.227	–0.310	0.450
Oil content	P							–0.103	–0.065
	G							–0.320	–0.593
Protein content									–0.144
									–0.564

*, **Significant at 5% and 1% level of probability

Table 3. **Path analysis at phenotypic (P) and genotypic (G) level taking erucic acid as dependent variable**

Characters		Palmitic acid + stearic acid	Oleic acid	Linolenic acid	Linolenic content	Eicosenoic content	Oil content	Protein content	Glucosinolate
Palmitic + Stearic acid	P	**–0.127**	–0.150	0.047	0.080	–0.040	–0.011	–0.011	0.005
	G	**–0.364**	–0.094	0.004	–0.115	–0.089	–0.083	0.199	–0.005
Oleic acid	P		0.0001	–0.646**	0.453**	–0.678**	0.039	0.201*	–0.536**
	G		0.426	–0.929	1.105	–0.766	–0.127	0.287	–0.708
Linoleic acid	P			–0.084	–0.287**	–0.193*	0.084	0.018	0.056
	G			–0.664	0.436	–0.319	0.099	0.306	–1.105
Linolenic acid	P				–0.303**	0.265**	–0.030	–0.258**	0.293**
	G				–0.687	0.600	0.280	–0.596	0.890
Eicosenoic acid	P					–0.407**	0.041	–0.001	–0.260**
	G					–0.936	–0.129	–0.113	–0.587
Erucic acid	P						0.068	–0.153	0.331**
	G						0.227	–0.310	0.450
Oil content	P							–0.103	–0.065
	G							–0.320	–0.593
Protein content									–0.144
									–0.564

*, ** Significant at 5% and 1% level of probability
(Direct effects in bold)

linolenic acid (-0.383) and resulted into its significant and positive correlation with erucic acid. Looking into positive relationship, it would be desirable to practice selection for low linolenic acid. Negative direct effect of eicosenoic acid (-0.243) and its negative indirect effect via oleic acid is an indication of reduction in eicosenoic acid by an increase in oleic acid and in turn the reduction in erucic acid. Oil content had low positive direct effect (0.101) as well as positive but non-significant correlation with erucic acid. Protein content also had non-significant negative correlation with erucic acid. Hence, a change in fatty acid profile would not affect the protein and oil content. Glucosinolate content had negative direct effect but it had been neutralized by positive indirect effect via oleic and eicosenoic acid, which resulted into positive and significant correlation with erucic acid.

Genotypic level: The highest negative direct effect of palmitic + stearic acid (-0.364) on erucic acid and their negative indirect effects via oleic, linolenic, eicosenoic acid, oil and glucosinolate content was the cause of negative association with erucic acid. Besides negative direct effect of oleic acid (-0.175), its negative indirect effects via linoleic, linolenic, eicosenoic acid and glucosinolate content were responsible for negative association between oleic and erucic acid. It is obvious that direct selection for high oleic content would be desirable to reduce the erucic acid. Linoleic and eicosenoic acid also showed negative direct effects on erucic acid. Its high indirect negative effect via linolenic acid (Table 3) indicated that linoleic acid would reduce with an increase in linolenic acid. The correlation coefficient between eicosenoic and erucic acid was the highest (-0.936) and negative due to its negative direct and indirect effects via other characters except linolenic acid. The high positive association between linolenic and erucic acid was the result of its highest positive direct effect. Oil, protein and glucosinolate content showed positive direct effects on erucic acid. Oil and glucosinolate content also had positive association with erucic acid. The relationship between glucosinolate content and erucic acid needs to be broken because both erucic acid and glucosinolate are considered undesirable. In the present investigation, the characters studied contributed 63% to the variability in the erucic acid content, hence many other factors responsible for variation in this fatty acid remained unknown, which need to be further investigated.

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Studies on Genetic Divergence in Safflower (*Carthamus tinctorius* L.)

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Euclidean cluster analysis was used for the characterization of 36 exotic germplasm accessions of different geographical origin and four check varieties of safflower (*Carthamus tinctorius* L.). A quantitative assessment of genetic divergence for eleven characters using Mahalanobis D^2 statistics revealed the presence of considerable genetic diversity.The forty genotypes were grouped into seven well defined clusters with variable number of genotypes. The inter-cluster distances (D value) ranged from 8.27 to 25.68. Among the plant attributes, hull content, number of seeds in main capitulum, seed yield/plant and number of effective capitula were found to be important in the present study. Accessions GMU 848, 4097, 4095, 5110 from Cluster V and GMU 1727, 1747, 5111 from Cluster VII were identified as potential parents in future hybridization programmes for genetic improvement in safflower.

Key Words: Safflower, Genetic divergence, Cluster, Cluster means

Introduction

Safflower (*Carthamus tinctorius* L.) is one of humanity's oldest crops, cultivated mainly for the orange red dye extracted from its coloured florets and the highly valued edible oil obtained from the seeds. Oil has been produced commercially and for export for about 50 years, first as an oil source for the paint industry, now as an edible oil for cooking. Over 60 countries grow safflower, but more than half is produced in India. Production in the USA, Mexico, Ethiopia, Argentina and Australia comprises most of the remainder (Li Dajue and Mündel, 1996). India occupies a premier position in the world in safflower area and production, however, its productivity is only about 80% of the world's productivity. Though there has been an increasing trend in area, production and productivity of safflower in the country during the past 30 years (Hegde and Sudhakara Babu, 2002), concerted efforts are still required towards breeding highly productive cultivars to bridge the gap between the domestic and international levels of productivity.

The role of plant genetic resources in the improvement of cultivated plants has been well recognized. Characterization and evaluation of both exotic and indigenous collections for information on useful traits forms the basic step for crop improvement programmes. Study of genetic divergence among a set of genotypes will therefore enable a plant breeder to choose suitable parents and plan an appropriate hybridization programme. D^2 statistics has proved to be a powerful tool in discerning genetic divergence among groups based upon multiple growth characters, assessing relative characters and assessing relative contribution of different components to total divergence (Bhatt, 1973). The present study was conducted to determine the magnitude of variability in yield and various agronomic traits and the degree of inter-relationship among traits in the exotic accessions of safflower and their performance against released high yielding varieties for identification of promising germplasm.

Materials and Methods

Forty diverse genotypes of safflower of different geographical origin were selected for the present study. Of these, thirty six exotic accessions were acquired from fifteen countries (Turkey, USA, Pakistan, Egypt, Iran, Jordan, Portugal, Germany, Israel, Spain, USSR, China, Argentina, Ethiopia and Canada), while four cultivated varieties (A-1, CO-1, Bhima, JSI-7) were included as checks. The experimental material was sown in Randomized Block Design with three replications at College Farm, Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad. Each entry was represented by three rows of 2.5 m length. The inter-row and inter-plant spacings were 60 cm and 20 cm, respectively. Five randomly selected plants of each genotype in each replication were used for recording observations on ten characters, *viz.*, days to 50% flowering, plant height (cm), diameter of main capitulum (mm), number of effective capitula, number of seeds in main capitulum, 100-seed weight, hull content (%), oil content (%), seed yield per plant (g) and oil yield per plant (g). Divergence was studied by multivariate analysis using Mahalanobis D^2 statistics and the genotypes were

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grouped into different clusters by employing Euclidean method as described by Rao (1952).

Results and Discussion

Multivariate analysis based on D^2 statistics indicated the presence of considerable amount of genetic diversity among the genotypes studied. This statistical tool has been widely employed to resolve genetic divergence at inter-varietal and sub-species level in classifying the crop plants (FAO, 1997). The forty genotypes were grouped into seven clusters by using Euclidean cluster method (Table 1). Cluster II was the largest consisting of 10 genotypes followed by cluster III, I and VI having 7, 6 and 5 genotypes, respectively. Clusters IV, V and VII consisted of four genotypes each. The pattern of distribution of genotypes into various clusters was at random suggesting that geographical distribution and genetic diversity were not related. This was in accordance with the results reported by Patil *et al.* (1984) and Patel *et al.* (1989). The magnitude of D^2 values suggested presence of considerable amount of diversity in the experimental material. Similar results were obtained by Ranga Rao *et al.* (1980), Agarwal *et al.* (1982), Mandal and Banerjee (1991), Patil *et al*. (1991), Dingming *et al.* (1993), and Ghongade and Navale (1995).

The analysis of dispersion for the test of significance of differences in the mean values based on Wilk's criterion revealed highly significant differences between the genotypes for the aggregation of ten characters.

The maximum intra-cluster distance was observed in cluster VII (9.96) and this might have been due to limited gene exchange or selection practiced among the genotypes for diverse characters. This was followed by cluster VI (7.74), cluster V (7.44), cluster I (7.31), cluster IV (7.28) and cluster II (6.62). Cluster III (6.17) displayed the least intra-cluster divergence revealing the similarity of genotypes within the cluster. Based on the inter-cluster distance, it was found that cluster IV was highly divergent from cluster V (25.68) followed by cluster II and cluster V (21.27) (Table 2). In the present study, inter-cluster distances were found to be greater than intra-cluster distances revealing considerable amount of genetic diversity among the genotypes evaluated.

Table 1. Clustering pattern of 40 genotypes of safflower

No. of Cluster	No. of genotypes	Genotypes/Check varieties
I	6	GMU 683, 807, 1186, 1232, 1238, 1872
II	10	GMU 740, 871, 874, 1037, 1209, 1233, 1240, 1778, 5121, 5127
III	7	GMU 1163, 1193, 1237, 1749, 1868, 5117, JSI-7
IV	4	GMU 1160, 1241, 1246, CO-1
V	4	GMU 848, 4097, 4095, 5110
VI	5	GMU 1230, 1402, 1429, 1741, A-1
VII	4	GMU 1727, 1747, 5111, Bhima

Table 2. Intra and inter-Euclidean cluster distances

Cluster No.	I	II	III	IV	V	VI	VII
I	**7.31**	8.50	8.58	12.11	20.57	15.22	14.88
II		**6.62**	8.27	9.65	21.27	14.86	15.88
III			**6.17**	11.84	16.95	10.84	12.84
IV				**7.28**	25.68	18.58	20.77
V					**7.44**	11.38	12.44
VI						**7.74**	11.75
VII							**9.96**

Values in bold are intra-cluster distances

The presence of variability in the 40 germplasm accessions was also reflected in the cluster means for the ten traits evaluated (Table 3). Genotypes in cluster III were early to flower (79.52) while maximum days to 50 per cent flowering was observed for cluster VI (81.40). Cluster IV recorded the maximum plant height (86.70 cm) but minimum values for 6 other traits, viz., diameter of main capitulum, number of effective capitula, number of seeds per capitulum, oil content, seed and oil yield were observed. Maximum diameter of main capitulum (25.26 mm), highest oil content (26.60%) and oil yield per plant (16.10 g) were recorded in Cluster V. Highest cluster mean for number of effective capitula was observed in Cluster I (33.63) which also recorded the least hull content (35.53%). Maximum number of seeds per capitulum (25.45) and seed yield per plant (60.67 g) were recorded in Cluster VII whereas maximum 100-seed weight was recorded in Cluster VI (5.51 g).

The number of times that each of the ten quantitative characters appeared in combination and their respective per cent contribution towards diversity is presented in Table 4. Greater emphasis should be laid on those characters contributing maximum to the D^2 values for the purpose of further selection and choice of parents for hybridization. Highest contribution in this regard was of hull content (46.79%) followed by number of seeds in main capitulum (17.05%), seed yield per plant (15.38%), number of effective capitula per plant (11.15%), plant height (6.03 %), oil content (1.67 %), oil yield per plant (0.77), diameter of main capitulum (0.64 %) and 100-seed weight (0.51 %). Days to 50 per cent flowering did not contribute towards genetic divergence.

The present findings can be used for the selection of suitable parents based on the traits identified for

Table 3. Cluster means for ten characters in 40 safflower genotypes

Cluster No.	Days to 50% flowering	Plant height (cm)	Diameter of main capitulum (mm)	No. of effective capitula	No. of seeds in main capitulum	100 seed weight (g)	Hull content (%)	Oil content (%) (g)	Seed yield plant (g)	Oil yield plant
I	80.72	80.88	23.19	33.63	23.42	4.56	35.53	25.13	29.30	7.41
II	79.93	74.47	22.49	29.24	19.45	4.82	35.69	26.28	29.34	7.76
III	79.52	80.52	22.69	27.75	22.19	4.64	38.02	26.08	28.28	7.34
IV	81.25	86.70	20.20	20.65	17.48	5.07	35.74	23.93	20.36	4.88
V	79.58	84.05	25.46	33.01	25.26	5.25	43.52	26.80	60.15	16.10
VI	81.40	79.26	22.68	29.74	20.86	5.51	41.84	24.33	38.77	9.41
VII	81.08	78.83	24.06	30.11	25.45	4.84	39.34	24.32	60.67	14.71

Table 4. Contribution of different characters towards genetic divergence (D^2) in 40 genotypes of safflower

Source	No of times ranked first	Per cent contribution towards divergence
Days to 50% flowering	0	0
Plant height (cm)	47	6.03
Diameter of main capitulum (mm)	5	0.64
No. of effective capitula	87	11.15
No. of seeds in main capitulum	133	17.05
100-seed weight (g)	4	0.51
Hull content (%)	365	46.79
Oil content (%)	13	1.67
Seed yield/plant (g)	120	15.38
Oil yield/plant (g)	6	0.77

improvement. Accessions GMU 848, 4097, 4095, 5110 from Cluster V and GMU 1727, 1747, 5111 from Cluster VII were identified as potential parents in future hybridization programmes for genetic improvement in safflower.

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Diallel Analysis for Yield and Yield Component Traits in Toria (*Brassica rapa* L.)

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Combining ability and reciprocal effects were estimated for yield and its components along with protein and oil content from a study of 8 x 8 full diallel set. Genotypes being open-pollinated and self-incompatible were bud pollinated to get the parental seed before inclusion into diallel mating. Significant *sca* variances exhibited their importance for all the traits except for oil content, while the *gca* variance were non-significant for, for plant height, siliqua length and oil content and significant for rest of the characters. However, preponderance of non-additive gene action was observed for all the traits as reflected by the ratio of *gca* and *sca* variances. Reciprocal variances were greater than both the *gca* and *sca* variances for plant height, number of primary branches/plant, siliquae on main shoot, siliquae length and seeds/siliquae indicating importance of maternal effects for the expression of these traits. The maternal effect, reflected in most of the crosses involved good general combiner as female parent. Genotypes PT-30, PT-9701, PT-9600 and PT-9700 were good general combiners for seed yield and yield contributing characters along with high *per se* performances. The high performing crosses for seed yield involved parents with high x high, high x low, low x low and low x high *gca* effects.

Key Words: Toria, Yield components, Diallel analysis, Combining ability, *Brassica rapa*

Introduction

Toria (*Brassica rapa* L. var. *toria*) is an important oilseed crop grown as a catch crop in between *kharif* and *rabi* season in northern and eastern part of the country. Increase in production through development of high yielding varieties necessitates selection of transgressive segregants segregating generation (F_2) of crosses. The nature and magnitude of combining ability help in identifying elite parents and desirable cross combinations. The information on additive and non-additive gene effects associated with yield and its component characters play important role in deciding the breeding strategies. In toria, information on gene action and relationship between combining ability effects and *per se* performance of parents and crosses is scanty and contradictory (Yadav and Yadava, 1996; Kumar *et al*., 1997). The present study was therefore, undertaken to understand the nature of gene action for different yield contributing characters following combining ability analysis for 8 diverse genotypes of toria.

Materials and Methods

A set of 8 × 8 full diallel crosses was obtained using eight toria genotypes, *viz.*, PT-9600, MSP-9212, PT-9700, PT-9701, PT-9719, PT-507, PT-30 and T-9. The 56 F_1s (including reciprocals) along with their parents were grown in a Randomized Block Design with two replications, in single row of 5 m length. The planting distances between and within the row were 30 cm and 10 cm, respectively. A single non-experimental row was grown all around the experimental area in each replication to neutralize border effect.

Observations were recorded on a sample of five randomly selected plants for 12 out of 16 characters studied, whereas, days to flowering and maturity recorded on plot basis and protein and oil contents estimated on random sample of seeds. Protein content was estimated by micro-kjeldahl method as per Jackson (1967), multiplying percentage 'N' by 6.25. Oil content was estimated using nuclear magnetic resonance (NMR) technique. The data was analysed with Model II and Method 1 of Griffing (1956) and estimates of *gca*, *sca*, reciprocal effects and gene action were obtained. The relative significance of additive versus non-additive gene effects was assessed by the ratio $\left(\frac{Mg - M'e}{2n}\right) \Big/ (Ms - M'e)$ as described by Singh and Chaudhary (1996).

Results and Discussion

Analysis of variance for combining ability revealed that variances due to general combining ability (*gca*), specific combining ability (*sca*) and reciprocal effects were highly significant for all characters except oil content, while for

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Table 1. Analysis of variance for *gca*, *sca* and reciprocal effects

Source of variation	Degree of freedom	Mean sum of squares								
		Days of flower Intiation	Days to maturity	Plant height (cm)	Length of main shoot (cm)	No. of primary branches	No. of secondary branches	No. of siliquae on main shoot	No. of siliquae per plant	Siliqua length (cm)
General combining ability *(gca)*	7	2.813**	2.294*	27.834	94.738**	1.837**	15.037**	36.206**	5503.75**	0.119
Specific combining ability *(sca)*	28	3.090**	4.919**	86.708**	40.788**	0.777**	12.369**	27.252**	2932.487**	0.122**
Reciprocal effect	28	2.494**	2.522**	93.949**	43.943**	1.947**	14.408**	43.025**	3294.58**	0.191**
Error	126	0.577	1.106	24.766	11.066	0.401	0.801	4.893	168.910	0.064
$\left(\frac{Mg - M'e}{2n}\right) \Big/ (Ms - M'e)$		0.06	0.19	0.004	0.18	0.24	0.08	0.09	0.12	0.06

Table 1. Contd.

Source of variation	Degree of freedom	Mean sum of squares						
		No. of seeds per siliqua	1000-seed weight (gm)	Seed yield per plant (gm)	Biological yield per plant (gm)	Harvest index	Oil content (%)	Protein content (%)
General combining ability (*gca*)	7	2.865**	0.1393**	35.845**	521.943**	12.531**	0.177	3.243**
Specific combining ability (*sca*)	28	2.660**	0.0687**	22.377**	430.349**	24.311**	0.277	5.027**
Reciprocal effect	28	3.337**	0.079**	22.507**	365.981**	19.807**	0.255	4.677**
Error	126	0.546	0.011	0.9219	12.465	0.008	0.233	0.366
$\left(\frac{Mg - M'e}{2n}\right) \Big/ (Ms - M'e)$		0.07	0.14	0.10	0.08	0.03	0.07	0.03

plant height and siliquae length *gca* variance were found to be non-significant (Table 1). This indicates existence of genetic variability in experimental material. Significance of *gca*, *sca* and reciprocal effects have also been reported by Rawat (1992) and Yadava *et al*. (1974). Wang and Qiu (1990) suggested significance of *gca*, and *sca* variances for protein content. Significance of both *gca* and *sca* variances indicated importance of both additive and dominance gene action in the expression of the characters. The results are in accordance with Rishipal and Singh (1980) for rapeseed and Gupta and Sharma (1999) for Indian mustard. However, the ratio of non-additive/additive variance showed that the non-additive type of gene effects were more important than the additive type in the expression of different characters. None of the lines was found to be good general combiner for all the characters. PT-30 was found as the best general combiner with highest *gca* effects for length of main shoot (4.39) followed by PT-9719 (2.48), number of secondary branches (2.02) followed by PT-9719 (0.08ns), siliquae on main shoot (2.06), followed by PT-507 (1.27), siliquae per plant (28.87) followed by PT-9700 (19.91), 1000-seed weight (0.14), followed by MSP-9212 (0.12), seed yield (2.78) followed by PT-9701 (1.85) and biological yield per plant (9.68) followed by PT-9701 (7.31). PT-9600 was good general combiner for days to flower initiation (-0.84), maturity (-0.63) and harvest index (1.35). PT-9700 was good general combiner for number of siliquae per plant and PT-9701 for seed yield per plant and biological yield per plant, PT-9719 for length of main shoot, number of siliquae per plant and PT-507 for number of siliquae on main shoot were found to be good general combiner (Table 2). These parents can be used in crossing programme for improving seed yield, its contributing characters and evolving early genotypes to suit particular crop rotation because of high general combining ability effects, additive effects and additive × additive epitasis. Singh and Lallu (2004) also reported similar results in Indian mustard. Alternatively desirable parents can be put into a central gene pool through multiple crossing to generate useful segregates as suggested by Jenson (1970). Presence of significant reciprocal effects suggested the scope for choosing the parents either as female or male to exploit the heterotic effect of the cross to its maximum potential.

The order of ranking of toria genotypes was unpredictable as mean value did not correlate with *gca* effects for all the characters and all the genotypes. Higher

Table 2. Correspondence of best parent, best general combiner, best specific cross combination and best reciprocal cross combination

S.No.	Character	Best parent (mean value)	Best general combiner	Best specific cross combination	Best reciprocal cross combination
1.	Days to flower initiation	PT-9600 (33.3)	PT-9600 (-0.84**)	PT-9600 × T-9 (-1.99**)	PT-30 × PT9700 (-2.17**)
2.	Days to maturity	PT-9719 (92.3)	PT-9600 (-0.63**)	PT-9600 × PT-50 (-2.59**)	PT-30 × PT9700 (-3.00**)
3.	Plant height (cm)	PT-9719 (103.7)	PT-9600 (-2.15ns)	PT-9600 × PT-30 (-12.65**)	PT-30 × PT-507 (-19.51**)
4.	Length of main shoot (cm)	MSP-9212 (68.7)	PT-30 (4.39**)	PT-9700 × PT-9719 (8.43**)	PT-507 × PT-9701 (10.03**)
5.	Number of primary branches	T-9 (8.4)	PT-9700 (0.58**)	MSP-9212 × PT-9700 (0.88*)	T-9 × MSP-9212 (2.23**)
6.	Number of secondary branches	T-9 (16.3)	PT-30 (2.02**)	PT-9701 × PT-9719 (4.18**)	T-9 × MSP-9212 (5.38**)
7.	Siliquae on main shoot	PT-9600 (42.4)	PT-30 (2.06**)	PT-507 × PT-30 (8.43**)	T-9 × MSP-9212 (9.11**)
8.	Siliquae per plant	T-9 (229.7)	PT-30 (28.87**)	PT-9719 × T-9 (79.79**)	T-9 × MSP-9212 (88.57**)
9.	Siliquae length (cm)	PT-9719 (6.3)	MSP-9212 (0.12ns)	PT-9701× PT-507 (0.51**)	PT-507 × PT-9719 (0.49**)
10.	Seeds per siliqua	MSP-9212 (22.6)	PT-9719 (0.59**)	PT-9719 × PT-30 (2.81**)	PT-507 × MSP-9212m (2.66**)
11.	1000-seed weight (g)	PT-30 (3.05)	PT-30 (0.14**)	PT-9700 × T-9 (0.28**)	PT-507 × PT-9700 (0.96**)
12.	Seed yield per plant (g)	PT-9600 (10.8)	PT-30 (2.78**)	PT-9701× PT-9719 (5.66**)	PT-9700 × MSP-9212 (8.21**)
13.	Biological yield per plant (g)	PT-9700 (85.8)	PT-30 (9.68**)	PT-9701 × PT-9719 (25.08**)	T-9 × PT-30 (31.84**)
14.	Harvest index	PT-9701 (47.4)	PT-9600 (1.35**)	PT-9600 × T-9 (6.44**)	T-9 × PT-9701 (8.34**)
15.	Oil content (%)	PT-507 (43.8)	PT-9700 (0.13ns)	MSP-9212 × PT-30 (0.65*)	PT-30 × MSP-9212 (0.94**)
16.	Protein content (%)	PT-30 (42.9)	PT-507 (0.64**)	PT-9701 × T-9 (1.81**)	PT-30 × PT-9600 (3.76**)

sca effects were not necessarily associated with higher mean value in F_1 for most of the characteristics except for number of primary branches and 1000-seed weight. In most of the crosses where reciprocal effects were higher, it was observed that parents of these crosses had high mean values but they could not be able to set high *sca* effects, when crossed. This suggested that it is important to select parent as male or female in toria breeding programme for higher expression of heterotic effects in F_1s. Also it is important that when the character mean is desirable, still due weightage needs to be given to *gca/sca* scored in F_1, depending upon the objective, and nature of the crop.

A critical perusal of top five crosses with desirable *sca* effects and top five crosses with highest reciprocal effects for seed yield per plant (Table 3) indicated high × high, high × low and low × low combinations with respect to parental *gca* effects. Crosses PT-9701 × PT-9719 (high × low *gca*) and MSP-9212 × PT-30 (low × high *gca*) exhibited high seed yield per plant coupled with desirable *sca* effect for number of siliquae per plant and seeds per siliquae, respectively. Result suggested the presence of non-additive allelic interactions. The present study suggested that recurrent selection for *sca* could be followed in the segregation of such crosses as this type of relation was proposed on the assumption (Sharma *et al.*, 2002) that an important part of heterosis results from non-linear interaction of genes at different loci, from interaction between alleles at the same locus or from both causes in combination as also suggested by Sharma *et al*. (2002). It was found that *sca* of yield may be influenced by the *sca* of yield components; therefore, combining ability of the parents may serve as a reliable guide in assessing the yield potential of a cross. For the cross PT-9700 × PT-9719, significant *sca* effects were the reflection of low × low *gca* effects of parents, suggesting a non-additive type of gene action. The cross PT-9700 × MSP-9212, with highest reciprocal effect for seed yield (8.21) also included both the parents with low *gca* effect (-0.15ns and -0.40ns, respectively).

Crosses involving high × low and low × low general combiners in the present study are of considerable interest with reference to the possibilities of producing good transgressive segregates if additive effects of one parent and complementary effects of other parent act in same direction to maximize the expression of the character under study as suggested by Khulbe *et al*. (1998). Therefore, it is not necessary that parents having higher *gca* effects would also provide higher *sca* effects. On the basis of combining ability effects, the selection of parents can be done for hybridization. Like-wise, crosses can also be selected for handling of segregating generations with

Table 3. Top five crosses for *sca* and reciprocal effects for seed yield

Cross	F_1 mean	*sca* effect	Cross	RF_1 mean	Reciprocal effect
PT-9701 × PT-9719	7.56	5.67**	PT-9701 × MSP-9212	10.38	8.12**
PT-9701 × PT-30	13.30	4.94**	T-9 × PT-30	11.95	5.39**
MSP-9212 × PT-507	23.29	4.94**	T-9 × PT-9719	8.43	5.19**
PT-9700 × PT-9719	14.19	3.70**	T-9 × MSP-9212	15.49	5.14**
MSP-9212 × PT-30	16.55	3.68**	T-9 × PT-9701	8.79	4.17**

an aim to obtain transgressive segregates for commercial exploitation of heterosis as suggested by Gupta and Sharma (1999). An overall view of the results suggested that genetically diverse parents with good *per se* performance and general combining ability should be selected for breeding programmes aimed at improvement for yield and other characters in toria.

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Multivariate Analysis in Tropical Japonica "New Plant Type" Rice (*Oryza sativa* L.)

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Genetic diversity among fifty two "new plant type" lines including four improved cultivars was studied using Mahalanobis D^2 statistic under shallow lowland ecosystem. The genotypes were grouped into 10 clusters showing fair degree of relationship between geographic distribution and genetic divergence. Cluster I with 33 genotypes was the largest, while cluster III, IV, V, VII, VIII, IX, X were monogenotypic. Genotypes in cluster VI had highest intra-cluster divergence followed by cluster II and I while highest inter-cluster divergence was between cluster VI and IX followed by VII and X. Maturity duration contributed the maximum to the total divergence. Other traits with appreciable contribution to total divergence were spikelets per panicle, grain filling (%), panicle number/m^2, panicle length (cm) and harvest index (%). All the minimum and maximum cluster mean values were distributed in relatively distant clusters. The member of the clusters VII, X, VI and I may be further evaluated as these clusters were observed to possess high cluster mean for grain yield. Further, it is suggested that cross combination of IR73964-120-5-3-2 x IR72164-110-1-2, IR73964-120-5-3-2 x IR72967-12-2-3, Naveen x IR71701-28-1-4-3, IR75268-45-2-5-3 x IR71676-106-10-3, Naveen x IR72967-12-2-3, IR73964-120-5-3-2 x IR71701-28-1-1 showing high D^2 matrix value are expected to produce superior progenies.

Key Words: Genetic diversity, New plant type, Rice, Yield component

Introduction

A quantitative assessment of genetic diversity present among selected genotypes serves as a valuable tool to exploit the genetic variability for the rapid progress in breeding programmes. The more diverse the plants, the greater chances of obtaining heterotic F_1's and broad spectrum of variability in the segregating generations (Chen *et al.*, 2002). Therefore, parental diversity plays a vital role in the success of any hybridization programme. In the present study, genetic diversity among tropical *Japonica* "New Plant Type" (NPT) lines was investigated using this technique for further choice of donors in the hybridization programme.

Materials and Methods

The experimental material comprised of 48 NPT lines and 4 check varieties (IR64, PR106, Lalat and Neveen). These lines were received from International Rice Research Institute (IRRI), Los Baños, the Philippines and evaluated at Central Rice Research Institute, Cuttack, Orissa, India. The experiment was laid out in a complete randomized block design with three replications during wet season 2005 and 2006. Twenty one days old seedlings were transplanted in field. Each plot had five rows of two meter length with an inter and intra-row spacing of 20 cm x 15 cm, respectively. The normal cultural practices (120 N: 60 P: 40 K kg/ha) and need based crop protection practices were followed to raise healthy crop. The observations on total biomass production (t/ha), harvest index (%), number of panicle/m^2, spikelet number per panicles, panicle length (cm), grain filling (%), 1000-grain weight (g), and grain yield (t/ha) were recorded on ten randomly selected plants. The mean values were subjected to analysis of variance and then to multivariate analysis using Mahalanobis D^2 analysis to measure genetic distance as suggested by Rao (1952). The genotypes were grouped into clusters following Tocher's method. The criterion used in clustering was that any two genotypes belonging to the same cluster at least on an average, show a smaller intra-cluster distance than the inter-cluster distance. The relative contributions of different characters towards genetic divergence were also worked out as the percentage contribution in which the characters were ranked first using Tocher's method.

Results and Discussion

The analysis of variance revealed highly significant differences among the genotypes for all the characters. The results indicated high variances for most of the characters under study.

The forty-eight NPT lines including checks were grouped into ten clusters (Table 1). Cluster I was the largest comprising of 33 genotypes followed by Cluster II having seven genotypes. Five genotypes were clubbed in Cluster VI and Cluster III, IV, V, VII, VIII, IX and X had one genotype each. All the genotypes each belonging

Table 1. Clustering pattern of 52 genotypes on basis of D^2 values

Cluster No.	No. of Genotypes	Genotypes
I.	33	IR72158-116-6, IR73707-45-3-2-3, IR75279-43-2-1-3, IR73896-51-2-1-3, IR77186-34-2-3-3, IR73930-41-5-3-1, IR72158-10-2-1-3, IR71780-1-1-3-2, IR72969-143-5-3-6-2, IR739333-8-2-2-3, IR72158-16-3-3, IR72967-94-3-1-1, IR75268-45-2-5-3, IR73944-143-3-2-3-2, IR72158-11-5-2-3, IR75279-43-2-1-3, IR72967-12-2-3, IR73971-87-1-1-1-1, IR73931-40-1-2-3-2, IR71701-28-1-4, IR74714-141-3-3-2-3, IR72158-62-6-3, IR73439-11-1-3-1, IR71676-106-10-3, IR73898-71-2-6-3, IR72176-140-1-2-2-3, IR72158-16-3-3-1, IR73895-33-1-3-2, IR74295-2-2-2-3, IR72985-65-3-1, IR71676-90-2-2, IR72981-92-1-1-2-2, IR71693-111-6-2-2
II.	7	PR106, IR 64, IR73930-313-2-2, IR72176-307-4-2-2-3, IR73963-86-1-5-2-2, IR71698-193-3-2, IR77186-122-2-2-3
III.	1	IR72164-348-6-2-2-2
IV.	1	IR72196-143-5-3-6-2
V.	1	IR74963-262-5-1-3-3
VI.	5	IR72164-110-1-2, IR73973-27-1-1-1-2, IR72967-12-2-3, IR72164-352-2-5-5, IR71701-28-1-4-3
VII.	1	IR73907-75-3-2-3
VIII.	1	IR75282-58-1-2-3
IX.	1	Neveen
X.	1	Lalat

to this cluster were developed at IRRI, the Philippines. D^2 values of the cluster ranged from 0.00 to 68.72 indicting that the material was quite diverse. Sister lines selected from the same cross were found to be grouped in different clusters. The average intra-cluster distance ranged from 0.0 (cluster III, IV, V, VII to X) to 10.18 (cluster VI). Cluster III, IV, V, VII to X were having minimum or no-cluster distance as these were monogenotypic clusters and possessing negligible genetic diversity among the genotypes for each character. Maximum intra-cluster distance was observed in cluster VI (10.18) followed by cluster II (8.82). Therefore, care should be taken to select the member of these two clusters as these may give superior progenies in combination with other members of the cluster. Genotypes in cluster VI and IX had the maximum inter-cluster divergence (D^2=68.72), while the closest proximity was observed between clusters I and V (Table 2). Taking multivariate analysis into account and the D^2 matrix value of the pairs of the genotypes, combinations, like IR73946-120-5-3-2 x IR72164-110-1-2, IR73964-120-5-3-2 x IR72967-12-2-3, IR75282-58-1-2-3 x IR71701-28-1-4-3, IR75268-45-2-5-3 x IR71676-106-10-3, IR75282-58-1-2-3 x IR72967-12-2-3 and IR73964-120-5-3-2 x IR71701-28-1-4 were predicted to give good spectrum of variability in F_2 generation. The results suggested a possibility for obtaining greater variation in the segregating generations derived from hybridization between genotypes of cluster VI and IX, VIII and X and IX and X (Table 3). The relative contributions of different characters towards total divergence (D^2) indicated that maturity duration had the maximum contribution (45.25%) and this together with panicle number (10.41%), panicle length (5.88%), spikelet/panicle (19.83%), grain filling (12.97%) and harvest index (3.93%) accounted for 95 % of total divergence. Similar findings were also reported by Shukla *et al*. (2006) and Ahmad and Baroh (1999). The present study suggested that spiklets per panicle, grain filling (%), panicle number/m^2, panicle length (cm) and harvest index (%) deserved consideration besides maturity duration while choosing parents.

Table 2. Average intra (diagonal) and inter-cluster D^2 values and distances (in parentheses) for ten clusters of fifty two genotypes of *Oryza sativa* (L.)

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X
I	6.81	19.98	12.04	11.42	1.76	18.67	12.39	12.61	36.60	27.24
II		**8.82**	17.72	16.32	16.32	30.25	20.25	18.23	23.72	25.20
III			0.00	23.72	26.21	36.97	9.24	10.96	17.56	38.94
IV				0.0	3.00	6.0	21.25	39.56	49.84	12.82
V					0.00	8.94	24.90	35.28	54.76	18.40
VI						1018	28.62	57.15	68.72	18.66
VII							0.00	26.21	21.16	23.72
VIII								0.00	16.40	58.52
IX									0.00	57.84
X										0.00

Table 3. Cluster mean values for nine agro-morphologic characters

Characters	Duration (No.)	Panicle number per plant	Panicle length (cm)	Spiklets per panicle (No.)	Grain filling (%)	1000-grain weight (No.)	Total biomass production (g)	Harvest index (%) (t/ha)	Grain yield (t/ha)
I	129.45	395.77	24.39	97.20	74.74	23.75	14.42	42.64	6.17
I	121.95	358.10	22.10	74.20	70.55	23.76	12.74	41.71	5.13
III	135.00	367.00	25.33	84.17	70.33	22.57	11.90	48.67	5.77
IV	117.67	379.33	24.33	92.73	70.90	23.97	12.40	43.13	5.36\
V	118.83	396.00	20.67	93.33	70.80	22.47	14.53	41.83	5.89
VI	117.40	397.20	24.40	100.94	71.83	24.06	14.73	42.38	6.28
VII	133.00	355.67	21.67	94.30	79.60	22.63	15.93	44.20	6.73
VIII	136.00	369.33	23.97	98.77	84.97	23.07	12.27	39.80	4.89
IX	135.67	346.33	27.67	82.40	83.70	23.43	13.77	41.47	5.00
X	115.33	375.00	20.00	100.53	81.87	25.37	16.93	41.00	6.61

The cluster means for different traits varied considerably. Breeding lines of duration (115-118 days) were grouped in cluster IV, V, VI and X. Cluster X and VIII had the genotypes with proper grain filling. Long panicle length was observed in the members of cluster IX. All the cluster possessed high number of panicles/m^2. Maturity of the clusters possessed good number of spikelets per panicle. High biomass was observed in cluster X and VII, while high harvest index was observed in cluster II, High grain yield was observed from cluster VII, X, VI and I.

Considering the importance of genetic distance, relative contributions of characters towards total divergence and yield potential of genotypes, the present investigation suggested that hybridization between cluster IX (for panicle length and grain filling), cluster VI (for 1000-grain weight, panicle number per plant and spikelets per panicle), cluster VII (for harvest index and total biomass production) would produce heterotic F_1 combinations. Total duration, spikelets per panicle, total panicle number grain filling and panicle length were major contributors to the genetic divergence among the genotypes. These traits can be utilized as parameters in selecting genetically diverse parents. Further, the members of the cluster VII, X, VI and I showed high grain yield and may be evaluated for grain yield and desirable traits for identification of the superior genotypes.

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Preliminary Observations on Fruit Ripening, Predation and Seed Dispersal in the Wild *Momordica* Species

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The present paper presents observations on fruit ripening and dispersal, predation and seed dispersal in the wild *Momordica* species. Fruit morphology of the genus *Momordica* L. is highly adapted for bird dispersal. Association of specific species of birds in seed dispersal and ant predation in seed germination was observed. An understanding of the biotic agents involved in the perpetuation of biological processes is a prerequisite for devising a holistic conservation strategy for the wild *Momordica* genepool.

Key Words: *Momordica*, Phenology, Fruit ripening, Seed predation and Dispersal

Introduction

The genus *Momordica* L. (Family Cucurbitaceae) assumes significance for conservation of genetic diversity in India by virtue of being the wild relative of cultivated bitter gourd, besides their direct utility as nutritious vegetables and multipurpose medicinal plants. Six species occur in India and among them, *M. dioica* Roxb. and *Momordica charantia* var. *muricata* (Willd.) Chakrav. have wider distribution scattered over the entire geographical territory (Joseph, 2005; Joseph *et al*., 2006; Joseph and Antony, 2007). *M. Sahyadrica* Joseph & Antony is endemic to the Western Ghats (Joseph and Antony, 2007) and *M. balsamina* L. is restricted to the arid belt of Rajasthan and Gujarat (Joseph, 2005). *M. cochinchinensis* (Lour.) Spreng., commonly known as 'sweet gourd', occurs in a wild state in Andaman Islands and North-eastern states (Bharathi *et al.*, 2006). *M. subangulata* ssp. *renigera* deWilde (Teasle gourd), a native of northeast India, is now cultivated in the whole North East, West Bengal and Andaman Islands (Joseph *et al*., 2006). *M. charantia* and *M. balsamina* are monoecious annuals whereas the rest of the species dealt here are dioecious perennials with tuberous roots. All are essentially seed propagated though vegetative propagation through adventitious tubers is observed in *M. subangulata* ssp. *renigera*.

However, a perusal of its status in *ex situ* holdings and genebanks indicate its poor representation and neglect in the existing biodiversity conservation programmes. For devising a sound conservation strategy for the wild genepool of *Momordica*, taking into account its present conservation status and perceived threat of genetic erosion, it is mandatory to have a good understanding of the phenology and reproductive biology of the genus.

Phenology involves different stages in the lifecycle of the plant/species such as sprouting of dormant tubers and seed germination, flowering, fruit ripening and senescence. Fruit ripening is a genetically determined and regulated event that prepares the fruit or seed for dispersal. However, the control mechanism in ripening varies because of the species diversity and variation in morphology of the fruit (Brady, 1987). Ripening is regarded primarily as a manifestation of senescence of the fruit in which intercellular organization begins to break down (Sucher, 1973). The work on ripening of fruits has been restricted to horticultural crops especially to temperate pome and stone fruits, and citrus, avocado and mango to some extent (Hulme, 1971). The most readily apparent phenomena in the ripening process are colour changes which involve chlorophyll loss resulting in subsequent synthesis of new pigments, alterations in flavour, changes in acidity, astringency, sweetness and softness of the fleshy tissues (Rhodes, 1970).

Materials and Methods

In the germplasm characterization plot, ten plants each of *M. charantia* var. *muricata*, *M. balsamina*, *M. subangulata* spp. *renigera*, *M. sahyadrica* and *M. dioica* were observed regularly during the *Kharif* season during 2002, 2003 and 2004. Fruits of all the five taxa were observed from female flower opening to bursting of orange ripe fruits through colour breaker, mature ripe and red ripe stages. Ten fruits in each species were tagged the day after pollination, days taken to reach bursting of fruits were calculated and major morphological stages associated with ripeness recorded. As stage of harvest for vegetable is also important, the time up to which the seeds remain tender and soft, while attaining maximum

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size and weight was determined in another set of ten fruits in each species by passing a sharp knife through the fruit from 10th to 18th day of fruit development.

In the germplasm characterization plots, observations were recorded on fruit presentation, seed predation and dispersal. Bird activity in and around *Momordica* vines were observed at close quarters from a hidden place. Vernacular names of common birds were used to record the bird visits and then their zoological identity was later confirmed with the ornithologists of Kerala Forest Research Institute, Peechi, Kerala. Polythene sheets were spread below the bearing vines and fallen seeds (de-pulped) if any were counted. Similarly, seed predation was calculated by placing 100 seeds each with both washed and red fleshy aril intact on a newspaper sheet and observing their predation by various species of ants.

Results and Discussion

Ripeness in fruits is determined using several methods and these methods vary depending upon the fruit type and specific requirement. The visual assessment of appearance is the simplest method. The changes in colour from green to yellow or orange is effective in many crops. Fruit ripening and loosening from the plant are considered as indicators of maturity in a variety of fruits (Jackson, 1986). There are several approaches to quantify the ripening process. The number of days required to reach fruit maturity from full bloom is a reliable indicator (Jackson, 1986).

M. balsamina has the shortest and *M. subangulata* ssp. *renigera* has the longest ripening span (Table 1). Build up of red tinge in spine tips do not indicate seed coat hardening in *M. subangulata* ssp. *renigera*, whereas, full size and turgid appearance are a reliable indicator of fruit maturity. Physiologically mature fruits soften within 24-48 hours from harvesting in *M. sahyadrica* and *M. dioica*, whereas, *M. subangulata* ssp. *renigera* fruits remain green and fresh for longer periods. Thus, *M. subangulata* ssp. *renigera* has better keeping quality and shelf life than others.

Mature fruits in all species attain full size, become bright in colour (green or whitish green or off white), fruit surface is turgid, with bumps and tubercle bases spread out. When the fruits begin to ripen, the exterior colour changes to orange yellow and the pulp (seed aril and placenta) becomes gelatinous and scarlet red. Coinciding with colour changes, the fruit pulp loses bitterness and becomes sweet. Fruits start developing yellow colour and then change to orange colour gradually and uniformly in *M. subangulata* ssp. *renigera* whereas in all other taxa, fruits change colour suddenly and is localized and spreads within a day or two. Thus, in *M. subangulata* ssp. *renigera*, redness cannot be taken as indicator of ripeness. The fruits remain intact until bursting open in to three or more pieces from base, usually in a star like configuration. Ripe fruits do not abscise, as the pendant fruit stalks remain strong and split fruit wall dry up and shrivel or wither and crumble due to rain and sun.

Species of frugivorous birds and ants feeding on seeds are given in Table 2. *Megalima lineata* (barbet) is often a pest of coffee estates, feeding on coffee berries. It is interesting to note that highest population of *M. sahyadrica* is found in coffee estates, hence adding credence to bird dispersal. Although crows, koyal, crow-phesant ('uppan') and sparrows were found as infrequent visitors, seed feeding was not observed. Even though, seeds per fruit varied from 15.0 to 30.0 (up to 50.0 in *M. sahyadrica*), no depulped seed was found on the floor (the fleshy fruit wall is not eaten by any of these birds), giving credence to the inference that while feeding on the fleshy aril, the seeds are gulped. All the *Momordica* species have very thick seed coat, enabling their passage through bird gut undamaged, but slightly reduced in size as it is partially digested. Strong pendulous fruit stalks, attractive orange red colour, fruits splitting open from base and rolling back and expanding in a star like configuration exhibiting rows of scarlet red aril (covered seeds), and small round or flat dented seeds are adaptations for bird dispersal. Ethnobotanical interviews

Table 1. Observations on various stages of fruit maturity

Species	No. of days to full fruit size	No. of days to colour breaker	No. of days to red stage	No. of days to bursting stage	No. of days to seeds remain tender
M. charantia var. *muricata*	12	25	26-27	29-30	8
M. balsamina	9	22	24	25	8
M. dioica	15	28	29	30-31	12
M. sahyadrica	15	30	31	32-33	12
M. subangulata ssp. *renigera*	18	20	35	38	15

Table 2. Seed dispersal and predation in various *Momordica* species

Species	Biotic agent	Zoological name	Common/vernacular name	Activity
M. charantia	Ant	*Myrmicaria* Saeeuders sp.	Koonan	Feeding on red sweet aril
var. muricata	(Family	*Odontomachus* Latrelli sp..	Katturumbu	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu*	it in ant hives
	Bird	*Rufus treepie*	South Indian Tree Pie	Feeding fleshy aril, gulping
		Megalima viridis	Small green barbet	seeds
		Pycnonotus sp.	Red whiskered bulbul	
M. dioica	Ant	*Odontomachus* Latrelli sp.	Katturumbu	Feeding on red sweet aril
	(Family	*Myrmicaria* Saeeuders sp.	Koonan	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
		Solenopsis Westw. sp.	Neyyurumbu*	
	Bird	*Pycnonotus* sp.	Red whiskered Bulbul Barbet	Feeding fleshy aril, gulping
		Megalima viridis		seeds
M. sahyadrica	Ant	*Odontomachus Latrelli* sp.	Katturumbu	Feeding on red sweet aril
	(Family	*Myrmicaria* Saeeuders sp.	Kooonam	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
		Crematogaster Leud sp.	Small black ants	
	Bird	*Megalima viridis*	Small green barbet	Feeding fleshy aril, gulping
		Rufus treepie	Tree Pie	seeds
		Pycnonotus sp.	Bulbul	
M. *subangulata*	Ant	*Odontomachus Latrelli* sp.	Katturumbu	Feeding on red sweet aril
ssp.	(Family	*Myrmicaria* Saueeders sp.	Koonan	Carrying dry seeds and storing
renigera	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
	Bird	*Megalima lineata*	Lineated barbet	Feeding fleshy aril, gulping
		Rufus treepie	Tree Pie	seeds
		Pycnonotus sp.	Bulbul	

*observed to feed only on aril

with the tribal inhabitants and spotting of *M. dioica* seedlings rooted in crevices of stonewalls add further credence to the involvement of birds in seed dispersal (Joseph, 2005).

Ripe fruits of all species were found densely covered with ants and they were predating on red fleshy sweet aril. Many species of ants were found carrying dry seeds of *M. dioica*, *M. sahyadrica* and *M. subangulata* ssp. *renigera* and were recovered from their hives. Besides, carrying to small distance, ant feeding may help to scarify the seeds by releasing formic acid. *M. dioica* seeds are reported to contain up to 39 percent oil (Dubey and Gaur, 1990). The ant genera falling under Formicidae family in general has been reported as primary seed dispersing ants and Crematogaster species has been found as an important dispersal agent in tropical forests (Beattie, 1985).

The unit of dispersal (diaspore) is seed in the case of *Momordica*. A two-pronged strategy for dispersal is evident; colourful arils as food reward for birds and oiliferous seeds for dispersal by ants. The fleshy aril (sarcotesta) is of placental origin and it turns to scarlet crimson colour on ripening. The sweet and slimy aril attracts a host of birds, snails and ants. Seed coat is hard enough and passes unharmed through the guts and bird dispersal is the rule in the genera. The fallen seeds on the floor are carried to a small distance (even up to 8 m) by ants.

The place of production of seeds does not have the carrying capacity to grow and sustain all of them. An unhealthy competition is avoided by dispersing seeds even at the danger of some casualities. Dependence on animals for seed transport means that the plants are susceptible to dispersal failure when their seed vectors become rare or extinct. Disruption of this mutualism can have serious consequences for the maintenance of plant/species populations. This again highlights the need for devising a holistic approach to conservation of *Momordica* genepool involving the biotic agents as well.

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Towards Improving the Genetic Base of Rapeseed-Mustard Through an Indo-UK Research Collaboration

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A wide range of oilseed *Brassica* accessions, including breeding lines developed at Rothamsted Research (UK) with a wide differential resistant profile to *Hyaloperonospora parasitica*–formally *Peronospora parasitica*, were introduced to India during Phase-I (1991-1998) of an Indo-UK research collaboration. These included 54 accessions of *Brassica napus*, 52 of *B. juncea* and 23 of *B. rapa*. All accessions were put to intensive field trials at GB Pant University of Agriculture and Technology (Pantnagar) and other sites for adaptation, evaluation and further selection. Two of the *B. napus* accessions, EC338986-2 and EC338996-1, maintained high resistance to downy mildew and white rust as well as tolerance to *Alternaria* blight and *Sclerotinia* stem rot; a third accession, EC339000, stood out as relatively early maturing with yield exceeded the national check GSL-1, particularly in the hilly regions like Kangra (Himanchal Pradesh) and R.S. Pura (Jammu and Kashmir). Four of the *B. juncea*, accessions, EC399296, EC399299, EC399301 and EC399313 expressed some tolerance to *Alternaria* blight disease with no visible symptoms of infection with downy mildew, white rust and *Sclerotinia*; two more accessions, EC414308 (NRCR-837) and EC414319 (NRCR-836) were found to be tolerant to downy mildew, white rust, and *Sclerotinia* stem rot when evaluated in initial variety trials (IVT). EC414308 was promoted to advanced variety trials–1 (AVT-1). Research strategies to fully realize the potential contribution of genetic enhancement to sustainable production of rapeseed-mustard has also been suggested and discussed.

Key Words : Rapeseed-mustard, Disease resistance, Germplasm introduction, Genetic enhancement, International cooperation

Introduction

Increasing production of edible oil in India continues to be a high priority where import has touched 4.42 million tonnes which is *ca.* 50% of the national consumption valued at *ca.* US$2.74 billion (SEA, 2007). This makes India the world's largest importer of vegetable oils. Diet surveys by the National Nutrition Monitoring Bureau in 10 States of India show that daily visible fat intake varies from 1-7 kg/person/year in rural India (Singh, 2000), which is far below the minimum nutritional norm of about 14 kg/person/year, prescribed by the Indian Council of Medical Research (Rai, 1987). Moreover, the consumption of edible oil is highly price elastic; a fall in price will increase the demand immensely (Shukla *et al.*, 2000).

In spite of India occupying a premier position in the world oilseeds production, its productivity is very low. Average production is around 0.9 tonne per hectare and in the case of small holder farms the yield can be lower than 0.4 tonne per hectare. This is far below that of developed countries (2.5-3.0 tonnes per hectare) and even the world average (1.5 tonnes per hectare) (Anon, 2007a). Low productivity is mainly due to disease and pests, vulnerability to drought coupled with poor dry farming practices, less inputs and poor soils.

The major annual oilseed crops in India are rapeseed-mustard, soybean, groundnut, sunflower, sesame, safflower, cottonseed, niger, linseed and castor seed; the last two are non-edible industrial oilseeds. During 2005-06, rapeseed-mustard, soybean and groundnut accounted for 29.2%, 29.5% and 28.5% of national outputs (Anon, 2007b), respectively. However, rapeseed-mustard contributed to 65% of the total *rabi* oilseed output (Bajoria, 2000).

The group rapeseed-mustard (*Brassica napus*, *B. juncea* and *B. rapa*), which is the least water requiring (80-240 mm) among other *rabi* crops, covers nearly 7 million hectares (harvested area) and produces *ca.* 6.3 million tonnes of seed per year with a local market value of US$2.72 billion. These crops are among the most widespread in small farm systems throughout India and are some of the most commonly grown across a wide range of agro-ecological environments. In addition to the use of seeds to produce vegetable oil (seed oil content is *ca.* 40%) and the residual cake as a high value animal foodstuff, these crops have a wide range of other important local rural livelihood uses. The leaves are consumed as a vegetable for human and animal fodder and the seeds as condiments. The oil is also used for

massaging and hairdressing. The dried foliage and stalks left in the field after harvesting are used as domestic fuel.

The four main diseases of rapeseed-mustard (downy mildew, white rust, *Alternaria* blight and *Sclerotinia* stem rot) are causing yield losses of 20%-70% (Kolte, 1985). Powdery mildew disease (*Erysiphe cruciferarum*) may also cause significant yield loss, particularly in rain-fed areas. This is in addition to drought losses, which are reported to range from 17%-57% (Ali *et al*., 1990) and 66%-94% (Sharma and Kumar, 1989) in *B. juncea*.

The ability to control rapeseed-mustard diseases and minimize the effects of drought would have a significant economic impact. Considerable effort has gone into developing chemical and non-chemical disease control strategies, but chemicals may not be readily available at affordable prices by resource poor farmers. Chemical control also increases the production costs and is becoming a controversial issue because of environment and food safety concerns.

The Indo-UK Research Collaboration on Rapeseed-Mustard, Phase-I (1991 to 1998) between Rothamsted Research (UK) and GB Pant University of Agriculture and Technology (GBPUAT)-Pantnagar focused mainly on resistance to downy mildew. Phase-II (ongoing from December 1998), which was formulated with expanded mandate, is being implemented by Rothamsted Research (UK) in collaboration with three Indian institutions and three DFID supported rain-fed farming and watershed projects - under the umbrella of the Indian Council of Agricultural Research:

- National Research Center on Rapeseed-Mustard, Bharatpur (Rajasthan)
- GBPUAT- Pantnagar (Uttarakhand)
- The Energy and Resources Institute (TERI), New Delhi
- Gramin Vikas Trust (GVT)-Eastern India Rain-fed Farming Project (Jharkhand, West Bengal and Orissa)
- GVT-Western India Rain-fed Farming Project (Rajasthan, Gujarat and Madhya Pradesh)
- Karnataka Watershed Development Society (Karnataka)

Phase-II is an institutional-cum-farmers' participatory research and rural livelihood development project involving innovative approaches in interdisciplinary research, new partnerships and community based decision-making processes. The project's main objectives are to produce drought and disease resistant varieties as well as to develop oilseeds crops focusing on rapeseed-mustard throughout 15 districts across seven states in India (Gujarat, Rajasthan, Madhya Pradesh, Jharkhand, West Bengal, Orissa and Karnataka (Nashaat *et al*., 2007).

Genetic enhancement involves either adding new genes to an existing gene pool, which may be narrow, or creating variability using the existing genetic base through various methods including induced mutation and/or crossing to create segregating materials from which desirable genotypes can be selected.

Breeding for sustainability is largely a process of fitting cultivars into an environment rather than altering the environment by adding inputs such as fertilizers and pesticides. Thus, most of the genetic enhancement objectives pertaining to sustainable agriculture emphasize on tolerance to biotic stresses (diseases and other pests) and abiotic stresses such as drought.

This paper highlights some of the activities associated with germplasm of rapeseed-mustard introduced to India during the first phase of the Indo-UK Collaboration on rapeseed-mustard. The paper also discusses the durability of disease resistance, sensitivity to fungicides and merits of genetic enhancement. Research strategies for strengthening national programs, enhancing disease resistance, nutrient and water use efficiency as well as yield potential have also been discussed.

Germplasm Collection and Introduction

A world-wide collection of germplasm, sufficiently diverse and preferably characterized for specific beneficial traits, is usually the starting point for any genetic enhancement programme. This is followed by the identification and generation of novel variation in key traits. It is in this context that a wide range of oilseed *Brassica* accessions were provided by Rothamsted Research to GBPUAT during phase-I of the project. Most of these accessions were selected for differential resistance to Indian and UK isolates of *Hyaloperonospora parasitica* (formerly *Peronospora parasitica*) (downy mildew) or bred for resistance to a wide range of these isolates under controlled conditions (Nashaat and Rawlinson, 1994; Nashaat and Awasthi, 1995; Nashaat *et al.*, 1997, 1998). They included 54 accessions of *B. napus*, 52 of *B. juncea* and 23 of *B. rapa* which were incorporated in successive field trials at GBPUAT-Pantnagar and other sites to: (i) assess their response under field conditions to natural infection with downy mildew, white rust, *Alternaria* blight

and *Sclerotinia* stem rot diseases; (ii) make selections for superior agronomic traits; (iii) regenerate seed from these accessions for further use.

Gobhi Sarson (Brassica napus)

The *B. napus* field trials were initiated during the *rabi* (spring) seasons 1992-93 with 54 accessions provided by Rothamsted Research. These accessions were mostly classified into six differential host response groups to 4 UK isolates of *H. parasitica* derived from the same host species (Nashaat and Rawlinson, 1994; Nashaat *et al.*, 1997). Out of these, 53 were successfully germinated and 9 did not flower. Initial selections for superior agronomic and disease resistance/tolerance traits were made mainly from 12 accessions with the highest seed yields. Following successive selections and selfing for four generations, two lines (EC338986-2 and EC338996-1) with high field resistance to downy mildew and white rust coupled with tolerance to *Alternaria* blight and *Sclerotinia* stem rot were selected from EC338986 (RESBN-15) and EC338996 (RESBN-25), respectively. Both lines maintained high resistance/tolerance to the above diseases when assessed under All India Coordinated Research Project on Rapeseed-Mustard (AICRP-R&M) multi-location trials and were subsequently recommended as sources of resistance/tolerance to these diseases. However, their yield did not exceed the required increase (>10%) over the national check GSL-1 and therefore were not incorporated in the Plant Breeding Trials under AICRP-R&M. A third line, EC339000 (selected from Optima L), stood out as relatively early maturing with high yield, particularly in hilly regions such as Kangra (Himachal Pradesh) and RS Pura (Jammu and Kashmir), where its yield exceeded the national check (GSL-1) by more than 5%. This line was later included in All India Coordinated Plant Breeding Initial Varietal Trial (PB-IVT) and was subsequently promoted to Plant Breeding Advance Varietal Trial 1 (PB-AVT-1) for the year 2003-04 (Table 1). The initial inclusion of this accession in the PB-IVTs was through the National Research Center on Rapeseed-Mustard- Bharatpur (code named NCRM-1).

Indian Mustard (Brassica juncea)

B. juncea field trials included 31 accessions received from Rothamsted Research in 1996, followed by 21 accessions in 1998. These accessions or their derivatives were classified into 17 groups (A to Q) according to their differential responses under controlled conditions to 14 isolates of *H. parasitica*, nine from *B. juncea* and three from *B. rapa* in India in addition to two from *B. napus* in the UK. All the above 21 accessions belonged to group "Q", which tested resistant against 12 of the above isolates (Nashaat *et al.*, 1998, 2004). Field trials with the above 31 accessions were initiated at Pantnagar during 1996-97 *rabi* crop season-only 17 accessions flowered and produced seeds. Four of these accessions [EC399296 (RESJ-140), EC399299 (RESJ-294), EC399301 (RESJ-177) and EC399313 (RESJ-295)] showed very little or no symptoms of infection with downy mildew, white rust and *Sclerotinia* and clear signs of tolerance to *Alternaria* blight diseases (Table 2). The resistance/tolerance of the above four accessions to downy mildew, white rust and *Alternaria* blight was confirmed by artificial inoculation with field isolates collected from the experimental field station at Pantnagar and later on under multi-locations Uniform Disease Nursery Trials of AICRP-R&M during

Table 1. Performance of *B.napus* accessions in Plant Breeding Initial Varietal Trial in zone I and Zone II under All India Coordinated Research Project on Rapeseed-Mustard during 2002-03*

Accession	Zone I yield (kg ha^{-1})			Zone II yield (kg ha^{-1})					
	Kangra (1)	Dhaula Kuan (2)	Mean	Bhatinda (3)	Ludhiana (4)	Hisar (5)	RS Pura (6)	Mean	Overall mean (1) to (6)
TKG-20	548	939	743	652	1022	804	874	838	806
HNS-0001	1171	1286	1229	1138	1309	764	913	1031	1096
RK (N) 02-8	368	365	366	853	1037	638	784	828	674
RK (N) 02-07	474	1007	741	1111	1002	729	841	921	860
ACN 130 (00)	1771	973	1372	1197	1269	693	842	1000	1124
GSL-1 (NC)	1200	1024	1112	696	874	709	856	626	893
Kranti (NC)	1112	816	964	1286	1432	733	764	1054	1023
Varuna (NC)	1063	661	862	865	1309	670	838	628	901
RSPN-26	1210	833	1022	1102	1077	713	1219	1027	1025
NRCN-1 (EC339000)	1829	516	1173	–	1210	583	1254	1016	1078
HNS-007	1166	996	1081	–	1235	725	1108	1022	1046
$LSD_{(P=0.05, df=32)}$	118	180	–	138	213	94	85	–	–

*Source: Annual Report, AICRP-R&M 2002-2003

2002-03. Unfortunately, all four accessions appeared to be susceptible when they were tested in isolation at Rothamsted Research against Indian isolates of white rust collected from Karnataka and Jharkhand, though resistance was maintained against other isolates from Pantnagar, Delhi and Bharatpur. The resistant components of these accessions can be used as donors towards breeding multiple races resistance in rapeseed-mustard. Field trials on the other 21 accessions, which were initiated during 1998, showed that two of these accessions, EC414319 (RESBJ-836) and EC414308 (RESBJ-837), yielded significantly higher quantity of seeds (958-1977 kg/ha) than the local checks, Kranti and Varuna (814-1624 kg/ha) and were subsequently code named as NRCR-836 and NRCR-837 and included in the PB-IVTs/ PB-AVTs through the National Research Center on Rapeseed-Mustard (Bharatpur). Both lines also showed little or no symptoms of downy mildew, white rust and *Sclerotinia* stem rot, but were susceptible to *Alternaria* blight under field conditions.

Yellow Sarson (Brassica rapa)

B. rapa field trials included 23 accessions provided by Rothamsted Research representing six differential host response groups to 12 pathogen isolates of *H. parasitica*, seven from *B. juncea* and three from *B. rapa* in India in addition to two from *B. napus* in the UK. The yields of two accessions, EC414292 (RESBR-191) and EC414293 (RESBR-219), were on par with national checks under field conditions at GBPUAT-Pantnagar. Both lines, were later code named NRCYS-191 and NRCYS-219, respectively, and included through the National Research Center on Rapeseed-Mustard (Bharatpur) in the PB-IVT during 2003-04 under AICRP-R&M. Both entries were also included under AICRP-R&M in the multi-location Plant Pathological Screening Trials for reaction against downy mildew, white rust and *Alternaria* blight diseases. Furthermore, EC414293 (RESBR-219) was included in on-farm testing trials at Eastern India Rain-fed Farming Project (GVT-Ranchi) during the cropping season 2003-04.

Durability of Resistance and Sensitivity to Fungicides

The development of long-term sustainable solutions to recurring pest and disease problems lies not only in the development of genetically resistant varieties, but also in the careful use and management of such varieties through an effective Integrated Pest Management (IPM) strategy. In some cases, resistance may be short-lived due to the occurrence of new physiological races, strains or pathotypes. Controlling the disease with fungicides may become necessary at some stage while developing new resistant varieties. However, fungicides may not always be reliable as, for example, resistance to metalaxyl, which at first provided effective control against downy mildew, has been reported frequently (Vishunavat *et al.*, 1998). These considerations indicate the need for identifying or deploying genes/co-factors for specific/multiple races

Table 2. Response of *B. juncea* accessions against infection with downy mildew (DM), white rust (WR), *Alternaria* blight (AB) and *Sclerotinia* stem rot (SSR) diseases under epiphytotic conditions during 1997-98

Accessions		Disease Index on cotyledons (%)		Disease severity % on leaf		Staghead % (**)		AB Index %		SSR (%)	Yield/ plant	1000-seed
	RES No (*)	DM	WR	DM	WR	Incident	Severity	Leaf	Pod		(g)	weight (g)
EC399288	RESJ- 564	2.0	0.0	18.0	30.0	68.0	15.0	28.0	37.0	20.0	6.4	4.4
EC399293	RESJ- 577	1.0	9.0	19.0	27.0	8.0	13.0	46.0	41.0	14.0	5.7	3.8
EC399294	RESJ- 600	2.0	1.0	9.0	29.0	15.0	18.0	27.0	44.0	19.0	7.0	4.2
EC399296	RESJ- 140	0.0	0.0	8.0	10.0	2.0	2.0	34.0	20.0	0.0	2.0	1.8
EC399299	RESJ- 294	0.0	0.0	7.0	16.0	0.0	0.0	39.0	3.0	0.0	4.4	2.5
EC399300	RESJ- 224	0.0	0.0	12.0	23.0	33.0	18.0	41.0	40.0	15.0	5.5	3.7
EC399301	RESJ- 177	2.0	0.0	0.0	0.0	0.0	0.0	48.0	7.0	0.0	3.0	2.5
EC399302	RESJ- 132	85.0	2.0	15.0	17.0	1.0	1.0	37.0	43.0	3.0	2.4	2.4
EC399303	RESJ- 447	7.0	18.0	22.0	25.0	32.0	23.0	54.0	30.0	10.0	3.2	4.1
EC399307	RESJ- 446	17.0	3.0	26.0	55.0	8.0	16.0	44.0	26.0	6.0	3.2	3.6
EC399308	RESJ- 599	28.0	12.0	22.0	52.0	9.0	16.0	42.0	29.0	4.0	5.0	4.4
EC399312	RESJ- 563	9.0	2.0	22.0	51.0	5.0	20.0	35.0	32.0	1.0	5.2	4.4
EC399313	RESJ- 295	4.0	0.0	12.0	16.0	0.0	0.0	40.0	7.0	0.0	2.9	5.3
EC399315	RESJ- 450	15.0	3.0	12.0	36.0	7.0	20.0	29.0	20.0	5.0	2.6	3.6
EC399316	RESJ- 578	6.0	0.0	16.0	47.0	6.0	10.0	36.0	26.0	7.0	5.0	3.8
EC399317	RESJ- 233	20.0	10.0	25.0	61.0	42.0	15.0	23.0	40.0	16.0	7.0	5.5
EC399318	RESJ- 222	20.0	6.0	29.0	33.0	2.0	10.0	22.0	41.0	7.0	3.4	3.8
$LSD_{(P=0.05, DF=50)}$		2.8	1.4	3.5	5.4	4.6	3.7	5.1	4.5	1.9	0.5	0.4

(*) Rothamsted Research designation (**) Hypertrophied/deformed tissues, mainly the flowering parts, caused by white rust

resistance/tolerance into the genetic background of acceptable varieties, which has been one of the primary objectives of the Indo-UK collaboration on rapeseed-mustard (Nashaat *et al*., 2007). Such sources might usefully be deployed with fungicides to prolong the effectiveness of both control procedures.

Merits of Genetic Enhancement

(a) Improved rapeseed-mustard varieties that will not require the use of pesticide would contribute to improving the quality of environment and harvested crops

(b) Improved varieties that are more efficient in extracting nutrients from the soil and can utilize nutrients more efficiently would reduce fertilizers costs and improve ground water quality

(c) Varieties with high water use efficiency and tolerance to drought would reduce irrigation costs and stabilize yield

(d) Development of a wide range of cultivars with different maturity duration would allow the exploitation of rotation niches and the development of alternative cropping systems

(e) Sustainable rapeseed-mustard production would help meet the demand for vegetable oil and reduce imports.

Research Strategies

To fully realize the potential contribution of genetic enhancement to sustainable rapeseed-mustard production, the following points may need to be reinforced:

Strengthening National Programmes

National programs particularly AICRP-R&M in India have different priorities and levels of expertise. There are limited resources, and the interaction between research scientists, extension workers and farmers is often weak. To deal with these problems and improve rapeseed-mustard productivity in diverse cropping systems, strengthening the capacity of AICRP-R&M must continue by encouraging and enforcing the following strategies: (i) delivering genetic material to AICRP-R&M such as parents breeding lines, segregating populations or finished lines according to the need of the program; (ii) creating a closer links between AICRP-R&M and other research networks to facilitate solving problems of common concern and exchange research results; (iii) strengthening AICRP-R&M capacity to involve farmers in technology evaluation and setting of research priorities; (iv) stimulating AICRP-R&M to develop sustainable and productive crop management system.

Diseases

Considerable progress has been made on reducing losses due to diseases, but further effort is needed to: (i) identify or develop differential sources of resistance capable of discriminating and monitoring the evolvement of new pathogen races; (ii) generate genotypes with a broader genetic base for multiple disease resistance; (iii) develop integrated control strategies to complement genetic resistance while reducing pesticide application.

Nutrient and Water Use Efficiency

Adopting the following strategies may relieve nutrient and drought constraints as well as improve nutrient and water use efficiency: (i) Breeding genotypes with improved ability to absorb nutrients from soil; (ii) Generating rapeseed-mustard genotypes with improved adaptation to water stress; (iii) identifying mechanisms and develop more efficient screening methods for tolerance to drought.

Yield Potential

A gradual improvement of disease resistance would go hand in hand with increasing demands to enhance the yield potential of rapeseed-mustard. Little progress has been made in this area, especially on breeding short duration varieties with multiple disease resistance suitable for drought prone areas. Recent efforts to solve this problem have focused on: (i) greater emphasis on selection for yield in drought-prone areas; (ii) exploiting the genetic variation across gene pools as a means to optimize the utilization of genes conditioning yield; (iii) improving plant type for increased productivity; (iv) studying yield-maximizing physiological traits, such as crop growth rate and maturity, to determine which factor can be optimized for higher yield potential.

Conclusion

Increased productivity potential of rapeseed-mustard genotypes for low-input cropping systems is crucial to the development of safe and sustainable agricultural systems to meet the increasing demands of growing populations. Key factors to increase production are the evaluation of a wide range of genotypes under appropriate environmental conditions. Selection of improved lines should be based on a better understanding of the stability of the components of the desirable traits for which they were selected, such as disease resistance and drought tolerance. Genetic enhancement will continue to be an

exciting and important dimension for the improvement of cropping systems and will certainly contribute to future sustainability of crop production.

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Estimation of Genetic Variability and Heritability in Lettuce (*Lactuca sativa* L.)

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Twenty-five genotypes of lettuce were evaluated to study the variability and heritability parameters at Experimental Farm, Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology (K), Shalimar, Srinagar during 2006 and 2007. The analysis of variance showed significant differences for all the characters. Variability revealed that phenotypic coefficient of variation (PCV) in general were higher that the corresponding genotypic coefficient of variation (GCV) for all the characters. The high phenotypic as well as genotypic variance were observed for carotenoids only, while the characters like number of leaves per plant, leaf yield per plant, vitamin C, average leaf weight, calcium, plant spread and potassium exhibited moderate PCV as well as GCV. High estimates of heritability ranging from 69.90% to 94.10 % were recorded for most of the characters. However, days to first picking (45.60), duration of picking (50.20), leaf breadth (56.20) and plant height (58.70) exhibited low heritability. The characters like carotenoids (50.81%), leaf yield per plant (33.53), number of leaves per plant (32.25%), vitamin C (30.67), calcium (26.03), average leaf weight (23.24), duration of picking (22.67) and potassium (22.42) recorded maximum genetic gain as percent of mean. High heritability associated with high genetic advances was obtained in the case of number of leaves per plant, leaf yield per plant, vitamin C and carotenoids, which further suggested substantial additive gene effect governing these characters and phenotypic selection may be useful in improving these traits.

Key Words: Lettuce, Improvement, Variability, Heritability, Genetic advance

Lettuce is an important salad vegetable, well represented in temperate and sub-tropical growing regions of the world and thrives well in winter season. The leafy type lettuce is a rich sources of vitamin C, pro-vitamin A and minerals and popular for its daily use in diet particularly in USA and Europe. Its crisp and crunchy leaves are used in sandwiches or red leaves for beautiful colour in salads. Recently it is gaining popularity in India too, owing to its nutritional qualities.

The role of genetic variability in a crop is of paramount importance in selecting the best genotypes for making rapid improvement in yield and related characters as well as to select the most potential parents for making the hybridization programme successful. The success of breeding programme depends on the availability of genetic variability present in the available germplasm. The study of biological parameters is often considered to be a successful step in the study of genetic variability. Since most of the plant characters of economic importance are polygenic in nature and are highly influenced by environment, it is necessary to work out whether the observed variability is heritable or due to environment. This suggests the imperative need to work out the phenotypic variation into heritable and non heritable components. Genotypic and phenotypic coefficient of variability helps to access the divergence of the characters. Selection would be more meaningful for characters which exhibit high variability and heritability along with moderate to high genetic gain. Realizing the importance of the crop there is urgent need to isolate such breeding line having desirable horticultural traits, better quality coupled with high yield potential. Under such situation, an attempt was made in the present investigation to analyse variability of its components with hope that the result might be of practical use to the plant breeder to achieve desirable level of improvement in this crop.

The extent of genetic improvement that could be achieved is largely determined by nature and magnitude of variability present in a breeding material of a given crop. Greater the diversity in the material, better are the chances for evolving promising and desired types. Since the genetic facts are inferred from phenotypic observations arising as a result of interaction between genotype and environment, the information on variability parameters becomes essential for selection of genetically superior types. Hence, an attempt was made to assess the available genetic variability in lettuce by partitioning of over all variability into its heritable and non-heritable

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components as genetic parameters like genotypic coefficient of variation, heritability and expected genetic advance.

Materials and Methods

The experiment was carried out at Sher-e-Kashmir University of Agricultural Sciences & Technology (K), Shalimar, Srinagar during winter 2006 and summer 2007. Twenty-five genotypes of lettuce were utilized for the study. Each genotype was sown in 3 rows of 2.25 meters length spaced 45x45 cm apart between row-to-row and plant-to-plant, respectively. The recommended agronomic and plant protection practices were adapted for raising a healthy crop. The observation were recorded on five randomly selected plants in each replication for each genotype on 16 quantitative and qualitative traits viz. plant height (cm), plant spread (cm), number of leaves/plant, average leaf weight (g), leaf size (cm^2), leaf length, leaf breadth, days to first picking, duration of picking, leaf yield/plant(g), dry matter content, vitamin C, carotenoids, calcium, phosphorous and potassium (mg/100 g on fresh weight basis). The mean values obtained from two seasons were used for analysis. For estimation of leaf area, leaf area metre was utilised. The genotypic, phenotypic and environmental coefficient of variation was calculated as per the formula suggested by Burton and De Vane (1953) and Allard (1960). Heritability in broad sense and expected genetic advance were calculated as per the formula given by Allard (1960) and Johnson *et al*. (1955), respectively.

Results and Discussion

The analysis of variance revealed highly significant differences for all the characters studied which indicated that the genotypes differed significantly for all the character. Estimates of range, mean, PCV, GCV, environmental coefficient of variation (ECV), heritability in broad sense (h^2) and genetic advance as per cent of mean for various characters are presented in Table 1. High range of variability also been observed by Singh *et al.* (2007) in lettuce for vitamin C, dry matter content and yield per plant and Khan (2007) in kale for number of leaves, average leaf weight and carotinoids.

High estimates of PCV were observed for carotenoids (26.23) and duration of picking (21.93). The moderate values of PCV were observed for number per of leaves/ plant (17.67), leaf yield per plant (17.61), vitamin C (17.15), average leaf weight (14.47), calcium (14.08), days to first picking (12.05), plant spread (11.74) and potassium (11.97). The lowest value of PCV was obtained for only dry matter content (6.75). PCV is greater than GCV in all cases. Such finding was also observed by Meglic *et al*. (2000) in lettuce and Khan (2007) in Kale.

The GCV was high for only one characters i.e. carotenoids (25.44), while leaf yield per plant (16.93), number of leaves per plant (16.63) vitamin C (15.98), calcium (13.34), duration of picking (15.13), average leaf weight (12.76) and potassium (11.41) showed moderate GCV. The characters which exhibit lower GCV values were phosphorus (4.73), dry matter content (5.65), days

Table 1. Estimation of different genetic parameters for important characters in 25 lettuce genotypes

S.No.	Characters	Range	General Mean ± SE(m)	Coefficient of Variation (%)			Heritability (h^2 %) (broad sense)	Genetic Advance	Genetic Advance as % of Mean
				PCV	GCV	ECV			
1.	Plant height (cm)	13.59 – 20.09	17.17 ± 0.47	7.40	5.61	4.75	58.70	1.54	8.96
2.	Plant spread (cm)	20.80 – 37.73	35.45 ± 0.94	11.74	10.61	2.51	81.70	6.41	19.75
3.	No. of leaves/plant	23.30 – 49.26	37.92 ± 0.13	17.67	16.63	5.97	88.60	12.23	32.25
4.	Leaf weight (g)	6.80 – 11.54	8.99 ± 0.34	14.47	12.76	6.72	78.30	2.09	23.24
5.	Leaf area (cm^2)	143.38 – 247.85	204.47 ± 0.49	10.56	9.68	4.22	84.00	37.37	18.27
6.	Days to first picking	45.00 – 60.00	49.46 ± 0.25	12.05	8.14	8.88	45.60	5.60	11.32
7.	Duration of picking	16.65 – 30.00	26.20 ± 0.23	21.93	15.13	15.47	50.20	5.94	22.67
8.	Leaf yield/plant (g)	131.67 – 367.60	276.81 ± 0.77	17.61	16.93	4.84	92.40	92.83	33.53
9.	Leaf length (cm)	12.43 – 20.94	17.99 ± 0.63	11.17	9.33	6.13	69.90	2.89	16.06
10.	Leaf breadth (cm)	11.17 – 17.44	13.37 ± 0.67	13.26	9.94	8.77	56.20	2.05	15.33
11.	Dry matter content (%)	7.64 – 10.23	8.96 ± 0.19	6.75	5.65	3.68	70.10	0.87	9.70
12.	Vitamin C (mg/100 g)	22.73 – 46.18	35.40 ± 0.12	17.15	15.98	6.21	86.90	10.86	30.67
13.	Carotenoids (mg/100 g)	0.82 – 3.57	2.44 ± 0.89	26.23	25.44	6.34	94.10	1.24	50.81
14.	Calcium (mg/100 g)	66.10 – 123.81	94.44 ± 0.24	14.08	13.34	4.50	89.70	24.59	26.03
15.	Phosphorus (mg/100 g)	39.96 – 57.79	47.33 ± 0.12	6.59	4.73	4.59	51.40	3.30	6.97
16.	Potassium (mg/100 g)	151.24 – 256.13	204.19 ± 256.13	11.97	11.41	3.58	91.00	45.78	22.42

to first picking (8.14), leaf area (9.68) and plant height (5.61). Similar findings were reported by Ruthbenlah and Veeraragavatha (2003) for green yield in amaranth and Sharma *et al*. (2003) in cabbage.

Moderate to high PCV and GCV were observed for number of leaves per plant, average leaf weight, leaf yield per plant, vitamin C, calcium, potassium, duration of picking and caroteniods, indicating that selection of these traits may be comparatively less effective than those having high PCV and GCV. These results are similar to those reported by Tamin and Popova (1977), Thakur *et al*. (1997) and Ruthbenlah and Veeraragavatha (2003).

The environmental coefficient of variation ranged from 2.51% (plant spread) to 15.47 % (duration of picking). In general, estimates of ECV were lower than the corresponding estimates of GCV except days to first picking (8.88) and duration of picking (15.47), indicating that these characters were influenced by the environment. Heritability estimates are high for almost all the characters except days to first picking and duration of picking, which exhibited low heritability of 45.60 and 50.20 percent, respectively. These results were similar to those reported by Tamin and Popova (1977) and Meglic *et al*. (2000) in lettuce.

The highest value of genetic advance as percent of mean was obtained for carotenoids (50.81) followed by leaf yield per plant (33.53), number of leaves per plant (32.25) and vitamin C (30.67), while phosphorous (6.97) showed the lowest value. Johanson *et al*. (1955) suggested that heritability along with the genetic advance would be more useful and reliable than heritability alone. In this context high heritability associated with high genetic advances was obtained in the case of number of leaves per plant, leaf yield per plant, vitamin C and carotenoids, which further suggested substantial additive gene effect governing these characters and phenotypic selection may be useful in improving these traits. The high genetic advance along with high heritability estimates have also been reported by Varalakshmi and Reddy (1994) in amaranthus for number of leaves per plant, Rastogi *et al*. (1995) in Chinese cabbage, and Ruthbeulah and Veeraragvatha (2003) in amaranthus for leaf yield per plant, plant height and vitamin C.

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Quarantine Processing of Imported Transgenic Rice and Evaluation of Risk in Import

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The germplasm of transgenics with desirable traits is being imported into the country for various research programmes. The National Bureau of Plant Genetic Resources (NBPGR) is the nodal agency to issue the import permit, to undertake quarantine processing of germplasm including transgenics and also to ensure absence of embryogenesis deactivator gene. During 1997-2008, a total of 7,008 samples of transgenic rice with different traits from nine countries were processed at NBPGR for quarantine clearance. Of the total samples, 1,642 samples were found infested/ infected with various pests from different countries. These comprised 1,548 from Singapore, 65 from Belgium, 16 from Vietnam, 7 from USA, 4 from China and 2 from the Philippines. The pests intercepted were insects viz., *Cryptolestes ferrugineus, C. pusillus, Liposcelides* spp., *Rhizopertha dominica, Sitophilus oryzae, Sitotroga cerealella* and *Tribolium castaneum*; nematode *viz.*, *Aphelenchoides besseyi*; and pathogens viz., *Alternaria alternata, A, padwickii, Drechslera halodes, D. rostrata, Fusarium dimerium, F. moniliforme* and *Phoma glumarum.* All the infested and infected samples were salvaged using various techniques. Also the risk associated (literature-based) with the import of rice from source countries has been evaluated.

The samples were also tested to ensure the absence of *cre recombinase* gene (the gene sequence involved in one of the steps of terminator technology) using polymerase chain reaction with the designed primer pair and *cre* gene sequence was not detected in any of the tested samples.

Key Words: Quarantine, Transgenic rice, Pest interceptions, Embryogenesis deactivator gene

Introduction

Transgenics or genetically modified crops are under cultivation in different countries including India. The germplasm of transgenics with desirable traits is being imported into the country for various research programmes. Movement of planting material poses the risk of inadvertent introduction of exotic pests, which may prove more dangerous in the new environment. This necessitates the strict implementation of plant quarantine regulations for the introduction of planting material. In India, import of transgenic planting material is permitted only for research as per the Plant Quarantine (Regulation of Import into India) Order, 2003. The National Bureau of Plant Genetic Resources (NBPGR) is the nodal agency to issue the import permit, to undertake quarantine processing of germplasm and also to ensure absence of embryogenesis deactivator gene (Khetarpal and Pandey, 2002). A number of pests have been intercepted in the introduced germplasm of transgenic and non-transgenic crops in the country (Khetarpal *et al*., 2006; Singh *et al*., 2003).

Materials and Methods

During 1997-2008, a total of 7,008 samples of transgenic rice with different traits from nine countries were processed at NBPGR for quarantine clearance (Table 1).

Quarantine Processing of Transgenic Rice

All the samples were first examined visually under higher magnification and then subjected to various techniques for detailed examination for detection of various pests (insects, mites, nematodes, fungi, bacteria and viruses) as given below:

Detection of Insect-pests: All the imported samples were examined visually either by naked eye or with the help of magnifying glass for detecting the presence of dead or actively moving larval and adult stages of insects, damaged/ deformed/ discolored seeds, plant parts, plant debris, dust, flour, webbing, presence of excreta, soil clods, etc.

Detection of Nematodes: As the paddy seeds are known/ suspected to carry seed-borne nematodes, these were soaked in water overnight to soften the seed coat and seeds were teased/ opened under the stereobinocular

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Table 1. Details of Transgenic Rice Processed for Quarantine Clearance

Transgene/trait	Source	No. of Samples
Ama1 for improved nutrition	Philippines	34
Herbicide (Basta) resistance, EPSPS-5 (enolpyruvylshikimate-3-phosphate synthase)	USA	3
cry1 Ac for resistance against lepidopteran pests	UK	14
*cry9C, cry*1*Ab* for resistance to lepidopteran pests	Belgium	86
*cry*1*Ab* for resistance to stem borer; *Xa 21* for resistance to bacterial blight; *PR* for resistance to sheath borer	Philippines	4
Phytoene synthase (Psy), bacterial phytoene desaturase (crt I) and lycopene B-cyclase (lcy)-genes for synthesis of β-carotene in rice endosperm	Switzerland	1
cry1Ab for resistance to stem borer	Belgium	75
Xa-21 for resistance to bacterial blight	Philippines	2
Psy, *crtl* and lycopene *b-Cyclase* (*Icy*) for synthesis of Beta-carotene in rice endosperm	Vietnam	21
Transposable element Ds	Singapore	6,598
"Cocodrie" capable of synthesizing β-carotene containing *Psy* (Phytoene synthase), *crtl* (Phytoene desaturase)	UK (England)	24
psy (Phytoene synthase), *crtl* (Phytoene desaturase) "Kaybonnet" capable of synthesizing β-carotene	USA	12
GFM *Cry1A* (*cry1Ab-1Ac*) Bt fusion gene Imparting insect-resistance	China	3
cry1Ab and *bar, cry1Ab, cry1Ac, PNC1* for resistance to lepidopteran insects and *bar* for resistance to glufosinate ammonium	Belgium	131
Total		7,008

microscope. "Staining technique" (Byrd *et al*., 1983; Holbrook *et al*., 1983) is used to locate the infected tissues in 20 days old seedlings. The plant parts were boiled in acid fuchsin lactophenol solution for few minutes and then destained in clear lactophenol. Nematodes, if present, retain red stain more deeply than the plant tissue and can easily be detected under stereobinocular microscope.

Detection of Fungi and Bacteria: All the samples were examined visually for detecting presence of fungal sclerotia, smut balls, malformed seeds, fungal frucitifications and symptoms on seed surface etc. Seeds were then subjected to Blotter test to detect fungal/ bacterial pathogens producing fungal and bacterial growth (Singh *et al*., 2003). Observations for the associated pathogenic fungi and bacteria were recorded on 8th day under stereobinocular microscope. Wherever needed, slides were also prepared for associated fungal spores/ conidia and for bacterial ooze and observed under compound microscope.

Post-entry Quarantine Inspection: Samples of rice grown by the indenters in Department of Biotechnology (DBT)-approved containment facilities/ glass houses were also inspected for seed-borne pests.

Ensuring the Absence of Embryogenesis Deactivator Gene Sequence

The samples were tested for ensuring the absence of embryogenesis deactivator gene. Seeds of all these samples were grown in National Containment Facility, 3-4 week old seedlings were used for DNA extraction and the residues were incinerated. DNA was extracted using protocol of Dellaporta *et al.* (1983) and Polymerase Chain Reaction analysis (PCR) was carried out using the primers designed for *cre* sequence of embryogenesis deactivator gene. Plasmid cloned with *cre* sequence was used as positive control in PCR analysis.

Risk of Pests Associated with Import of Rice from Source Countries

Available literature was screened for the associated risk of introducing exotic pests (pests not yet reported from India) with the import of rice from the source countries viz., Belgium, the Philippines, Singapore, Switzerland, UK, USA and Vietnam.

Results and Discussion

Of the total samples, 1,642 samples were found infested/ infected with various pests from different countries. These comprised 1,548 from Singapore, 65 from Belgium, 16 from Vietnam, 7 from USA, 4 from China and two from the Philippines. The pests intercepted are presented in Table 2.

The pests detected through visual examination were insect pests viz., *Cryptolestes ferrugineus, C. pusillus, Liposcelid* spp., *Rhizopertha dominica, Sitophilus oryzae, Sitotroga cerealella* and *Tribolium castaneum*. The

Table 2. Interception of Pests in Transgenic Rice

Pest	Country
Insects	
Cryptolestes ferrugineus, C. pusillus, Liposcelides spp., *Rhizopertha dominica, Sitophilus oryzae, Sitotroga cerealella, Tribolium castaneum*	Singapore
C. ferrugineus, R. dominica, S. cerealella, T. castaneum	China
Nematode	
Aphelenchoides besseyi	Singapore
Pathogens	
Fusarium moniliforme	Belgium
Alternaria padwickii	China
A. alternata, A, padwickii, Fusarium dimerium	Philippines
Drechslera halodes, D. rostrata, F. moniliforme, Phoma glumarum	Singapore
Curvularia lunata, D. oryzae, F. semitectum	Singapore, Vietnam
F. moniliforme	USA
Nigrospora oryzae, Verticillium cinnabarinum	Vietnam

soaking test revealed the presence of nematode, *Aphelenchoides besseyi*. The blotter test has led to the interception of fungi viz., *Alternaria padwickii, Drechslera halodes, D. oryzae, D. rostrata, Fusarium dimerium, F. moniliforme, F. semitectum, Nigrospora oryzae, Phoma glumarum* and *Verticillium cinnabarinum.*

Prior to release all the infested/ infected samples were salvaged and also provided prophylactic treatments by using various methods.

The infested seed lots were cleaned mechanically by removing dead/ live insects, damaged/ infested seeds, soil clods, plant debris, weeds and discoloured/ deformed seeds. Samples infested with insect pests were salvaged by fumigating with a mixture of EDCT (ethylene dichloride: carbon tetrachloride in the ratio of 1:4) mixture @ 320mg/ litre for 48 h at normal atmospheric pressure. The remaining healthy samples were also given prophylactic fumigation to safeguard against insect attack. For eliminating bacteria and nematodes, seeds were given hot water treatment at 52^0 C for 30 min. as a salvaging/ prophylactic treatment.

Post-entry Quarantine Inspection

The post-entry quarantine inspection of 137 samples grown in DBT approved containment facilities by the indenters viz., Hybrid Rice International (98) at Gurgaon and M/S Mahyco Seeds Ltd. (39) at Jalna was undertaken. Leaf and soil samples were collected and subjected to laboratory testing. The pests detected were fungi: *F. equisetum* and *N. oryzae*. However, no exotic pest of quarantine significance was detected.

Significance of Important Interceptions

Cryptolestes ferrugineus (Stephens) – (Coleoptera: Cucujidae), rusty grain beetle intercepted from Singapore can survive in sub-zero temperatures (Lee *et al*., 1992). *C. pusillus*, flat grain beetle is widespread in regions with warmer climates, can spread internationally with the movement of grain/ stored commodities. ***Liposcelides* spp.** (Psocoptera: Liposcelididae), psocids damage results in the loss of quality. Heavy infestation elicits an allergic response in susceptible people (Turner *et al*., 1996). All the stages can be transported with infested commodities. ***Rhizopertha dominica*** Fabricius (Coleoptera: Bostrychidae), lesser grain borer, a serious pest of stored products with wide host range is of quarantine significance in international trade in food products (CAB International, 2007). ***Sitophilus oryzae*** Linnaeus (Coleoptera: Dryophthoridae), rice weevil, a serious pest with adult longevity of about 7-8 months, causes loss in stored rice (unhusked). Also causes reduction in protein content of grains (CAB International, 2007). Though reported from India, it is of quarantine significance as 38 strains of three species of *Sitophilus* are reported (Grenier *et al*., 2000). ***Sitotroga cerealella*** Olivier (Lepidoptera: Gelechidae), rice grain moth is a major pest in storage and also occurs in field in tropical and subtropical countries and has 12 generations per year. An overall yield losses upto 30% have been reported (Singh and Benazet,1975). *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae), red flour beetle is a secondary pest of stored material. A single larva can cause a mean dry weight loss of 12.3 mg, in laboratory tests on millet (Roorda *et al*., 1982). Larvae primarily feed on germ point and damaged grains are unfit for sowing. Adults may live for about 18 months depending on weather conditions.

Aphelenchoides besseyi (Aphelenchoididae) is widely distributed and causes damage more in lowland and deep water systems than in upland environments. Though species is reported from India, there is an inherent risk of introduction of new biotypes having wider host range (Rajan *et al*., 1990; Gokte *et al*., 2001). The seed-transmitted nematode swims vigorously in water, readily cultures on most of the fungi and can survive drying in adverse situations.

Alternaria padwickii (Ganguly) M.B. Ellis (= ***Trichoconis padwickii*** Ganguly) – a fungus causes grain discoloration alone or in combination with other

fungi, can influence the market value (Lee *et al.*, 1986). High levels of seed infection and associated seed rotting can seriously affect crop establishment in nursery beds and in the field (Ou, 1985). ***Drechslera oryzae*** (Breda de Haan) Subram. & Jain (=***Cochliobolus miyabeanus*** (Ito & Kurib.) Drechsler ex Dastur), causes brown leaf spot of rice and this was the main cause of the Great Bengal Famine of 1943 in India, which resulted in yield losses ranging from 40 to 90% (Padmanabhan, 1973). ***Fusarium moniliforme*** Sheldon (= ***Gibberella fujikuroi*** (Sawada) S. Ito) causes bakanae disease of rice, and yield losses have been reported as high as 40-50% in Japan, 15% in eastern districts of Uttar Pradesh, India, and 3.7-14.7% in northern and central Thailand (Ou, 1985). In 1993 disease incidences of 4.17 and 96.25% caused grain losses of 3.04 and 95.45%, respectively, on inoculated rice cultivar Taraori Basmati in India (Sunder *et al.*, 1997).

The samples with different transgenes (Table 1) were tested to ensure the absence of embryogenesis deactivator gene. PCR analysis was carried out using the primers designed for *cre* sequence of embryogenesis deactivator gene. Plasmid cloned with *cre* sequence was used as positive control in PCR analysis. The amplicon of 1031 bp size was amplified only in positive plasmid sample while, no amplicon of corresponding size was observed in any of tested rice samples thus ensuring the absence of embryogenesis deactivator gene (Fig. 1).

Screening of the available literature revealed that the import of rice from different countries is associated with risk of introducing pests (Table 3). These are the pests which are either not yet reported from India or requires additional declaration under Schedule V and VI of Plant Quarantine (Regulation of Import into India) Order 2003.

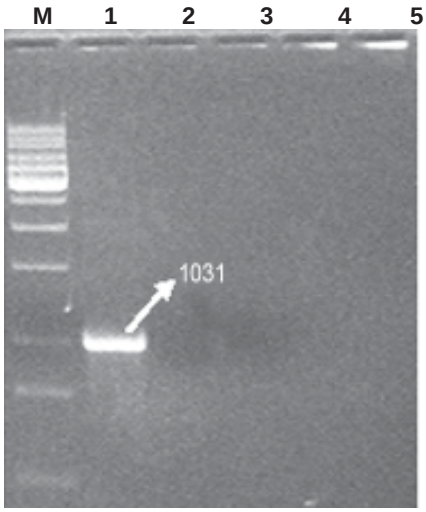

Fig. 1: Polymerase chain reaction-based detection of *cre* terminator gene sequence in transgenic rice

The number of interceptions made during quarantine of imported transgenic rice and the literature screening reveals that its import also poses the risk of introduction of various pests as their non-transgenic counterparts and highlights the significance of quarantine. The pests with races/ biotypes/ strains are of quarantine significance as more virulent strains or races may get introduced. This further requires preparedness in terms of detection and disinfestation protocols to deal with the bulk imports. Analysis of risk prior to import is also the first step in this direction. Ensuring the absence of embryogenesis deactivator gene sequence is very important for the perpetuation of the material.

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Table 3. Risk of Introducing Pests of Quarantine Significance along with Import of Rice from Different Countries

Pest	Belgium	Philippines	Singapore	Switzerland	UK	USA	Vietnam
Insects							
**Ahasversus advena*, Foreign grain beetle	–	+	+	–	+	+	–
**Haplothrips aculeatus*, Cereal thrips	–	–	–	–	–	–	+
#*Sitophilus granarius*, Grain weevil	+	–	–	–	+	+	–
**Trogoderma variabile* Grain dermestid	–	–	–	–	+	+	–
Fungus							
* *Monographella nivalis*	+	–	–	+	+	+	–
Bacteria							
*# *Burkholderia glumae* Bacterial grain rot	–	+	–	–	–	–	–
**#Pseudomonas fuscovaginae* Sheath brown rot	–	+	–	–	–	–	–

* Pest not reported from India, # Pests requiring additional declaration as per Plant Quarantine (Regulation of Import into India) Order (2003), + reported from the country, - not reported from the country.

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Inventorying Plant Genetic Resources of Religious Importance and their *In Situ* Conservation: A Case Study of Farming Communities of Kumaon Himalaya, Uttarakhand, India

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Plant genetic resources (PGR) are considered to be the integral part of human life to provide food, medicine and industrial raw materials. They also offer immense potential and untapped benefits for future generations. The pattern of resource utilization link human beings firmly with the culture, beliefs and religion, which they have adopted socially since long past and in return knowingly or unknowingly played an important role in their conservation. In this way, the culture and religion, which are most important part of human life remain in harmony and in return, help in conservation of surrounding plant diversity for its sustainable utilization. In the present communication, an attempt has been made to study the role of folk culture, ceremonies and rituals performed by hill communities in PGR conservation. Therefore, an integration of traditional culture with modern scientific developments by adding value would help in effective conservation of plant diversity in the area of study. Information on the use of plant genetic resources for religious purposes have been collected and the role of religious ceremonies in conservation of PGR have been discussed.

Introduction

The relationship between human beings and plants has evolved gradually from the beginning and spread of agriculture. The Indian culture born and nourished in the lap of nature has been deeply influenced by plants, trees, herbs, creatures and other resources in the vicinity. The significance of plant species in human life has been illustrated thoroughly and systematically in ancient literature such as Vedas, Upanishads, Manusmriti, Arthasashtra, etc. According to Hindu mythology, none of the festivals, fasts, rituals or religious ceremonies complete without mentioning use of plants and plant parts (Agarwal, 1970; Randhawa, 1964). Water, Earth, plants, animals, human beings and the Divine forces have come together in the images of Goddess "*Prithvi*" and also identified as mother Earth or '*Devi*'. The Goddess Earth sustains the plant life in its multitude and for the reason, the plants are considered sacred.

Plants are indispensable to rituals and religion and are thought to provide a devotional ambience and symbolize a connection with God and they may even take the believer into the spiritual world. The eternal presence of God and spiritual being is continuously verified by some plants representing their existence or indelibly marked by their presence (Ford, 1978). The environment, particularly the vegetation has closely been associated with the human life and has occupied a prominent place in his traditional and cultural web (Campbell, 1915; Banerji, 1955; Pal, 1972; Chaudhary *et al.*, 1975, 1980; Agrawal, 1980; Ford, 1985; Gaur *et al.*, 1984). Many plant species are associated with the religious and ritual sentiments of the people and therefore, they are not destroyed by them. Religious and cultural activities promote the conservation of biodiversity up to a large extent (Krishnan and Ghosal, 1997).

In the present investigation, plant species used by hill communities during fast, festival, rituals and religious ceremonies in Kumaon Himalaya of Uttarakhand state were inventoried and documented. Consequently, the role of rituals, festivals, fasts and religious ceremonies in conservation of plant genetic resources (PGR) particularly *in situ* on-farm conservation was investigated. In addition, the role of PGR in socio-cultural development of local communities is also discussed.

Materials and Methods

Data pertaining to uses of plants in various festivals and religious ceremonies were gathered from primary sources by using planned structured and unstructured questionnaire/interview scheduled at each individual household level during the year 2000-2003. Sample households were randomly selected from all 33 development blocks of five hill districts of Kumaon Himalaya of Uttarakhand. Three to four villages were

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selected from each development block representing communities inhabiting in the region. In each selected village, five per cent households were randomly selected for interview by adopting lottery system. A total of 298 respondent households were interviewed for inventorying and documenting plant species used in various religious ceremonies, fast, festivals and rituals. The district-wise details of the development blocks, total number of villages, total households, number of villages selected during survey and the number of households visited are presented in Table 1. During the survey, a non-participant observation method was also deployed while recording the data on plant species associated with religious ceremonies and rituals. These included only the species that were part of regional crop diversity or wild species occurring in the vicinity. Commonly cultivated ornamental and fruit species (coconut, arecanut, betel leaf etc.) offered to perform the rituals, though very important but by and large were not considered in the present study as these were not cultivated in this region.

Using participatory rural appraisal (PRA), information was obtained on conservation of individual plant species widely used for religious purposes. Information obtained was authenticated from knowledgeable elderly people and *Purohits* or *Brahmins* who performed the religious ceremony and rituals on behalf of *Yajmans* (people belonging to other castes). The impact of fasts, festivals, religious ceremonies and rituals on conservation of these plant species was also analyzed.

Results and Discussion

Apart from cultivated species used for food and other purposes, many plant species growing in surroundings are also used to fulfill the day-to-day requirements. It is a well-known fact that many plants or plant parts (flowers, leaves, fruits, seeds, roots, tubers, flowering twigs etc.) are used to perform various religious rituals in different phases (from birth to death) of life. The religious literature indicates that the Hindu religion is one of the ancient religions; the mention of uses of plants and plant parts in performing religious ceremonies is a common phenomenon. Our religious *gurus*, *rishis*, who spent a long span of their life in the forests and mountains, used to perform different rituals as a mark of respect to God. It is believed that the garland from *Cicer microphyllum* (whole plant), occurring in higher hills were worn by the *'Rishi-Maharshi'* for life longevity. The *Bhotiya* tribe in remote areas of Uttarakhand is still using bark of *Betula utilis* and *C. microplyllum* for this purpose. Similarly, *Cynodon dactylon* (*Doob*) is a common grass found almost everywhere is used in different religious rituals. Since, there is a reference to this grass in various Indian scriptures and even in the *Vedas* and according to mythology, Lord Rama used it as a substitute for food during his 14-years exile. Great poet Tulsi Das also wrote about its importance in religious rituals.

The land of Uttarakhand is globally known as *'Dev-bhumi'* (Land of Gods) due to its spiritualistic values. Several local deities (gods and goddesses) are worshipped in the entire hill region because of their deep faith and belief. Different plant species are offered to different deities on the occasion of worship, ceremonies and funeral rites. According to Hindu religion, 16-*Sanskars* are necessary to be performed in different phases of life. The important among these are: *Namkaran-Sanskar* (naming a new born child), *Annaprashan-Sanskar* (offering food to a new born child for the first time), *Mundan-Sanskar* (removing hair of a child for the first time), *Yagyopawit Sanskar* (wearing a religious thread), *Panigrahan-Sanskar* (marriage), *Antim-Sanskar* (funeral). Except funeral rites, Lord *Ganesha* is worshipped first of all as he has been given prime place among all gods and goddesses and supposed to check all hurdles to be faced during performing of rituals. In place of idol of Lord *Ganesha*, fresh cow-dung of calf is used for making symbol of *Ganesha* and the runner having green leaves of *C. dactylon* is placed on top of the triangle like structure. According to the nature of particular ritual, rite or ceremony, different plant species are used or some times flexible approach is also adopted due to non-availability

Table 1. Number of development blocks, villages and households of Kumaon surveyed for recording of information on plant species of religious importance

District	Development blocks	Total no. of villages	Total no. of households	No. of villages selected	No. of household surveyed
Almora	11	937	36480	33	100
Bageshwar	3	302	12182	9	32
Champawat	4	297	11981	12	31
Nainital	7	698	26822	21	63
Pithoragarh	8	720	23604	24	72
Total	33	2954	111069	99	298

of related *Puja Samagri* (material for worshipping) and locally available plants or plant parts are offered in place of those plants which are not indigenous to the region. In case of marriage, young uprooted plant of *Musa balbisiana* (banana) or its leaves, twigs/ branches of *Prunus cerasoides* (*pajja*/*payyan*), twigs of *Pinus roxburghii* (chir) are commonly used for erecting *Lagan Mandap* (*Bedi*). Leaves of *Mangifera indica* (*aam*) and *Ficus religiosa* (*peepal*) are put on the top (mouth) of *Kalash,* a pot filled with water for performing ritual related to marriage. Likewise, in funeral rites, the *Pindas* from grain flour of barley (*Hordeum vulgare*) are prepared and offered in respect of recently deceased person. In this ritual, plants like *Eclipta alba*, *Asparagus adscendens*, plants bearing white coloured flowers and *Eragrostis cynosuroides* are used. Similarly, *Anaphalis contortus* (heads) and *Eragrostis cynosuroides* (leaves and stems) are used on occasion of *Shradh Paksh* in each annual rites of dead person. Species like *Stephania glabra* (tuber), *Asparagus adscendens* (twig), *Cousinia thomsoni*, *Verbascum thapsus* (whole plant), *Orchis latifolia* (roots), *Zanthoxylum armatum* (stem) etc. are used to get rid off evil spirits.

There are also similar examples to be cited with regard to local festivals celebrated by the people in which the indigenous plants are used. In the month of *Chaitra* according to Hindi calendar (April-March), the children celebrate a local festival locally known as "*Ghhoga Mata"* or "*Phooldehi"* during first eight days of the month. Basically, this is the welcome of spring season when a number of plants flower in the nature. For prosperity and happiness, the children collect flowers of *Reinwardtia indica* (*phyunli*) in a basket made up of bamboo along with the flowers of *Rhododendron arboreum* (*burans*), *Pyrus pashia* (*mol-mundi*), *Valeriana jatamansi* (*sumaya*), *Tulipa stellata* (*ghongla*) and *Buddleja paniculata* (*khanki*) from surroundings in the evening. On next day morning, all the flowers are first offered to God in village temple and then put at the doorstep of every household and local song is chanted to make the act musical with full of cultural feelings:

Jai Ghhoga mata Phyunli ka phool
Jai Ghhoga mata Mol-mundi ka phool
Jai Ghhoga mata Burans ka phool
Jai Ghhoga mata Khankia phool

A total of 81 plants species used in 83 rituals and ceremonies in Uttarakhand region of Kumaon Himalaya are given in Table 2. These belong to 37 families of higher plants and are considered as sacred plants by the local inhabitants. The flowers, leaves, flowering twigs, fruits, etc. of a number of plant species offered to local deities as per the nature of ritual to be performed are given in Table 3. In Uttarakhand, the flowers, leaves, bark, roots etc. of a variety of species like *Delphinium denudatum, Origanum vulgare, Betula utilis, Myrica esculenta, P. cerasoides, Saussurea obvallata, Nardostachys jatamansi, V. jatamansi, Salix wallichiana,* etc. are used only on some special occasion by the inhabitants residing in upper reaches of Kumaon Himalaya. The seeds, fruits, leaves, stems (woods) etc. of about 15 plant species are offered in worship of local deities, gods and goddesses. Different dried plant parts (leaves, flowers and roots) of some of the species like *Skimmia laureola, Artemisia japonica, Cupressus torulosa, Juniperus communis* (leaves), *Achillea mellifolium, Chrysanthemum nubigenum, Nardostachys jatamansi, V. jatamansi, Tancetum longifolium, Jurinea dolomieae, Selinum tenuifolium* (roots) are burnt for incense during religious ceremonies. Most of such plant species contain essential oils and due to burning they emit a fragrance and help in purification (*shuddhi*) of the air all around. Generally, dried plant parts of several of these species are burnt mixing with butter or *ghee* (animal fat).

Plants have been used in body sacrament (*Sarir-sanskar*) rites since ancient time. Goddess Parvati used to collect the *Kush* (*Eratgrostis cynosuroides*) for worship (puja); she also adorned herself with the (*doob* grass) *C. dactylon* during her wedding (Karmakar, 1951). In present investigation, 15 plant species were observed being used in various types of ceremonies (8 species in marriage, 5 in *Yagyopawit Sanskar* and two in funeral rites). In the Uttarakhand hills, there is a tradition of worshipping local deities with offering porridge prepared from newly harvested grains like *Amaranthus paniculatus, Fagopyrum esculentum* and *Triticum aestivum.* Local festivals are supposed to be the happiest occasions of enjoyment and celebrated with great gaiety and enthusiasm. Plants as a whole and seeds/grains of cultivated crops are used for different purposes in local festivals. Eight plant species are found useful for this purpose. Apart from the above, trees are worshipped, as it is believed that gods and goddesses live in the species like *F. religiosa*, *F. benghalensis* (*bargad*) and *Emblica officinalis* (*aonla*). *Peepal* is considered symbol of Lord Krishna and depicts true love and longevity of life of husband, mango is offered to Lord Shiva and *aonla*

Table 2. Plant species used for religious ceremonies and rituals in Uttarakhand Himalayas

S.No.	Botanical name	Vernacular	Family	Habit, habitat and distribution	Local use in rituals
1	*Abies pindrow* Royle	Raga	Pinaceae	Tree, sub-alpine zone, 3000-3500 m	To ward-off evil spirits
2	*Achillea millefolium* L.	Gandrayan	Asteraceae	Herb, sub-alpine zone, 3000-3500 m	Roots are burnt for incense
3	*Aegle marmelos* (L.) Correa*@	Bael	Rutaceae	Tree, sub-tropical zone, up to 1000 m	Leaves are offered to Lord Shiva
4	*Amaranthus paniculatus* L.*	Chaulai, chuwa	Amaranthaceae	Herb, tropical to temperate zone, up to 3000 m	Porridge is offered to local deities. Breads are offered to Lord Shiva on occasion of *Shivratri*
5	*Anaphalis contorta* (D. Don) Hook.f.	Bugula	Asteraceae	Herb, temperate Himalaya, 1200-1800 m	Flowers referred as God and Goddesses. Flowering twigs used in funeral rites
6	*Anemone vitifolia* Buch-Ham. ex DC.	Khagsya	Ranunculaceae	Herb, temperate Himalaya, 1500-2200 m	Flowers considered as sacred and offered to local deities
7	*Artemisia japonica* Thunb.	Kunajor	Asteraceae	Herb, temperate Himalaya, 1800-2500 m	Leaves used as burning incense for worship
8	*A. nilagirica* (Cl.) Pamp.	Pati	Asteraceae	Herb, temperate Himalaya, 1000-1500 m	Twigs are offered to soul of dead person during funeral
9	*Asparagus filicinus* Buch.-Ham. ex D. Don	Kairua	Liliaceae	Scandent shrub, temperate zone, 2000-2800 m	Flowers and twigs are offered to local deities
10	*Avena sativa* L.*	Jai	Poaceae	Cultivated up to 2500 m	Seeds used in *Harela* festival with other four plant species.
11	*Bauhinia vahlii* Wt. & Arn.	Malu	Fabaceae	Tree, sub-tropical and sub-temperate zone, up to 1500 m	Leaves are used in body sacrament ceremony (*Yagyopawit-Sanskar*)
12	*Bergenia ciliata* Royle 1200-2000m	Silphara	Saxifragaceae	Herb, Temperate Himalaya,	Flowers and twigs offered to local deities
13	*Betula utilis* D. Don	Bhojpatra	Betulaceae	Tree, Alpine zone 2800-4000 m	Garland of bark worn by Bhotias for life longevity
14	*Brassica juncea* (L.) Czern. & Coss. var. *yellow sarson**	Pili sarson	Brassicaceae	Herb, tropical and temperate zone, up to 1600 m	Seeds used in worship and marriage ceremonies
15	*Buddleja paniculata* Wall.	Phurpatia, khanla	Buddlejaceae	Under-shrub, temperate zone, 1200-1800 m	Flowers considered as sacred and offered to local deities
16	*Butea monosperma* (Lam.) Taub	Dhank	Fabaceae	Tree, tropical zone, up to 600 m	Leaves are used as body sacrament ceremony (*Yagyopawit-Sanskar*)
17	*Caltha palustris* L.	Maniyar	Ranunculaceae	Herb, alpine Himalaya, 3000-3500 m	Flowers considered as sacred and offered to local deities
18	*Cannabis sativa* L.*	Bharg	Cannabinaceae	Shrub, sub-tropical and temperate zones, 350-2600 m	Leaves are offered for Lord Shiva's worship
19	*Cedrus deodara* (Roxb.) Loud.	Deodar	Pinaceae	Tree, temperate Himalaya, 1800-3000 m	To scare devil spirit and branches are used to erect the wedding *Mandap* (*Bedi*).
20	*Chrysanthemum nubigenum* (DC.) Hand-Maz.	Dhoop	Asteraceae	Herb, alpine Himalaya, 3000-3500 m	Roots used as burning incense
21	*Cicer microphyllum* Benth.	Chukton, Vantoor	Fabaceae	Herb, alpine Himalaya, 3000-4000 m	Dried stems are made as garland and worn by Bhotias for life longevity
22	*Citrus aurantifolia* (Christm.) Sw., *C. reticulata* Osbeck* Blanco, *C. sinensis* (L.)	Narangi	Rutaceae	Tree/fange shrub, sub-tropical-temperate zone 800-1800 m	Fruits used in the naming ceremony of new born child
23	*Corydalis govaniana* Wall.	Balsam jad	Papaveraceae	Herb, alpine Himalaya, 3000-3200 m	Roots used as burning incense
24	*Cousinia thomsoni* Cl.	Kanai	Asteraceae	Herb, alpine Himalaya, 3200-3500 m	Plant is hung over the houses to get rid of evil spirits
25	*Cupressus torulosa* D. Don	Surai	Pinaceae	Small tree, sub-tropical zone up to 1000 m	Leaves are used as burning incense during worship
26	*Curcuma domestica* Valet. *	Haldi	Zingiberaceae	Cultivated, sub-tropical and sub-temperate Himalaya, 600-1500 m	Rhizomes are used in wedding ceremony or any auspicious occasion

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S.No.	Botanical name	Vernacular	Family	Habit, habitat and distribution	Local use in rituals
27	*Cynodon dactylon* (L.) Pers.	Doob	Poaceae	Herb, sub-tropical and sub-temperate zones, up to 1500 m	Green runners are offered to Lord Ganesha in each type of worship
28	*Datura alba* Nees.	Dhatura	Solanaceae	Herb, sub-tropical zone, up to 1400 m	Flowers, fruits and leaves offered to Lord Shiva mainly on occasion of *Shivratri*
29	*Delphinium denudatum* Wall. ex Hook. f.	Nirvishi	Ranunculaceae	Herb, alpine Himalaya, 3000-3200 m	Flowers and twigs are considered as sacred and offered to local deities
30	*Eclipta alba* Hassk.	Bhringraj	Asteraceae	Herb, throughout India up to 1300 m	Plant is considered as auspicious. Offered in *Shradh* for paying respect to a recently deceased person
31	*Emblica officinalis* Gaertn.*	Aonla	Euphorbiaceae	Tree, tropical zone, up to 1200 m	Leaves and twigs are offered to Lord Shiva
32	*Eragrostis cynosuroides* Beauv.	Kush	Poaceae	Herb, sub-temperate zone, 1000-1400 m	Leaves are used for making Brahma idol and in wedding ceremonies and funeral rites
33	*Fagopyrum esculentum* Moench.*	Phapar, ogal	Polygonaceae	Herb, temperate and sub-alpine Himalaya, 1800-3200 m	Porridge offered to local deities
34	*Ficus benghalensis* L.@	Bad/Bargad	Moraceae	Tree, sub-tropical zone up to 1200 m	Tree considered as sacred and worshipped. Leaves are used as a body sacrament (*Yagyopawit-Sanskar*)
35	*F. religiosa* L.	Peepal	Moraceae	Tree, sub-tropical and temperate zone up to 1400 m	Tree considered as sacred and worshipped. Leaves are used in making of *Kalash*. Dried branches are burnt in *Homa*
36	*F. roxburghii* Wall.	Timula	Moraceae	Tree, sub-tropical and sub-temperate zones, 650-1500 m	Leaves are used in worship and wedding ceremonies and also used to prepare small bowls for putting *Puja-samagri*
37	*Grewia optiva* J.R. Drumm.ex Burret@	Bhimal	Tiliaceae	Small tree, sub-temperate zone, 1000-1500 m	Leaves are used in the worship of local deities
38	*Hordeum vulgare* L.*	Jau	Poaceae	Herb, temperate Himalaya, 1200-3200 m	Grains are burnt in *Homa* in worship of gods and goddesses in the end of *Puja* so that its fume reaches to every corner of the house and brings prosperity and happiness
39	*Hypericum uralum* Buch.-Ham. ex D. Don	Chaya	Hypericaceae	Herb, temperate Himalaya, 1200-2000 m	Flowers and twigs considered as sacred and offered to local deities
40	*Juniperus communis* L.	Jhora	Cupressaceae	Small tree, Alpine Himalaya, 3000-3500 m	Leaves are used as burning incense
41	*Jurinea dolomiaea* Boiss.	Lakkad dhoop	Asteraceae	Herb, alpine Himalaya, 3000-3500 m	Roots are used as burning incense
42	*Lingularia amplexicaulis* DC.	Kalankee	Asteraceae	Herb, temperate Himalaya, 2200-2800 m	Flowers and twigs are considered as sacred and offered to local deities
43	*Macrotyloma uniflorum* Roxb.	Gahat, kulthi	Fabaceae	Cultivated, sub-temperate zone 1000-1800 m	Grains are cooked at the time of *Harela* to celebrate the local festivals
44	*Mangifera indica* L.*	Aam	Anacardiaceae	Tree, tropical zone up to 1000 m	Leaves are tied and use in the entrance during auspicious occasions, used to make *Kalasha* in *Puja* and garland for doors. Dried branches/ wood is burnt in *Homa*

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S.No.	Botanical name	Vernacular	Family	Habit, habitat and distribution	Local use in rituals
45	*Mentha longifolia* L.	Pudina	Lamiaceae	Herb, temperate Himalaya, 1600-2800 m	Garland offered to Lord Vishnu at Badrinath temple
46	*Musa balbisiana* Colla*	Kela, kadli phal	Musaceae	Tall herb, tropical zone up to 1400 m	Tree and leaves are used in Satya Narayana worship and also used for making of wedding *Mandap*
47	*Myrica esculenta* Buch.-Ham. ex D. Don @	Kaphal	Myricaceae	Tree, temperate Himalaya, 1500-2000 m	Twigs are used in preparation of wedding *Mandap*, considered as sacred and religious tree
48	*Nardostachys jatamansi* DC.	Masi	Valerianaceae	Herb, alpine Himalaya 3200-4000 m	Roots are used for making of burning incense
49	*Ocimum basilicum* L.*	Tulsi	Lamiaceae	Herb, sub-tropical Himalaya, up to 1400 m	Treated as sacred herb and worshipped in every house hold
50	*Orchis latifolia* L.	Hathajari	Orchidaceae	Herb, alpine Himalaya, 3200-3500 m	Roots are used to get rid off evil spirit
51	*Origanum vulgare* L.	Van-tulsi	Lamiaceae	Herb, temperate and alpine Himalaya, 1600-3500 m	Plant is considered as sacred and offered to local deities in particular. Garland of plant is offered to Badrinath
52	*Oryza sativa* L.*	Dhan	Poaceae	Herb, tropical-temperate zone up to 1800 m	A particular variety '*sanwadhan*' is used in Devi Parvati's worship. *Chiwda* (parboiled rice) of lal dhan used in *bhaiduj teeka*
53	*Paeonia emodi* Wall. ex Royle	Chandra	Peonaceae	Herb, temperate Himalaya, 2000-2800 m	Flowers treated as sacred and offered to local deities
54	*Pinus raxburghii* Sarg.	Chir/saal	Pinaceae	Tree, sub-temperate Himalaya, 1200-1600 m	Twigs are offered to Goddess Parvati and branches are used to make wedding *mandap*
55	*Pleurospermum densiflorum* (Lindl.) Cl.	Tagar	Apiaceae	Herb, temperate and alpine Himalaya, 2500-3200 m	Leaves and flowers are used as burning incense
56	*Potentilla fulgens* Wall. ex Hook.	Bajradanti	Rosaceae	Herb, temperate Himalaya, 1400-2000 m	Flowers offered to local deities
57	*Primula denticulata* Sm.	Jalkutra	Primulaceae	Herb, alpine Himalaya, 2800-3500 m	Flowers offered to local deities
58	*Prunus cerasoides* D. Don	Panya	Rosaceae	Small tree, temperate Himalaya, 1400-1800 m	Branches and leaves are used for body sacrament ceremony, making of wedding mandap and burning incense. A local worship '*Samyo pooja*' is also performed with the branches of this sacred tree
59	*Psidium guajava* L.*	Amarood	Myrtaceae	Tree, sub-tropical zone up to 1000 m	Fruit used in the worship of local deities in parts of Pithoragarh district
60	*Punica granatum* L. @*	Darim	Punicaceae	Small tree, sub-tropical and temperate Himalaya, 1000-1600 m	Fruits are used in a local festival '*Herela*' and twigs are used for making of wedding '*Kalash*'
61	*Pyrus pashia* Buch.-Ham. ex D. Don @	Mehal, Molmundi	Rosaceae	Small tree, sub-temperate Himalaya, 1200-1800 m	Twigs with fruits are used in a local festival '*Ghee-Sankaranti*'
62	*Reinwardtia indica* Dumort.	Phenuli, piunli	Linaceae	Herb, temperate Himalaya, 1200-2500 m	Flowers treated as sacred and offered to local deities
63	*Rhododendrun arboreum* Sm.	Buransh	Ericaceae	Small tree, temperate Himalaya, 1500-2500 m	Beautiful Flowers treated as sacred and offered to local deities and used in a local flower festival '*Phooldehi*'
64	*Rosa brunonii* Lindl.	Kunja	Rosaceae	Shrub, temperate Himalaya, 1200-1800 m	Flowers offered to local deities

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S.No.	Botanical name	Vernacular	Family	Habit, habitat and distribution	Local use in rituals
65	*Saccharum officinarum* L.	Sugarcane; Ganna	Poaceae	Herb, sub-tropical zone, 700-1200 m	Whole stem with leaves are used to worship Lord Satya Narayana and making of wedding *Mandap*
66	*Salix wallichiana* Anders.	Bhains	Salicaceae	Small tree, temperate Himalaya, 1800-2800 m	Treated as sacred herb and offered to local deities
67	*Saussurea obvallata* (DC.) Edgew.	Brahma kamal	Asteraceae	Herb, alpine Himalaya, 3500-4500 m	Sacred flowers offered to Lord Vishnu in Badrinath
68	*Selinum tenuifolium* Wall. ex DC.	Bhootkeshi	Apiaceae	Herb, alpine Himalaya, 3000-3500 m	Rots are burnt as incense. Flowers offered to local deities
69	*Sesamum indicum* L.*	Til (black seeded type)	Pedaliaceae	Herb, sub-tropical zone, 1000-1500 m	Seeds are used in *Homa* and wedding ceremonies
70	*Skimmia arborescens* Ander. ex Gamble	Kedarphali, nihar	Rutaceae	Shrub, temperate and sub-alpine Himalaya, 2800-3200 m	Leaves are used as burning incense
71	*Stephania glabra* (Roxb.) Miers	Gindaru	Menisperma-ceae	Herb, sub-tropical zone, up to 1400 m	Tubers are used in *tantrik puja*, psyco-medicine
72	*Strobilanthes wallichii* Nees	Kangdali	Acanthaceae	Herb, temperate Himalaya, 2000-2800 m	Used in a local Bhotia festival *'Kangdali'*
73	*Tanacetum longifolium* Wall. ex DC.	Dhoop	Asteraceae	Herb, alpine Himalaya, 3000-3500 m	Whole plant is used as burning incense
74	*Triticum aestivum* L.*	Gehun	Poaceae	Herb, growing up to 1800 m	Porridge made of newly harvested grains is offered to local deities and seeds are also used in a local festival *'Harela'*
75	*Tulipa stellata* Hook.	Ghongla	Liliaceae	Herb, sub-temperate Himalaya, 1000-1500 m	White flowers are offered to devi to celebrate the *'Phooldehi'* festival
76	*Valeriana jatamansi* Jones	Indian valeriana; Sumaya, samer	Valerianaceae	Herb, temperate Himalaya, 1400-2800 m	Roots are used as burning incense
77	*Verbascum thapsus* L.	Iklavir	Verbenaceae	Herb, temperate Himalaya, 1400-3000 m	Whole plant is used to get rid of evil spirit
78	*Vigna mungo* (L.) Hepper*	Mash, urd	Fabaceae	Cultivated up to 1800 m	Seeds mixed with rice are offered to devil spirit to get rid of and seeds are also used in a local festival *'Harela'*. Sticks are kept in temples as well as home to scare devil sprits
79	*Zanthoxylum armatum* DC.	Timur	Rutaceae	Shrub, temperate Himalaya, 1000-1800 m	Sticks are kept in temples as well as homes to scare devil spirits
80	*Zea mays* L.*	Makka	Poaceae	Herb, up to 1800 m	Seeds are mixed with four other crop seeds and used to grow in a local festival *Harela*
81	*Zingiber officinale* Rosc.*	Adarak	Zingiberaceae	Herb, up to 1500 m	Whole plant is used to offer to local deities

*: Cultivated; @ semi-domesticated

generates the sentiments of belief in women for gods. In some cases, the local men having knowledge about *Tantra-Mantra* also use plants to scare the devil souls. It is just a matter of belief, there is no scientific reason behind it, but it has the social recognition in the region (Shah and Joshi, 1971).

Plants including other biological resources play a key role in the development of culture and traditions among the society. The uses of plant and plant parts are very common as compared to other commodities across the country in religious ceremonies and rituals. The religious importance of several plants species such as *peepal*, *gular*, *bargad*, mango, *bael*, *aonla*, *tulsi*, banana etc. has been mentioned in Puranas, Vedas, Upanishads and many other manuscripts (Heerak, 1994). In Kumarasambhava, Kalidasa described many plant species, which are useful in rituals and religious ceremonies in the Himalayan region particularly in the Uttarakhand hills (Pant, 2002).

Table 3. Categories and number of species used in different religious ceremonies and rituals in Kumaon hills

Uses of plant species	No. of plant species
Flowers, twigs, leaves and fruits offered to local deities	18
Plants/ plant parts used in the worship of gods, goddesses and local deities	15
Used as burning incense in the worship or other rituals	16
Used in marriage ceremonies and body sacraments	13
Used in local festivals	8
Trees worshipped as gods	4
Garland offered to local deities	3
To prepare porridge (from newly harvested grains) offered to local deities	3
To scare devil spirits	6
Offered to dead bodies during funeral rite	2

Plants with fragrant breeze and useful in rituals are also adorned the Shiva's meditation ground, Vashishtha ashram and Kanwa's ashram (Karmakar, 1951; Dixit, 1953; Tripathi, 1991). In this way, conservation of plant diversity evolved in the human society.

The seeds of yellow sarson, barley and sesame are commonly used in worship performed on wedding ceremonies and *Janam-din* (birthday) celebration. For welcoming the *Baraatis* (people accompanying bridegroom), 2-3 twigs of *Punica granatum* are kept in to the water filled copper tumbler to show the gratitude for coming. It is believed that the Goddess *Parvati* nurtured *Cedrus deodara* tree as her son and Lord *Shiva* deployed a watchman to protect it. Pine (*Pinus roxburghii*) twigs are also offered to *Parvati* as a mark of respect (Karmaka r,1951; Shastri, 1975). For the worship of a local deity *'Samyo'* in the Kumaon region of Uttarakhand, the branches of *Prunus cerasoides* are essentially required as an important component of the act. A particular variety of paddy *'Sanwadhan'* grown in Uttarakhand is offered to Goddess *Parvati* and because of this very cause, the local farming communities grow the variety frequently. It is a strong belief that if a variety is under cultivation, its cultivation should never be stopped in the future. Owing to such belief among the people of the region, this variety has been conserved *in situ*/on farm.

Religious ceremonies, rituals, local fasts, festivals, worship of local deities etc. have played an ideal role in the conservation of plant genetic resources (PGR) occurring in the Uttarakhand region. The cultural traditions are transferred verbally from one generation to other. There are some festivals celebrated on the basis of cropping seasons. For celebrating the crop-based festival in the Uttarakhand hills, rice, wheat, barley, maize, blackgram, horsegram, *mehal* (*P. pashia*) and *darim* (*P. granatum*) are essentially required for offering to deities and preparation of different dishes. Many plant species are considered auspicious if grown around the human dwellings.

To overcome the evil effects of architectural error (*Vaastu clash*), many plants/trees are grown around different directions of the house (Joshi, 2007). Today there are some crop landraces in barley, yellow sarson, sesame (black seeded) and a variety of paddy (*Sanwadhan*) etc. that are of less importance as food crops in this region but have great religious value. Local communities still grow these crops on a small piece of land because of their importance in the rituals. Without the availability of these seed materials, some religious ceremonies cannot be performed. The followers of Hindu religion in this region consider that the seeds of these crops should be conserved for future. Wheat, amaranth and some local crops are grown essentially because the porridge of newly harvested grains are offered to local deities after every harvesting season in the higher parts of Himalayan region. The wood from *peepal*, *bargad* and mango is considered very good for quality furniture and other household items, but local people worship them as god and goddesses hence they protect them.

Similarly, selective use of those plants/parts (twigs, flowers, leaves, seeds, woods, roots etc.), which are important components of various Hindu ceremonies and rituals help to a large extent in protection of the species from exploitation. The plant species used in various rituals, local communities prefer to plant them around their houses/villages because of their routine requirement in the households. These plant species are collected from their natural stand in the forest and sustainably utilized from generation to generation.

The plant species associated with the religious ceremonies and rituals belonging to category of food crops, wild relatives, fruits and wild edibles, medicinal and aromatic plants are mainly trees, shrubs, herbs, grasses, climbers etc. (Table 4). Due to their religious importance, these are being conserved in the Uttarakhand region as cultural heritage of the local communities. There are examples when selected crop landraces have been conserved because of their value in performing the local rituals in the Philippines (Barnett, 1969). The present study highlights the role of folk religion, culture and

Table 4. Categories of plant species used in various religious ceremonies in Uttarakhand Himalayas

Categories of plant species	No. of species
Food crops and wild relatives	15
Fruits and wild edibles	16
Medicinal and aromatic plants	31
Other miscellaneous plant species (trees, shrubs, herbs, grasses etc.)	19
Total	81

tradition in the conservation of several such species in Uttarakhand Himalaya. Nature mother has provided platform to human beings for cultural development by growing plants and using them. Thus, the plants are considered as integral part of human culture and obviously without the association of plants, no culture can survive for long. There are many local folk songs in the region, which emphasize the sense of conservation of plant species along with creating balance in surrounding environment. A couple of them are mentioned here:

Ni kato, ni kato, hariya jungla,
Nana dai mein jhan maria chot,
Jas hamar nan tina vaisa jungla vot;

———

Uncha daanaa rouchha saima, bhali tumari baani
Tyar dali ko doodh pichha, baanj vot ko paani
Yo madua ka bala, gharagud ka tala

————

The essence of these folk songs is to consider tree/plant as one's child who is, to be carefully nurtured and protected and conveys a message regarding living in harmony with the environment and nature has also been floated. Through suitable conservation measures, a sustainable relationship between mankind and environment particularly in the above mentioned species can be achieved.

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SHORT COMMUNICATION

Relative Susceptibility of Maize Single Cross Hybrids to Pink Stem Borer (*Sesamia inferens* Walker)

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Key Words: ***Sesamia inferens*, Maize, Leaf injury rating (LIR), Least susceptible, *Rabi***

Among all cereal crops in India, maize has recorded the maximum the growth rate in terms of area, production and productivity. However, productivity of maize in India (2.10 t/ha) is quite low as compared to world average (4.08 t/ha). One of the major causes of low productivity in maize is the damage done to the crop by borers at various stages of crop growth. Pink borer (*Sesamia inferens*) is an important pest during winter season in peninsular India. The grain yield losses due to *S. inferens* in different maize genotypes range from 25.7-78.9% (Chatterji *et al*., 1969). For resistance breeding, evaluation of breeding materials for their resistance is very much essential. An attempt has been made to determine the level of resistance against pink borer among single cross hybrids from CIMMYT.

The experimental material was comprised of a set of 45 single cross hybrids from CIMMYT along with two susceptible checks, *viz*., Basi local and DHM 105; and one resistant check, CM 500. The experiment was carried out in randomized block design with two replications during *rabi* 2005-06 at Hyderabad in 2.5 m row plots with inter and intra-row spacing of 75 cm and 20 cm, respectively. Each 10-12 days old maize seedling was infested with 12-15 neonate larvae. The leaf injury ratings (LIR) on 1-9 scale were recorded thirty days after infestation according to Rao (1983). The mean LIR were subjected to analysis of variance using Windostat software version 8.0.

Analysis of variation (ANOVA) showed significant variance among the genotypes in terms of response to pink borer attack. LIR scores of the 45 single crosses involving CIMMYT CA and P31 C4S5B-23-#-4-BBB-B-B lines and resistant and susceptible checks are presented in Table 1. The hybrids were grouped into four categories based on LIR: i) Least susceptible-LIR less than resistant check, CM 500, ii) Moderately susceptible -LIR above the resistant check and less than susceptible check 1, iii) Susceptible-LIR between susceptible check 1, Basi local and susceptible check 2, DHM 105, iv) Highly susceptible- LIR above the susceptible check 2.

It was found that the cross CAO 0102 x CA14502 (4.5) was least susceptible having the LIR less than the resistant check CM 500 (5.2). Four crosses , namely, CAO 3139 x CA14502 (5.80), CA14701 x CA 14502 (5.50), CA 14502 x P31 C4S5B-23-#-4-BBB-B-B (5.9) and P31 C4S5B-23-#-4-BBB-B-B x CAO3116. The remaining 3116 (5.4) were found to be moderately susceptible. The single crosses, namely, CA 14514´P31C4S5B-23-#-#-4-BBB-B-B, CA0 3141´CAO 0102, CA 14502´CAO 3116, P31 C4S5B-23-#-#-4-BBB-B-B´CA03118, CA 14509´CA14701, CA 14502´CAO 3118 were susceptible with LIR between 6.2 and 6.9. The remaining thirty four crosses were highly susceptible. CAO3139 x P31 C4S5B-23-#-4-BBB-B-B and CA14514 x CA 14502 recorded highest leaf injury rating of 9.0 on 1-9 scale. The least susceptible cross CAO 0102 x CA 14502 and the moderately susceptible crosses CAO 3139 x CA14502 (5.80), CA14701 x CA 14502(5.50), CA 14502 x P31 C4S5B-23-#-4-BBB-B-B (5.9) and P31 C4S5B-23-#-4-BBB-B-B x CAO3116 could be used directly in the areas where pink stem borer is a problem or utilized in the derivation of new lines adaptable to this environment. These crosses with moderate levels of resistance to pink borer will serve well keeping in view the need of the resource poor farmers and the ecological consequences of chemical control. The same views were opined by Bergvinson *et al.* (2002). In earlier studies Panwar *et al*. (2001) reported two genotypes resistant against *C. partellus*, while Sekhar *et al*. (2004) identified seven sources of resistance against S. *inferens.*

Table 1. Relative susceptibility of yellow single cross hybrids to pink stem borer

S.No.	Pedigree	Mean LIR (1-9 scale)
	Least susceptible	
1	CAO 0102´CA 14502	4.5
	Moderately susceptible	
2	P31C4S5B-23-#-#-4-BBB-B-B´ CAO 3116	5.4
3	CA 14701´CA14502	5.5
4	CAO 3139´CA 14502	5.8
5	CA 14502´P31 C4S5B-23-#-#-4-BBB-B-B	5.9
	Susceptible	
6	CA 14514´P31C4S5B-23-#-#-4-BBB-B-B	6.0
7	CA0 3141´CAO 0102	6.1
8	CA 14502´CAO 3116	6.5
9	P31 C4S5B-23-#-#-4-BBB-B-B´CA03118	6.6
10	CA 14509´CA14701	6.7
11	CA 14502´CAO 3118	6.8
	Highly susceptible	
12	CA 14514´CAO 3118	6.9
13	CAO 3141´CA 14502	6.9
14	CA14701´P31C4S5B-23-#-#-4-BBB-B-B	7.0
15	CAO 3139´CAO 0102	7.1
16	CAO 3139´CAO 3118	7.1
17	CA 145141´CAO 3141	7.1
18	CA 14514´CA 14701	7.1
19	CAO 3141´CA14701	7.1
20	CA 14509´P31 C4S5B-23-#-#-4-BBB-B-B	7.1
21	CA 14509´CAO3118	7.1
22	CAO 3139´CA 14701	7.2
23	CAO 0102´P31C4S5B-23-#-#-4-BBB-B-B	7.2
24	CA 14514´CAO 0102	7.3
25	CA 14509´CA 14502	7.3
26	CAO 03139´CA 14514	7.5
27	CAO 3139´CAO 3116	7.6
28	CAO 0102´CAO 3116	7.6
29	CAO 3141´CAO 3118	7.8
30	CAO 3139´CAO 14509	7.9
31	CA 14514´CAO 3116	7.9
32	CA 03141´CAO 14509	8.1
33	CAO 0102´CA 14701	8.1
34	CA 14509´CAO 3116	8.2
35	CAO 0102´CAO 3118	8.2
36	CAO 3116´CAO 3118	8.2
37	CA 14509´CAO 0102	8.4
38	CAO 3139´CAO 3141	8.5
39	CA 14514´CAO 14509	8.6
40	CAO 3141´P31C4S5B-23-#-#-4-BBB-B-B	8.7
41	CAO 3141´CAO 3116	8.7
42	CA 14701´CAO 3116	8.8
43	CA 14701´CAO 3118	8.8
44	CAO 3139´P31C4S5B-23-#-#-4-BBB-B-B	9.0
45	CA 14514´CA 14502	9.0
46	CM 500 (Resistant check1)	5.2
47	BASI LOCAL (Susceptible check 1)	6.0
48	DHM 105 (Susceptible check 2)	6.9

SE (D) 1.3
CD (0.05) 2.7

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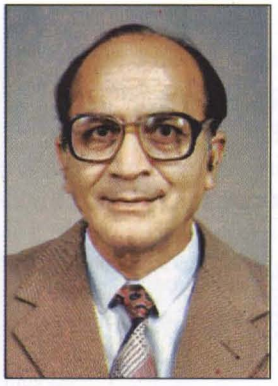
In Memorium – A Tribute to Dr. KL Mehra



Dr. KL Mehra, an eminent scientist and the first Director of the National Bureau of Plant Genetic Resources (NBPGR), New Delhi passed away on 11 August 2008. After serving on this position from 1976-1983, he joined the International Board for Plant Genetic Resources/ Food and Agriculture Organization (IBPGR/FAO) position in Indonesia, and later also worked in Maldives and Yemen mainly for germplasm collecting.

Before joining NBPGR, Dr. Mehra served in different capacities at the Indian Grassland and Fodder Research Institute, Jhansi (including its Director for a brief period), Central Potato Research Institute, Shimla and Indian Agricutural Research Institute, New Delhi. During his tenure as Director, NBPGR, Dr. Mehra was instrumental in creating a structural set-up for plant genetic resources (PGR) work on germplasm collecting, evaluation, documentation and conservation/use and coordinating PGR activities at the national/international level. Under his leadership, NBPGR organized a series of meetings, working groups and training programmes on various aspects of PGR management for the South and Southeast Asian region which increased visibility of the institute. With his wider interests, he produced a large number of valuable publications in the field of PGR, biosystematics, crop origin and domestication which are immensely valuable to the researchers and students.

Dr.Mehra acquired M.Sc. degree from Botany Department, University of Delhi and Ph.D. degree under Dr. Jack Harlan from Oklahoma State Agriculture University, USA. His work on biosystematic studies in grasses was very significant and based on taxonomic, cytogenetic and evolutionary studies provided evidence on the domestication of finger millet (*Eleusine coracana*) in Ethiopia and its subsequent spread and cultivation in India which is widely acclaimed and referred. Dr. Mehra also had the privilege of working with renowned American biosystematist, Dr. Edgar Anderson, at the Missouri Botanical Garden, St. Louis, Missouri, USA.

Dr. Mehra remained actively involved with PGR while working with different organizations including the FAO and was closely associated with several emerging international concerns/issues and actively participated in several FAO meetings. He was also closely associated with the Asian Agri-History Foundation, Secunderabad, India and actively involved with the publication activities of the Foundation pursuing his interest in archaeobotany as related to early history of crop plants and their domestication.

In the demise of Dr. Mehra, the PGR scientific community has not only lost a very learned scientist and a visionary in the field of plant genetic resources and evolutionary botany but also a human being par excellence.

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On the demise of Dr. K.L. Mehra, a renowned agricultural scientist of great national and international repute, all the members of the Indian Society of Plant Genetic Resources pay their homage and pray the Almighty to rest the departed soul in eternal peace.

Bhag Mal
President, ISPGR

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