Table 2. Simple correlation and linear regression between chlorosis and its components and yield

Chlorotic components	Y = a+bx	Correlation coefficient('r' value)
Chlorophyll	Y = 55.06 + (-24.43x)	-0.816**
Photosynthetic rate	Y = 130.97 + (-7.51x)	-0.927**
Chlorophyllase activity	Y = 10.64 + 11.49x	+0.959**
Zinc content	Y = 40.83 + (-4.88x)	-0.733**
Iron content	Y = 48.32 + (-9.31x)	-0.702**
Manganese content	Y = 28.99 + (-1.75x)	-0.568**
Yield	Y = 27.28 + (-0.498x)	-0.523**

chlorophyllase due to reduced levels of zinc, iron and manganese content leads to low chlorophyll content and thus reduced photosynthetic rate. Lopez *et al.* (1991) also obtained reduced photosynthetic rate in chlorotic leaves of citrus. A negative association obtained (-0.523**) in the present study between chlorosis and yield may be attributed to the reduced photosynthetic rate of the chlorotic trees and thus low yield.

It was revealed from the present study that the chlorosis in Sathgudi is due to low levels of zinc, iron and manganese content which may lead to increased activity of chlorophyllase enzyme. This enzyme decreases the chlorophyll content and further leads to chlorosis of the leaves. A strong positive correlation was obtained between chlorosis and chlorophyllase enzyme. Chlorosis had negative association with photosynthetic rate. The fruit yield also had negative association with chlorosis and thus yield decreases with the increase in chlorosis.

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INTERSPECIFIC HYBRIDIZATION BETWEEN PEARL MILLET AND NAPIER GRASS AND STUDY OF THEIR F1 HYBRIDS

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ABSTRACT

Field trial was conducted involving 15 genotypes of forage pearl millet of diverse origin, 5 genotypes of napier grass and 15 hybrids obtained from them along with a check CO 2 during 1991-92. The hybrids are sterile with abortive pollen grains and the diameter ranged from 24.54 to 29.97 m. Variability and heritability of 13 characters were studied in the hybrids in which 8 traits showed high heritability with high genetic advance. The traits were stem girth, number of tillers per clump, number of leaves per clump, leaf area per clump, leaf:stem ratio, green fodder yield, dry fodder yield and crude protein. Among the 15 hybrids, the hybrid IP 15507 x FD 429 was later promoted as an improved culture (ACK 2). The hybrids showed maximum direct effect of internode length, number of tillers per clump, dry fodder yield and leaf area per clump on green fodder yield.

KEY WORDS : Pearl millet x napier, variability, heterosis, path analysis, ACK 2

Grasses and legumes are the cheapest source of feeds for ruminants and among these, grasses have priority due to their high yield and perenniality. Pearl millet x napier hybrids under irrigated condition can augment our present demand of grass fodder. Stebbins (1974) suggested that interspecific hybridization can be of value in the arid and semi-arid regions where suitably adapted species are rare. With this, new genotypes were evolved by many workers combining the desirable economic traits of the parental species such as *Pennisetum americanum* (pearl millet) for its quality and *Pennisetum purpureum* (napier grass) for their perenniality and regular supply of green fodder.

MATERIALS AND METHODS

An experiment was conducted involving 15 genotypes of forage pearl millet, 5 genotypes of napier grass and 15 hybrids obtained from them (Table 1,2 and 3) along with a check Co 2 at the Agricultural College and Research Institute, Killikulam on 18 December, 1991. Each entry was grown in a single row of five metre length adopting randomised block design replicated twice. The trial was conducted in a normal red loamy soil with a pH of 7.2 and electrical conductivity (EC) of 0.31 millimhos/cm under irrigated condition. All farm management practices were followed as per the standard package of practices. In the case of napier grass and hybrids, four cuttings were taken. The first cutting was taken 60 days after planting while subsequent cuttings were taken at 45 days interval. In case of pearl millet, only one cutting was taken at 50 per cent flowering stage. The biometrical data were recorded on 13 traits at every harvest on five randomly chosen plants from each entry per replication.

Table 1. Details of pearl millet genotypes

Genotypes	Origin	Code No.
IP 3484	Tamil Nadu, India	C_1
IP 3489	Tamil Nadu, India	C_2
IP 3502	Tamil Nadu, India	C_3
IP 3518	Tamil Nadu, India	C_4
IP 3555	Tamil Nadu, India	C_5
IP 5296	Niger	C_6
IP 5908	Niger	C_7
IP 7460	Tanzania	C_8
IP 7470	Tanzania	C_9
IP 9256	Togo	C_{10}
IP 9324	Benin	C_{11}
IP 9354	Ghana	C_{12}
IP 15507	Burkina fasco	C_{13}
IP 15526	Burkina fasco	C_{14}
IP 15932	Togo	C_{15}

Table 2. Details of napier grass genotypes

Genotypes	Origin	Code No.
FD 429	Puerto - Rico	N_1
FD 439	Puerto - Rico	N_2
FD 444	U.S.A	N_3
FD 446	U.S.A.	N_4
FD 450	Kenya	N_5

RESULTS AND DISCUSSION

The pearl millet, napier grass and the pearl millet x napier hybrids were first examined for pollen fertility and diameter of the pollen grains to observe the sterility nature (Table 4). In pearl millet and napier grass, the fertility ranged from 93.25 to 97.38 and 89.15 to 94.50 per cent respectively. But in the hybrids, the fertility was zero per cent. The diameter of pollen grains in pearl millet and napier grass was from 34.98 to 39.96 and 47.63 to 50.42 µm respectively. In the hybrids the pollen diameter was from 24.54 to 29.27 µm i.e.. smaller in size than pearl millet and napier grass and there by showing the sterile nature of the hybrids.

Since green fodder yield is a complex trait, a knowledge of association of different components with yield and inter relation among themselves is important. Based on the data collected from parents and hybrids, statistical analysis was carried out to study (i) variability and heritability estimates (ii) heterosis and (iii) path analysis. The study was made separately in pearl millet, napier grass and pearl millet x napier hybrids. Variability and heritability studies revealed that traits *viz.*, leaf:stem ratio, dry fodder yield, leaf area per clump, green fodder yield, crude protein and

Table 3. List of pearl millet x napier hybrids

Hybrids	Code No.
IP 3484 X FD 450	H 1
IP 3489 X FD 450	H 2
IP 3502 X FD 446	H 3
IP 3518 X FD 450	H 4
IP 3555 X FD 439	H 5
IP 5296 X FD 429	H 6
IP 5908 X FD 429	H 7
IP 7460 X FD 444	H 8
IP 7470 X FD 439	H 9
IP 9256 X FD 450	H 10
IP 9324 X FD 450	H 11
IP 9354 X FD 450	H 12
IP 15507 X FD 429	H 13
IP 15526 X FD 429	H 14
IP 15932 X FD 446	H 15

Table 4. **Pollen fertility (per cent) and pollen diameter (μm) in parents and pearl millet x napier hybrids**

Pearl millet			Napier grass			Pearl millet x napier hybrids		
Genotypes	Pollen fertility (%)	Pollen diameter (μm)	Genotypes	Pollen fertility (%)	Pollen diameter (μm)	Genotypes	Pollen fertility (%)	Pollen diameter (μm)
C1	94.95	37.31	N1	89.15	47.63	H1	0.00	24.81
C2	96.30	37.64	N2	94.50	50.42	H2	0.00	28.14
C3	95.15	39.79	N3	94.28	46.03	H3	0.00	29.64
C4	95.37	39.63	N4	91.33	49.36	H4	0.00	24.98
C5	93.43	38.96	N5	94.40	48.29	H5	0.00	26.64
C6	96.88	37.30	-	-	-	H6	0.00	28.64
C7	93.25	34.98	-	-	-	H7	0.00	29.97
C8	96.16	40.63	-	-	-	H8	0.00	24.54
C9	97.12	39.30	-	-	-	H9	0.00	32.99
C10	96.06	38.46	-	-	-	H10	0.00	26.31
C11	96.87	37.96	-	-	-	H11	0.00	29.47
C12	96.31	39.96	-	-	-	H12	0.00	25.97
C13	95.56	38.79	-	-	-	H13	0.00	29.14
C14	97.38	36.30	-	-	-	H14	0.00	34.32
C15	97.19	37.63	-	-	-	H15	0.00	32.15

calcium content recorded high heritability coupled with high genetic advance values in pearl millet whereas in napier grass similar trend was observed in traits viz., stem girth, green fodder yield, dry fodder yield, leaf:stem ratio and calcium. In pearl millet x napier hybrids (Table 5), out of 13 traits studied, 8 traits showed high heritability with high genetic advance values. The traits were dry fodder, stem girth, number of tillers per clump, number of leaves per clump, leaf area per clump, leaf:stem ratio, green fodder yield and crude protein. The positive trend of these parameters showed preponderance of additive gene action in their expression (Johnson *et al.* 1995) of the above traits.

Among the 15 hybrids, the hybrid IP 15507 x FD 429 (H 13) was found to be superior based on *per se* performance and heterosis values for four of the 13 traits studied which was later promoted as an improved culture (ACK 2). The heterotic expression of this cross was found to be optimal for

Table 5. **Variability and heritability estimates in pearl millet x napier hybrids**

Traits	Mean	Variance		Coefficient of variability		h^2 (%)	G.A	G.A. as % over $\bar{X}$
		Genotypic	Phenotypic	GCV (%)	PCV (%)			
Plant height (cm)	283.03	770.02	790.61	11.55	11.70	97.40	56.47	23.51
Number of tillers/clump	18.88	11.34	12.60	17.80	18.77	89.97	6.59	34.82
Number of leaves/clump	176.86	1184.76	1223.30	19.47	19.79	96.85	69.85	39.52
Leaf area/ clump (m^2)	3.05	0.80	0.81	29.47	29.68	98.63	1.83	60.36
Internode length (cm)	17.86	4.27	5.33	11.51	12.86	80.14	3.81	21.25
Stem girth (cm)	2.87	0.36	0.36	21.34	21.38	99.63	1.23	43.92
Green fodder yield (g)	560.30	29180.18	29241.32	28.79	28.82	99.79	351.87	59.30
Dry fodder yield (g)	114.27	1371.36	1373.91	32.61	32.64	99.81	76.29	67.17
Leaf: Stem ratio	0.80	0.02	0.02	17.89	17.89	99.92	0.29	36.87
Crude protein (%)	8.40	0.97	1.00	11.81	11.99	97.03	2.00	23.99
Calcium (%)	0.79	0.006	0.007	9.82	10.03	95.83	0.16	19.82
Phosphorus (%)	0.20	0.0002	0.004	7.47	10.29	52.76	0.02	11.19
Oxalate (%)	3.01	0.02	0.04	4.47	6.44	48.28	0.19	6.41

GCV - Genotypic coefficient of variation h^2 - Heritability
PCV - Phenotypic coefficient of variation G.A.-Genetic advance

Table 6. Heterosis (per cent) for green fodder yield, dry fodder yield and leaf:stem ratio

Genotypes	Green fodder yield			Dry fodder yield			Leaf:stem ratio		
	di	dii	diii	di	dii	diii	di	dii	diii
H 1	73.36**	16.10**	-1.57	66.98**	9.33**	-5.65**	73.54**	61.68**	-11.97**
H 2	27.71**	-15.41**	-28.29**	22.28**	-21.76**	-32.48**	72.00**	66.04**	-9.60**
H 3	69.24**	6.39**	-4.18**	72.04**	6.57**	-14.70**	39.48**	35.95**	29.06**
H 4	33.06**	-13.21**	-26.42**	41.65**	-7.32**	- 20.02**	69.41**	46.93**	-20.00**
H 5	71.52**	10.99**	-20.51**	82.99**	19.68**	-22.32**	54.73**	48.03**	-29.06**
H 6	98.79**	48.51**	12.19**	128.96**	80.20**	23.86**	128.62**	100.11**	-1.08**
H 7	114.49**	32.13**	7.37**	117.93**	44.13**	-0.09	137.90**	112.05**	1.51*
H 8	231.14**	155.32**	29.30**	261.07**	197.11**	43.29**	104.98**	96.95**	4.26**
H 9	15.75**	-25.41**	-46.58**	23.08**	-19.75**	-47.91**	34.12**	14.74**	-45.01**
H 10	92.76**	20.34**	2.02	73.23**	4.07**	-10.19**	66.05**	50.10**	-18.27**
H 11	126.41**	41.34**	19.83**	105.34**	24.65**	7.57**	83.26**	76.73**	-3.71**
H 12	64.37**	-0.55	-15.69**	55.07**	-8.85**	-21.34**	61.31**	29.21**	-29.65**
H 13	136.90**	55.64**	17.57**	185.64**	94.92**	33.98**	143.55**	121.58**	1.29*
H 14	-34.02**	-57.54**	-67.92**	-31.41**	-55.66**	-69.52**	95.38**	94.68**	-27.06**
H 15	81.87**	18.89**	7.08**	95.44**	28.22**	2.63*	92.33**	79.23**	2.80**

* - Significant at 5 per cent level.
** - Significant at 1 per cent level.
di - relative heterosis
dii - heterobeltiosis
diii - standard heterosis Standard check Co 2

the three important characters viz., green fodder yield, dry fodder yield and leaf:stem ratio in di (relative heterosis), dii (heterobeltiosis) and diii (standard heterosis). The leaf:stem ratio of di and dii showed higher values which means the fodder is of succulent nature (Table 6).

Path analysis revealed that dry fodder yield recorded maximum direct effect on green fodder yield followed by leaf;stem ratio and number of leaves per clump in pearl millet. Similarly in napier grass dry fodder yield recorded maximum direct effect on green fodder yield followed by number of tillers per clump, leaf area per clump and stem girth. Similar findings were reported by Vijendra Das and Ratnam Nadar (1991) that green fodder yield was the result of direct effect of number of tillers, stem girth and leaf area. However, in case of

Table 7. Direct (bold figures) and indirect effects of yield components with green fodder yield in pearl millet x napier hybrids

	X1	X2	X3	X4	X5	X6	X7	X8	Genotypic correlation coefficient
X1	-2.162	-0.410	-0.249	0.315	2.747	0.028	0.325	- 0.229	0.366*
X2	0.450	1.967	-2.188	0.861	-0.988	-0.106	0.746	- 0.277	0.466**
X3	-0.210	1.678	-2.565	1.113	0.113	-0.067	0.783	- 0.295	0.550**
X4	-0.475	1.150	-1.989	1.435	0.109	-0.130	1.122	- 0.541	0.683**
X5	-2.010	-0.658	-0.098	0.053	2.955	0.091	0.015	- 0.148	0.200
X6	0.271	0.928	-0.769	0.830	-1.201	-0.224	1.035	- 0.375	0.497**
X7	-0.463	0.969	-1.327	1.088	0.030	-0.153	1.515	- 0.706	0.952**
X8	-0.550	0.607	-0.844	0.864	0.488	-0.093	1.190	- 0.898	0.763**

R = 0.261
* - Significant at 5 per cent level.
** - Significant at 1 per cent level.
X1 - Plant height
X2 - Number of tillers per clump
X3 - Number of leaves per clump
X4 - Leaf area per clump
X5 - Internode length
X6 - Stem girth
X7 - Dry fodder yield
X8 - Leaf:stem ratio

pearl millet x napier hybrids, internode length showed maximum direct effect on green fodder yield (2.955) but its ultimate correlation was not significant (Table 7). Hence, in the next order, the number of tillers per clump recorded highest direct effect (1.967) on green fodder yield followed by dry fodder yield (1.515) and leaf area per clump (1.435) showing significant positive correlation.

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VARIABILITY AND ASSOCIATION ANALYSIS OF YIELD COMPONENTS IN GREEN GRAM

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ABSTRACT

Variability parameters were estimated for seed yield and seven other quantitative traits in 30 genotypes of green gram. Heritability estimates were high for all characters except for number of clusters and number of pods. High heritability coupled with high genetic advance were observed for plant height and seed yield. Path analysis revealed that all direct effects towards seed yield were positive and the maximum was observed in the case of pod yield and number of pods indicating they are important traits for selection.

KEY WORDS : Variability, heritability, association analysis, path analysis

Seed yield in green gram (*Vigna radiata* (L.) Wilczek) is a complex trait, mainly dependent on many genetically controlled components. The nature and association of such characters with yield and among themselves play a vital role in choosing superior genotypes. The magnitude of genetic variability present in the genetic stock is important for improvement of yield. Heritability and genetic advance serves as a tool to the breeder in determining the direction and magnitude of selection. The present study was carried out to study the extent of variability, to study association of yield components among themselves and with seed yield and to study the direct and indirect effects of the components on seed yield in green gram.

MATERIALS AND METHODS

The experimental material consisted of 30 genotypes of green gram collected from various ecogeographical regions of India. Seeds were sown in randomised block design with three replications at the Millets Breeding Station, TNAU, Coimbatore during *Kharif* 1992. Each genotype

Table 1. Estimates of different variability parameters in green gram

Characters	Mean	PCV	GCV	Heritability	Genetic advance as per cent of mean
Plant height	32.48	31.71	29.87	84.01	54.94
No.of branches	1.63	17.52	16.20	85.52	30.49
No.of clusters	6.29	22.87	21.12	43.38	28.68
No.of pods	23.31	25.08	18.44	54.08	27.97
Pod length	6.92	28.26	25.48	81.33	47.38
Seeds/pod	10.89	8.05	6.98	75.18	12.48
Pod yield/plant	13.81	12.02	11.12	85.82	21.27
Seed yield	7.55	29.23	26.77	83.88	50.55