Table: – 1 Analysis of variance for eighteen characters in early maturing clones of sugarcane

Sl. No.	Characters	Mean sum of squares		
		Replication d.f.=2	Genotype d.f.=14	Error d.f.=28
1	Germination % at 45 DAP	18.42	37.95**	5.61
2	Number of Shoots at 120 DAP (000/ha)	100.16	169.62**	38.18
3	Plant height at 150 DAP (cm)	24.38	637.77**	76.40
4	Plant height at 240 DAP (cm)	102.84	1628.97**	176.08
5	Plant height at harvest (cm)	143.16	1440.10**	238.96
6	Cane diameter at harvest (cm)	0.024	0.073**	0.019
7	Millable canes at harvest (000/ha).	139.21	176.33**	59.87
8	Single cane weight at harvest (Kg).	0.004	0.046**	0.004
9	Brix at 8th month stage (%)	0.08	1.93**	0.31
10	Pol in juice at 8th month stage (%)	0.10	2.17**	0.20
11	Purity at 8th month stage (%)	0.04	4.35**	0.74
12	Brix at 10th month stage (%)	0.20	5.37**	0.13
13	Pol in juice at 10th month stage (%)	0.09	2.18**	0.09
14	Purity at 10th month stage (%)	1.76	12.21**	0.54
15	CCS at 8th month stage (%)	0.05	1.24**	0.11
16	CCS at 10th month stage (%)	0.06	0.78**	0.05
17	Sugar Yield At harvest (t/ha)	0.26	6.87**	1.12
18	Cane Yield At harvest (t/ha)	31.15	353.68**	67.10

* Significant at 5%, ** significant at 1%

Table: - 2 Grouping of clones into various clusters among fifteen genotypes of early maturing sugarcane clones

Clusters	Number	Clones
I	6	CoP11436
		CoLk12207
		CoP12436
		CoSe12451
		CoP14436
		CoP17438
II	**2**	CoP11437 (C)
		BO153 (C)
III	**3**	CoP15436
		CoP17437
		CoP17436
IV	**4**	CoP16437
		CoP16438
		CoP11438
		CoP15437

Table: - 3 Inter and Intra Cluster D^2 Distance of fifteen early maturing sugarcane clones

Clusters	I	II	III	IV
I	244.484	525.944	497.238	548.349
II		194.295	856.131	983.844
III			113.88	301.324
IV				161.183

Table: - 4 Cluster Means for eighteen characters of early maturing sugarcane clones

	Germination % at 45 DAP	Shoots per hectare at 120 DAP (000/ha)	Plant height at 150 DAP (cm)	Plant height at 240 DAP (cm)	Plant height at harvest (cm)	Cane diameter at harvest (cm)	millable cane Per hec at harvest (000/ha)	Single cane weight at harvest(Kg)	Brix at 8 month stage (%)	pol at 8 month stage (%)	Purity at 8 month stage (%)	Brix at 10 month stage (%)	pol at 10 month stage (%)	Purity at 10 month stage (%)	CCS at 8 month stage	CCS at 10 month stage	Sugar yield at harvest (CCS tonne/ha)	Cane yield (tonne/ha)
Cluster I	34.22	96.19	120.96	221.42	258.01	2.43	97.19	0.84	18.41	16.07	87.30	20.77	18.04	86.96	11.05	12.37	10.08	81.48
Cluster II	34.00	113.46	96.17	195.46	239.96	2.55	105.37	0.84	19.52	17.42	89.22	22.50	18.79	83.52	12.10	12.63	11.24	88.99
Cluster III	32.22	93.65	114.08	192.39	231.33	2.47	101.28	0.83	19.42	17.16	88.34	19.18	16.92	88.18	11.87	11.69	9.81	83.72
Cluster IV	36.08	100.48	122.50	239.23	273.92	2.77	93.23	1.09	19.10	17.00	89.06	20.45	17.98	87.97	11.80	12.41	12.56	101.26

Table: - 5 Character Contribution percent divergence of early maturing sugarcane clones

Character	Contribution %
1. Germination % at 45 DAP	0.01
2. Shoots at 120 DAP (000/ha)	0.01
3. Plant height at 150 DAP (cm)	0.01
4. Plant height at 240 DAP (cm)	0.01
5. Plant height at harvest (cm)	1.90
6. Cane diameter at harvest (cm)	0.01
7. Millable canes at harvest (000/ha)	0.01
8. Single cane weight at harvest (Kg)	2.86
9. Brix at 8 months stage (%)	0.01
10. Pol in juice at 8 months stage (%)	0.95
11. Purity at 8 months stage (%)	0.01
12. Brix at 10 months stage (%)	12.38
13. Pol in juice at 10 months stage (%)	44.76
14. Purity at 10 months stage (%)	0.01
15. CCS at 8 months stage (%)	2.86
16. CCS at 10 months stage (%)	0.01
17. Sugar Yield At harvest (t/ha)	18.10
18. Cane Yield At harvest (t/ha)	16.19

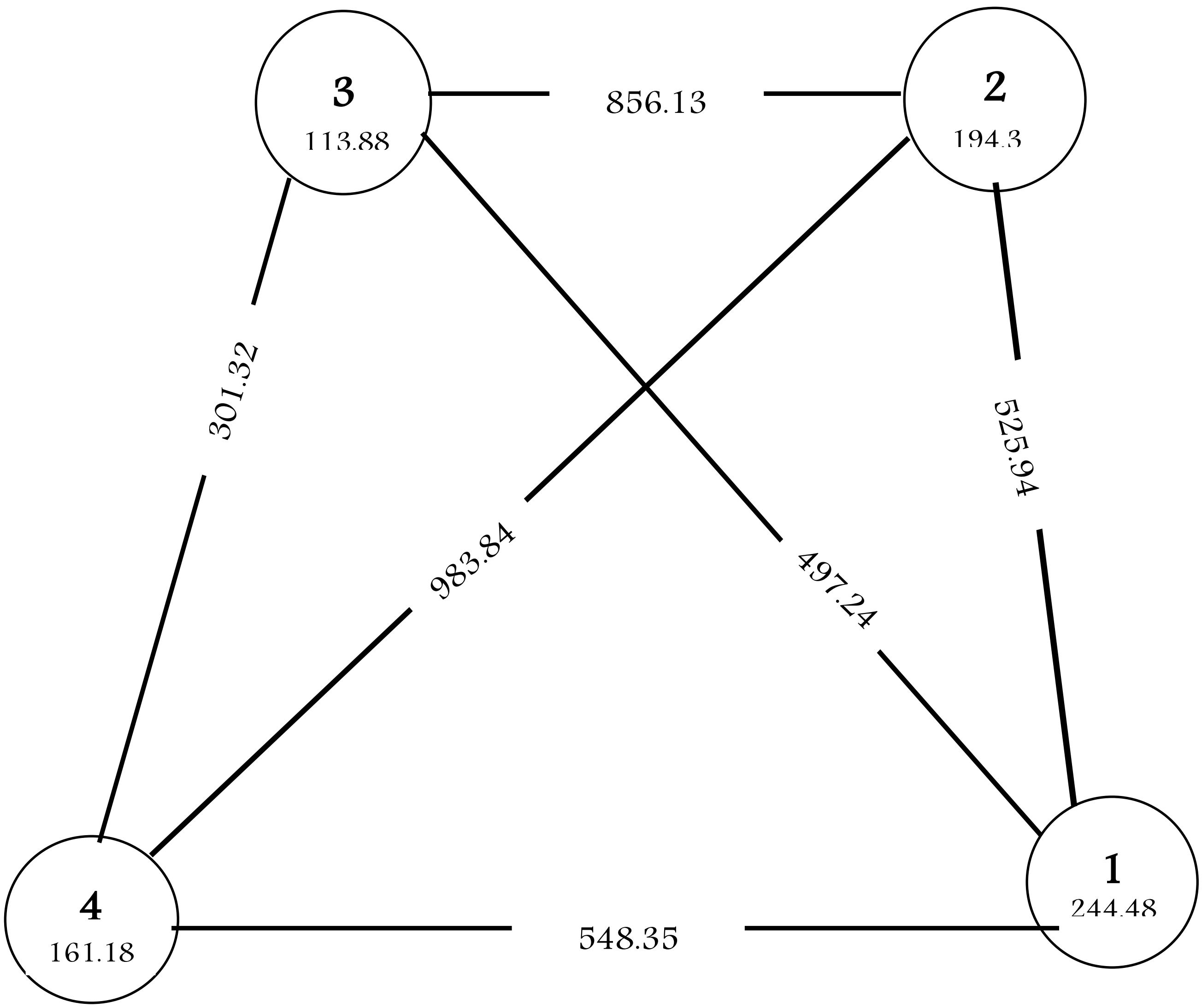

Figure 1 – Cluster diagram of 15 early maturing sugarcane clones

Result and Discussions

The ANOVA for 18 characters of early maturing sugarcane clones has been presented in Table-1. The analysis of variance showed high significant difference for all the traits. The results pointed out that clones differed significantly it means wide range of variability existing among the clones for all the characters. These variations had their bases in genetic differences among the clones.

All the clones were grouped into four distinguished cluster based on the method discussed previously. Table-2 mentioned the grouping of clones into various clusters among fifteen genotypes of early maturing sugarcane clones. Cluster I contained maximum number of clones (6) viz, CoP11436, CoLk12207, CoP12436, CoSe12451, CoP14436, CoP17438 followed by cluster IV (4) viz, CoP16437, CoP16438, CoP11438, CoP15437, cluster III (3) vizCoP15436, CoP17437, CoP17436 and cluster II (2) viz, CoP11437(C), BO153(C). The average intra- and inter-cluster distances were calculated from the D^2-values of respective clones within and between the clusters. References to Table-3 and figure-1 indicated that the intra-cluster D^2-values ranges from 113.88 to 244.484 (III-III, I-I) suggesting that substantial amount of diversities were present within the cluster itself. Maximum intra-cluster D^2distance was observed in cluster I (D^2= 244.484) and maximum inter-cluster D^2distance was observed between cluster II and cluster IV (D^2= 983.844). Figure 3 showed the Intra- and Inter-cluster D^2distancebetween the clusters. Table: - 4 showed the Cluster Means for different characters of early maturing sugarcane clones. Cluster II was observed to have highest cluster mean for number of shoots per hectare at 120 days, millable cane per hectare at harvest, brix at 8th month stage, pol percent at 8th month stage, purity at 8th month stage, brix at 10th month stage, pol percent at 10th month stage, ccs at 8th month stage and ccs at 10th month stage whereas cluster IV was observed to have highest cluster mean for germination at 45 days of planting, plant height at 150, 240 days and harvest, cane diameter at harvest, single cane weight at harvest, sugar yield at harvest and cane yield. Cluster III was observed to have highest cluster mean for only one character purity at 10th month stage. None of the characters was observed for highest cluster mean in cluster I. Table: - 5 showed the towards character contribution percent divergence of early maturing sugarcane clones. Pol percent at 10th month stage showed maximum character contribution percent towards divergence followed by sugar yield at harvest, cane yield, brix at 10th month stage etc.

The analysis of variance for all the eighteen characters indicated that clones, differed significantly for all the characters it means, presence of sufficient variability, scope for further selection, breeding superior clone and desirable genotypes. These variations had their bases in genetic differences among the clones and considerable improvement can be achieved by all these characters during selection. The finding of earlier workers namely Singh *et.al.* (2010), Ahmad *et.al.* (2010), Khan *et.al*. (2012), Ijaz *et.al.* (2013), Sanghera *et.al.* (2014), Kumar (2014), Sanghera *et.al.* (2015), Pandya *et.al.* (2015), Hiremath *et.al*. (2016), Sanghera *et.al*. (2017), Mehareb *et.al.* (2017), Patil *et.al*. (2017) and Ranjan and Kumar (2017) have already been reported the significant differences among the genotypes for all the characters.

Exploitation of heterosis largely depends on the degree of genetic divergence between the parents selected for breeding programme. Genetically diverse parents are expected to yield superior hybrids. Generally divergence study in performed to seek superior parents for having maximum heterosis by utilizing optimum level of diversity. The population that belong to heterogeneous environments are not necessarily genetically more diverse. Genotypes which are grouped together are less divergent as compared to those which belong to different clusters. Clusters separated by maximum statistical distance show the maximum divergence. Therefore, while selecting parents for crossing programme, two point should be considered:

1. The choice of clusters with maximum statistical distance and
2. Selection of two genotypes from already chosen clusters,

Crossing of genetically diverse parents with desirable gene controlling economic quantitative and quality characters may give elite progenies due to assembling of those desirable genes.

In the present investigation, all the fifteen genotypes were grouped into four clusters. Clustering pattern showed that the genetic diversity was more important than geographical diversity because genotypes belonging to different places of origin were also present in the same clusters. This confirms the findings of Patil et.al. (2017).

Maximum inter-cluster distance was observed between cluster II and cluster IV followed by between cluster II and cluster III, cluster I and cluster IV, cluster I and cluster II, cluster I and cluster III with a least value between cluster III and cluster IV. Maximum intra-cluster distance was shown by cluster I followed cluster II, cluster IV and cluster III.

Theoretically, a breeder may anticipate maximum manifestation of heterosis in hybrids derived from crossing of genotypes having maximum genetic distance. On this ground, crossing should be effected between the genotypes that belong to cluster II and cluster IV.

However, in selecting varieties from the already chosen groups, the maximum genetic distance suggested that genotypes with high index for specific characters that fall into different clusters could be inter-crossed to generate good number of sugarcane progenies having greater potentiality for breeding purpose by virtue of their desirable characters (Sanghera*et.al*. 2015), similar suggestion was also given by (Ahmad *et.al* 2010). It may be possible that genotypes having maximum genetic diversity possess low yielding ability and other characters with poor performance. Further-more, maximum expression of heterosis is often limited with the hybrids derived from genotypes that are neither closely nor distantly related.

The mean performance of the genotypes belonging to cluster IV with regards to characters for which selection may be practiced was high. However, the mean performance of the genotypes belonging to cluster II and cluster III that was separated by high genetic distance from cluster IV. A critical analysis of cluster means for different traits indicated that Cluster II was observed to have highest cluster mean for number of shoots per hectare at 120 days, millable cane per hectare at harvest, brix at 8th month stage, pol percent at 8th month stage, purity at 8th month stage, brix at 10th month stage, pol percent at 10th month stage, ccs at 8th month stage and ccs at 10th month stage whereas cluster IV was observed to have highest cluster mean for germination at 45 days of planting, plant height at 150, 240 days and harvest, cane diameter at harvest, single cane weight at harvest, sugar yield at harvest and cane yield. Cluster III was observed to have highest cluster mean for only one character purity at 10th month stage. The maximum genetic distance suggested that genotypes with high index for specific characters that fall into different clusters could be intercrossed to generate good number of sugarcane progenies having greater potentiality for breeding purpose by virtue of their desirable characters. Similar suggestions were given by Sanghera*et.al*. (2015)

Through the mean performance of the genotypes that fell into cluster II and cluster III was not as good as those of cluster IV, still high expression of heterosis for cane yield can be expected if complementary gene action is present with regard to cane yield. Hence, crossing between genotypes belonging to cluster II and cluster IV as well as cluster III and cluster IV may be advocated for maximum expression of heterosis in regard to cane yield.

Therefore, on the basis of present finding and their conclusive reasoning, bi-parental mating or poly cross technique involving genotypes belonging to cluster II and cluster IV as well as cluster III and cluster IV may be advocated in order to generate seedling to superior genetic background. Clonal selection in subsequent generation should be based on number of millable canes, number of shoot at 120 days and plant height at harvest for developing high yielding sugarcane varieties. Observations on germination at 45 days of planting, single cane weight, cane diameter should also be recorded and clonal surpassing these characters of standard varieties be advanced to next clonal generation. Quality attributes like brix, pol and purity percent cannot be ignored. These quality characters should also be recorded at 8th and 10th month of planting in order to develop short duration early varieties.

Summary and conclusion

The range of variations alluded possibility of improvement among the clones for the characters. However, the analysis of variance appraised significant differences for all the characters. Keeping all the genetic information and their conclusive interpretations, it can be safely concluded that to attained these objectives, further sugarcane breeding programme bi-parental mating or poly-cross technique used for developing high yielding sugarcane clones involving genotypes belonging to cluster II and cluster IV as well as cluster III and cluster IV may be tried

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