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STUDY OF INTER-RELATIONSHIP AND CAUSE-EFFECT OF YIELD AND ITS ATTRIBUTES OF SUGARCANE UNDER WATER-LOGGING CONDITION

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ABSTRACT
In a field experiment eighteen sugarcane clones were evaluated to study the correlation and path coefficient analysis based on eighteen traits under water logged condition. Correlation studies indicated that, traits *viz*. plant height at 150 days (0.698), 240 days (0.771) and 360 days (0.802), single cane weight (0.802), brix % at 10 month stage (0.577) and 12 month stage (0.907), pol % at 10 month stage (0.921) and 12 month stage (0.887) showed significant positive correlation and number of aerial roots/ node (-0.488) had significant negative correlation with cane yield under water-logged condition. Path analysis revealed that number of shoot at 120 days (0.745), plant height at 150 days (0.698), 240 days (0.771) and 360 days (0.802), cane diameter (0.254) at harvest, number of millable canes (0.672), single cane weight (0.802), pol % at 10 month stage (0.921), brix % at 12 month stage (0.907) and pol % at 12 month stage (0.887) showed positive direct effect towards cane yield at genotypic level showed importance of these characters for further yield improvement.

INTRODUCTION

Cane yield is the end product of interaction of which is influenced by a number of contributing characters. An understanding of the association between contributing traits and their relative contribution to yield is essential to bring a rational improvement in the desirable traits. Wright (1934) developed path coefficient analysis, a statistical device which is unique in partitioning the association into direct and indirect effects through other dependent variables. Cane yield and juice quality lower down under water-logged condition, depends upon location, depth and duration of water-logging, flow of water, aerial roots, stage of crop genotype, environmental vagaries including biotic and abiotic stress during its active growth conditions, stage of development and duration of inundation which could be minimized by development of improved genotypes. Suitability of genotypes to a particular agro-ecological situation is the most important factor in realizing their yield potential as the productivity under stress condition which depends upon the amount of variability and extent to adaptability present in particular genotypes (Arya *et al.*, 2013). The tolerant varieties elongate faster with early tiller formation showed compensatory mechanism for water logging tolerance (Kumar, 2009).The final yield of sugarcane is greatly depends upon the tillering habit of the genotype (Patel and Patel,2014).This study was conducted to find correlation between yield and its attributes under water-logging and to analyze cause along with their direct and indirect effects on yield and also to identify better combination as selection criteria for developing high yielding sugarcane clones under water-logged condition.

MATERIALS AND METHODS

The present study was undertaken with evaluation of high sucrose containing sugarcane clones under water logging condition (water depth 45 to 60 cm from July to October) involved eighteen sugarcane clones including two checks (BO 91 and CoLk 94184), were planted in Paddy block at Dr.Rajendra Prasad Central Agricultural University, Pusa, Bihar, in a Randomized Block Design with three replications during 2014 - 15. The characters studied *viz* .germination % at 45 DAP, number of shoots at 120 DAP, plant height at 150, 240 and 360 days, cane diameter at harvest, number of millable canes, brix, pol and purity % at 10 and 12 month stage, single cane weight, number of aerial roots/ node, length of aerial root, dry weight of aerial roots during the water-logging period and cane yield. Observed data for all the traits of 18 high sucrose containing sugarcane clones were assessed for statistical analysis.

Brix % at 10 & 12 month stage

It is a measure of total soluble solids present in the juice. It was taken directly by using a Brix hygrometer. 250 ml juice was taken in measuring cylinder and hygrometer dip into the juice then reading was recorded from the juice level. These readings were corrected to the temperature at 20 ^{o}by using temperature correction chart as described by Spencer and Meade (1955).

Pol % at 10 & 12 month stage

Pol refers to the sucrose per cent in juice. It was done according to the method described by Spencer and Meade (1955). It was estimated with the help of Polari scope. First 100 ml juice was taken in conical flask and 4 gm Honey dry lead sub acetate

was added and mixed well by shaking the flask. After few minutes this solution was filtered twice through a dry Whatsman no. 1 filter paper and the abstract was collected into a clean and dry beaker. The abstract poured into the Polari meter tube. These tubes were placed in the Polari scope. Thereafter, Pol values were recorded by polarising the clear juice in Polari scope this value called dial reading. Sucrose per cent in juice was obtained by referring the brix and dial reading to Schmitz's table.

RESULTS AND DISCUSSION

In present study the characters *viz*. plant height at 150,240 & 360 days, single cane weight, brix per cent at 10 & 12 month stage, pol per cent at 10 & 12 month stage, germination per cent at 45 DAP, number of Shoots at 120 DAP, cane diameter at harvest, number of millable canes and purity per cent at 10 & 12 month stage showed positive and significant correlation with cane yield at both genotypic and phenotypic level indicates that increase in these traits were ultimately increases the cane yield. Sanjeev *et al*. (2001) observed that cane yield was closely associated with number of tillers and millable cane, germination percentage and single cane weight. Setia *et al*. (2001) revealed that germination and number of millable canes were significantly associated with cane yield. Ishaq *et al*.(2002) stated that stalk weight, stalk height, number of stalk, leaf area, juice, stalk diameter were the major traits contributing to cane and sugar yield and similar result were obtained by Puneet *et al*.(2002), Thippeswamy *et al*. (2003), Krishna *et al*. (2004) also observed a significantly and positive correlation of cane yield with plant height at 120 and 240 days, number of millable canes, cane height, cane girth and single cane weight. Ravishankar *et al*. (2004) reported that the genetic correlation was greater than the phenotypic correlation and at both level number of tillers and single cane weight showed a highly significant positive association with cane yield. Rajib *et al*. (2007) reported that cane length, single cane weight, cane diameter and Purity percentage had high positive genetic association with both cane and sugar yield. Thangavelu (2011) also found significant positive annunciation among brix, sucrose and Purity at both levels. Tyagi *et al*. (2012) reported that cane and sugar yield components *like* number of millable cane, cane weight and cane height were desirable traits for selection criteria in sugarcane varietal improvement programme.While number of aerial roots per node negatively associated with cane yield whereas length of aerial roots, dry weight of aerial roots showed negative association with cane yield at both genotypic and phenotypic level which indicated that with increase in these traits will lead to decrease in cane yield. From results of both genotypic and phenotypic correlation coefficient, single cane weight came out as the main component character contributing to both cane and sugar yield.

In the present investigation, number of shoot at 120 DAP, plant height at 120 & 360 days, cane diameter, number of millable canes, single cane weight, brix per cent a 10 month stage, purity per cent 10 month stage, pol per cent 12 month stage and length of aerial roots were most important characters having positive direct effect on cane yield at phenotypic level indicates true relationship between them and direct selection for these traits will be rewarding for yield improvement while germination per cent at 45 DAP ,plant height at 240 days, pol per cent at 10 month stage, brix per cent at 12 month stage, purity per cent at 12 month stage, number of aerial roots per node and dry weight of aerial roots having negative direct effect on cane yield at phenotypic level.

At genotypic level number of shoot at 120 days, plant height at 150 days, plant height a 360 days, cane diameter at harvest, number of millable canes, single cane weight, pol per cent at 12 month stage, length of aerial roots, pol per cent at 10 month stage, brix per cent at 12 month stage, showed positive direct effect towards cane yield indicates true relationship between them and direct selection for these traits will be rewarding for yield improvement, while germination per cent 45 DAP, plant height at 240 days, brix per cent at 10 month stage, purity per cent at 10 month stage, purity per cent at 12 month stage, number of aerial roots per node, dry weight of aerial roots showed direct negative effect toward cane yield. These results were in support with similar findings of Kumar and Singh (1999), Navnit *et al*. (2015) and Krishna *et al*. (2004). They observed that single cane weight and number of millable canes had

Table 1: Genotypic Correlation coefficient of seventeen characters with cane yield in high sucrose containing sugarcane clones under water-logging condition

SNo	Character	G%	S120	PH150	PH240	PH360	CD	MC	SCW	B%10	P%10	PU%10	B%12	P%12	PU%12	NAR/N	LAR	DW	CY
1	G%	1.000	0.908	0.603	0.465	0.495	-0.019	0.528	0.201	0.621	0.763	0.365	0.821	0.715	-0.169	0.311	-0.117	0.071	0.756
2	S120		1.000	0.059	0.256	0.297	0.207	0.359	0.332	0.575	0.770	0.471	0.650	0.505	-0.474	0.447	-0.066	0.148	0.745
3	PH150			1.000	0.715	0.744	0.524	-0.258	0.964	0.707	0.730	-0.131	0.643	0.621	0.380	-0.334	-0.046	-0.443	0.698
4	PH240				1.000	0.902	0.261	0.217	0.511	0.574	0.629	0.002	0.705	0.699	0.468	-0.470	-0.459	-0.518	0.771
5	PH360					1.000	0.248	0.229	0.540	0.579	0.646	0.031	0.710	0.705	0.481	-0.496	-0.478	-0.544	0.802
6	CD						1.000	-0.972	0.833	-0.010	0.154	0.554	-0.081	-0.144	-0.476	0.213	-0.018	0.100	0.254
7	MC							1.000	-0.401	0.511	0.426	-0.387	0.627	0.654	0.698	-0.585	-0.089	-0.169	0.672
8	SCW								1.000	0.233	0.466	0.690	0.411	0.388	0.095	-0.098	-0.217	-0.194	0.802
9	B%10									1.000	0.956	-0.349	0.770	0.787	0.640	-0.062	-0.071	-0.148	0.577
10	P%10										1.000	-0.272	0.938	0.968	0.732	-0.007	-0.094	0.020	0.921
11	PU%10											1.000	0.243	0.228	-0.072	0.283	-0.019	0.541	0.749
12	B%12												1.000	0.914	0.734	-0.171	-0.331	-0.211	0.907
13	P%12													1.000	0.725	-0.256	-0.309	-0.212	0.887
14	PU%12														1.000	-0.685	-0.138	-0.130	0.566
15	NAR/N															1.000	0.555	0.662	-0.488
16	LAR																1.000	0.730	-0.476
17	DW																	1.000	-0.285
18	CY																		1.000

Table 2: Phenotypic Correlation coefficient of seventeen characters with cane yield in high sucrose containing sugarcane clones under water-logging condition

S.No	Character	G %	S120	PH150	PH240	PH360	CD	MC	SCW	B%10
1	G %	1	0.911**	0.213	0.353**	0.333*	0.029	0.153	0.116	0.280*
2	S120		1	0.193	0.252	0.232	0.147	0.097	0.177	0.288*
3	PH150			1	0.728**	0.728**	0.289*	-0.055	0.411**	0.318*
4	PH240				1	0.988**	0.224	0.141	0.336*	0.421**
5	PH360					1	0.227	0.168	0.341*	0.418**
6	CD						1	0.444**	0.523**	-0.006
7	MC							1	-0.197	0.256
8	SCW								1	0.173
9	B%10									1
10	P%10									
11	PU%10									
12	B%12									
13	P%12									
14	PU%12									
15	NAR/N									
16	LAR									
17	DW									
18	CY									

S.No	P%10	PU%10	B%12	P%12	PU%12	NAR/N	LAR	DW	CY
1	0.485**	0.300*	0.437**	0.335*	-0.144	0.216	-0.147	0.008	0.156
2	0.489**	0.319*	0.395**	0.310*	-0.142	0.274*	-0.123	0.068	0.224
3	0.326*	0.03	0.346*	0.377**	0.165	-0.181	0.007	-0.280*	0.275*
4	0.475**	0.101	0.578**	0.591**	0.224	-0.334*	-0.343*	-0.461**	0.394**
5	0.461**	0.087	0.581**	0.591**	0.214	-0.353**	-0.333*	-0.485**	0.411**
6	0.171	0.270*	-0.025	-0.073	-0.188	0.182	-0.012	0.061	0.121
7	0.256	-0.007	0.313*	0.373**	0.299*	-0.175	-0.159	-0.081	0.194
8	0.356**	0.329*	0.350**	0.308*	0.018	-0.114	-0.186	-0.151	0.418**
9	0.718**	-0.297*	0.690**	0.676**	0.218	-0.044	-0.082	-0.12	0.327*
10	1	0.402**	0.691**	0.631**	0.161	0.073	-0.057	0.016	0.400**
11		1	0.092	0.043	-0.029	0.15	0.019	0.237	0.243
12			1	0.923**	0.187	-0.115	-0.268	-0.202	0.632**
13				1	0.530**	-0.181	-0.291*	-0.196	0.614**
14					1	-0.243	-0.138	-0.047	0.152
15						1	0.338*	0.494**	-0.285*
16							1	0.657**	-0.257
17								1	-0.2
18									1

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

Table 3: Genotypic Path coefficient of eighteen characters in high sucrose containing sugarcane clones under water-logging condition

S.No	Character	G%	S120	PH150	PH240	PH360	CD	MC	SCW	B%10	P%10	PU%10	B%12	P%12	PU%12	NAR/N	LAR	DW
1	G%	-0.076	0.105	0.012	-0.011	0.089	-0.011	0.145	0.088	-0.219	0.104	-0.31	0.109	0-.135	0.075	-0.108	0.044	-0.36
2	S120	0.169	0.501	0.012	0.106	0.053	0.038	0.098	0.074	0.153	0.184	0.154	0.145	0.126	0.107	0.098	0.092	0.353
3	PH150	0.095	0.030	0.204	0.202	0.133	0.019	-0.057	0.031	0.259	0.034	0.081	0.032	0.025	0.158	0-.076	-0.473	0.082
4	PH240	0.036	0.013	0.086	0-.023	-0.162	0.017	0.089	0.083	0.203	0.026	0.083	0.126	0-.103	-0.095	0.076	-0.519	-0.389
5	PH360	0.088	0.045	0.081	0.102	0.179	0.019	0.095	0.034	0.204	0.048	-0.023	0.068	0.069	0.116	0-.086	-0.536	0.291
6	CD	0.096	0.015	0.061	-0.006	0.044	0.036	-0.163	0.063	0.083	0.025	0.147	-0.143	-0.078	0.198	-0.082	0.061	0.056
7	MC	0.046	0.038	-0.053	0.095	0.041	-0.035	0.219	-0.195	0.181	0.035	0.083	0.024	0.29	0.209	0-.071	-0.304	-0.309
8	SCW	0.055	0.017	0.061	-0.012	0.097	0.034	-0.088	0.437	0.082	0.055	0.1059	0.015	0.103	0.055	0.047	-0.126	0.133
9	B%10	-0.047	0.109	0.174	-0.013	0.104	0.021	0.127	0.102	-0.035	0.305	0.143	0.29	0.412	0.127	0-.084	-0.191	0.235
10	P%10	-0.058	0-.286	0.089	-0.014	-0.116	0.076	0.093	0.094	-0.337	0.001	0.034	0-.353	0-.306	0.092	0.042	0.012	-0.106
11	PU%10	0.128	0.124	-0.027	0.103	0.076	0.023	-0.085	0.212	0.123	-0.021	-0.085	0.071	0.039	0.124	0.029	0.334	-0.121
12	B%12	-0.063	0.033	0.063	-0.016	-0.127	-0.003	0.137	0.180	-0.271	0.057	-0.021	0.377	0-.179	-0.306	0.042	-0.113	-0.102
13	P%12	0.154	0.025	0.137	-0.016	0.201	-0.042	0.143	0.170	0.278	0.029	0.119	0.058	0.523	-0.302	-0.205	-0.123	0.131
14	PU%12	0.073	-0.267	0.084	-0.011	-0.086	-0.017	0.154	0.042	-0.226	0.034	0.106	0-.277	0-.204	-0.416	0.017	-0.108	-0.234
15	NAR/N	-0.024	0.017	-0.068	0.101	0.089	0.075	-0.128	-0.193	0.022	0.019	-0.024	-0.085	-0.254	0.273	-0.07	0.408	-0.025
16	LAR	0.089	-0.133	-0.115	0.121	0.090	-0.001	-0.02	-0.135	0.025	-0.031	0.202	-0.125	-0.242	0.087	-0.206	0.45	0.219
17	DW	-0.005	0.074	-0.103	0.039	0.097	0.005	-0.087	-0.285	0.052	0.017	-0.046	-0.055	-0.126	0.064	-0.168	0.616	-0.139
18	CY	0.756	0.745	0.698	0.771	0.802	0.254	0.672	0.802	0.577	0.921	0.749	0.907	0.887	0.566	-0.488	-0.476	-0.285

Residual effect = 0.346

Table 4: Phenotypic Path coefficient of eighteen characters in high sucrose containing sugarcane clones under water-logging condition

S.No	Character	G%	S120	PH150	PH240	PH360	CD	MC	SCW	B%10	P%10	PU%10	B%12	P%12	PU%12	NAR/N	LAR	DW
1	G%	-0.454	-0.413	-0.097	-0.160	-0.151	-0.013	-0.070	-0.053	-0.127	-0.220	-0.136	-0.198	-0.152	0.065	-0.098	0.067	-0.004
2	S120	0.312	0.343	0.066	0.086	0.080	0.051	0.033	0.061	0.099	0.168	0.109	0.235	0.306	-0.049	0.094	-0.042	0.023
3	PH150	0.011	0.010	0.053	0.039	0.039	0.015	-0.003	0.022	0.017	0.017	0.002	0.118	0.020	0.009	-0.010	0.009	-0.015
4	PH240	-0.079	-0.057	-0.163	-0.224	-0.222	-0.050	-0.032	-0.075	-0.095	-0.107	-0.023	-0.13	-0.133	-0.050	0.075	0.077	0.104
5	PH360	0.034	0.023	0.073	0.099	0.100	0.023	0.017	0.034	0.042	0.046	0.009	0.158	0.159	0.022	-0.036	-0.033	-0.049
6	CD	0.002	0.012	0.023	0.018	0.018	0.080	-0.036	0.042	-0.001	0.014	0.022	-0.002	-0.006	-0.015	0.015	-0.001	0.005
7	MC	0.011	0.007	-0.004	0.011	0.013	-0.033	0.075	-0.015	0.019	0.019	-0.001	0.023	0.028	0.022	-0.013	-0.012	-0.006
8	SCW	0.003	0.005	0.012	0.010	0.011	0.015	-0.006	0.029	0.005	0.012	0.010	0.012	0.009	0.001	-0.003	-0.005	-0.004
9	B%10	0.146	0.150	0.165	0.219	0.217	-0.003	0.133	0.090	0.519	0.373	-0.155	0.358	0.451	0.113	-0.023	-0.043	-0.062
10	P%10	-0.304	-0.307	-0.205	-0.298	-0.289	-0.107	-0.160	-0.224	-0.450	-0.628	-0.252	-0.434	-0.396	-0.101	-0.046	0.036	-0.011
11	PU%10	0.204	0.216	0.022	0.067	0.059	0.171	-0.005	0.224	-0.202	0.273	0.680	0.363	0.429	-0.020	0.102	0.013	0.161
12	B%12	-0.120	-0.108	-0.095	-0.159	-0.160	0.007	-0.086	-0.096	-0.189	-0.190	-0.025	-0.275	-0.254	-0.051	0.032	0.065	0.056
13	P%12	0.381	0.353	0.415	0.672	0.672	-0.083	0.424	0.350	0.769	0.718	0.049	0.249	0.137	0.603	-0.206	-0.332	-0.223
14	PU%12	0.066	0.065	-0.075	-0.102	-0.098	0.086	-0.136	-0.008	-0.099	-0.073	0.012	-0.085	-0.242	-0.456	0.111	0.062	0.022
15	NAR/N	-0.052	-0.066	0.044	0.081	0.085	-0.044	0.042	0.028	0.011	-0.018	-0.036	0.128	0.243	0.059	-0.241	-0.082	-0.119
16	LAR	-0.004	-0.003	0.014	-0.009	-0.009	0.012	-0.004	-0.005	-0.002	-0.002	0.001	-0.007	-0.008	-0.004	0.009	0.026	0.017
17	DW	-0.001	-0.006	0.027	0.044	0.046	-0.006	0.008	0.014	0.011	-0.002	-0.023	0.119	0.023	0.005	-0.047	-0.062	-0.095
18	CY	0.156	0.224	0.275*	0.394**	0.411**	0.121	0.194	0.418**	0.327*	0.400**	0.243	0.632**	0.614**	0.152	-0.285*	-0.257	-0.200

Residual Effect = 0.468

Abbreviations

G% = Germination per cent at 45 days after planting, S 120 = Number of shoots at 120 DAP (000/ ha), PH 150 = Plant height at 150 days (cm), PH 240 = Plant height at 240 days (cm), PH 360 = Plant height at 360 days (cm), CD = Cane diameter at harvest (cm), MC = Number of millable canes (000/ ha) , SCW = Single cane weight (kg) , B%10 = Brix at 10 month (%) , P%10 = Pol at 10 month (%), PU%10 = Purity at 10 month (%) , B%12 = Brix at 12 month (%), P%12 = Pol at 12 months (%), PU%12 = Purity at 12 month (%), NAR/N = Number of aerial roots/ node, LAR = Length of aerial roots (cm), DW = Dry weight of aerial roots (g), CY = Cane yield (t/ ha)

maximum direct effects on cane yield. Setia *et al*. (2001) revealed that number of millable cane and single cane weight had higher direct effect on cane yield also *via* number of millable canes, germination percentage and number of tillers had very high indirect effect on cane yield. Ishaq *et al*. (2002) showed that stalk weight, stalk height, number of stalks had high direct effect on cane yield. Praveen *et al*. (2004) revealed highest direct effect of single cane weight on cane yield. Chandrakant *et al*. (2007) revealed that number of millable canes and single cane weight were major contributor to cane yield, Rajib *et al*. (2007) reported that number of millable canes has maximum direct effect on cane yield and single cane weight has the maximum direct effect on sugar yield, whereas both sugar and cane yield were influenced directly by single cane weight, number of millable canes and sucrose percentage. Rahman *et al*. (2008) indicated that number of tiller, number of millable canes, stalk height, stalk girth and stalk weight were the most important contributors to cane yield. Mali *et al*. (2010) observed that sucrose percentage juice had highest positive direct effect on cane yield. Whereas, Seeja and Sreekumar (2011) revealed that single cane weight recorded high direct and positive effect on cane yield. Length of aerial roots showed high positive direct effect and negative correlation with cane yield indicates that in such situation direct selection for such trait should be practised to reduce the undesirable indirect effect.

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