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Research Note

Association study of yield and its component traits in sugarcane seedlings

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Abstract
An experiment was carried out to investigate the relationship between specific quantitative characters and sugarcane yield at the Sugarcane Research Institute, Pusa, Bihar, in February 2022. Thirty sugarcane seedlings obtained from three different crosses along with check were subjected to estimation trait association by correlation and path analyses. Cane yield showed strong positive and highly significant correlation with single cane weight, number of millable canes per clump and brix percent at 12th month. There was also positive significant correlation of number of shoots per clump with cane yield. Path analysis revealed the highest positive direct effect of brix percent at 12th month on cane yield followed by brix percent at 10th month and cane diameter. However, number of shoots per clump had considerable negative direct effects and indirect positive effects through single cane weight and number of millable canes per clump on cane yield. The traits that provide considerable positive correlation and positive direct effects to cane yield could be used as selection indices for yield improvement in for further clonal generations.

Keywords: Correlation; Cane yield; Path analysis; Sugarcane seedlings; Variability

Sugarcane and sugar beet, are the two main crops used to make sugar globally, with sugarcane accounting for around more than half of the production (Ruggeri and Corsi, 2019). A mature sugarcane stalk normally contains 63-73% water, 11-16% fibre, 12-16% soluble sugars, and 2-3% non-sugars (Tena *et al*., 2016). During 2021-22, India was the largest sugar-producing country in the world, with an approximate yield of 36.88 million metric tons of sugar. During this period, India became second largest exporter of sugar in the world. Approximately 5.098 million hectares of area was under sugarcane in India, with a yield of 430.50 million tonnes and a productivity of 84.44 t/ha. Conversely, it was grown on 0.219 million hectares in Bihar State, where it produced 13.97 million tonnes of cane yield with productivity of 66.25 t/ha (DES, Ministry of Agriculture and Farmers Welfare ,2021-22).

To develop new, high-yielding sugarcane cultivars, knowledge regarding the association of yield with other traits is essential. Assessment of correlation can shed light on the type and scope of the complex trait of cane yield's relationships with other characteristics (Al-Ashkar *et al,*. 2021). Though correlation analysis can provide insight into the type of relationship between various traits, simple phenotypic correlation is not an effective basis for selection. Thus, the evaluation of the pattern of innate relationships among the different traits is made possible by a phenotypic correlation that relies on the inheritance of the observed variation (Praneetha *et al*., 2024).

Considering the correlation coefficients truly are not sufficient to fully depict the relationship between yield qualities and other parameters. It is necessary to perform path analysis especially to know the interrelated components. Every correlation coefficient that exists between a dependent and independent variable is broken down into its constituent parts. These include the dependent variable's direct effect, also known as the path coefficient (a standardised partial regression coefficient), and indirect effects, which are the result of multiplying a correlation coefficient between two independent variables by the relevant path coefficient shown in the path diagram (Tena *et al*., 2016). This method allows for the evaluation of both the direct and indirect effects of various attributes on cane yield, which in turn helps the breeder create more effective selection strategies to increase yield.

In the February 2022 season, a trial was carried out using two general crosses, *i.e*., BO154 GC and CoP 11437 GC, and one biparental cross (Co 0238 x Co 775) seedlings that were raised from the fluffs of these crosses at the National Hybridization Sugarcane Garden, ICAR-SBI, Coimbatore, by the breeders of Sugarcane Research Institute, Pusa, Bihar, for evaluation. An un-replicated trial was employed in arranging the experimental materials so that selection of individual plants can be done more precisely and the check *i.e*., Rajendra ganna 1 was replicated for each cross. After transplantation, from each slot of crosses , ten seedlings were selected and tagged, including the check to collect data on quantitative traits. All recommended agronomic practices were followed (Kumar *et al*., 2019). Twelve months after planting, at the harvest period, following characteristics were measured: Plant height, number of shoots per clump (NS/C), leaf length, cane diameter, single cane weight (SCW), number of millable canes per clump (NMC/C), brix percent at 10th and 12th months along with cane yield.

For estimating the genetic relationships between the dependent trait *i.e*., cane yield and other independent traits, correlation analysis was performed as per Falconer (1964) and path analysis as per Dewey and Lu (1959) .

Correlation studies: The findings of correlation studies conducted on the seedlings of three crosses **(Table 1**) showed that the trait plant height had a negative significant correlation with leaf length (-0.4248), brix percent at 10th and 12th months (-0.5632, -0.4914), indicating that this trait contributed less to the sucrose content in the stalk. On the other hand, its contribution towards cane diameter (0.8263) and single cane weight (0.6398) was positive. Kumar and Kumar (2014) observed negative association of plant height with brix percent in his studies. Leaf length showed non-significant association with most of the traits but had significant negative correlation with single cane weight (-0.8237). This agrees with the findings of Kadian and Mehla (2006). The traits like brix percent at 10th month (0.7459), brix percent at 12th month (0.7645), cane diameter (0.5218) and number of millable canes per clump (0.9774) were found to be positive and significantly correlated with number of shoots per clump. This has a major impact on deciding the parental material to be selected for the hybridization procedure. Tabassum *et al.* (2023) and Rakesh *et al.* (2023) also mentioned the significance of this trait in cane yield selection. Brix percent at 10th month had positive and significant relation with brix at 12th month (0.9955) and NMC/C (0.8284) whereas brix percent at 12th month was positive and significantly correlated with only single trait *i.e.,* NMC/C (0.8558). A positive association of brix with millable canes was observed in the results obtained by Devendra *et al.* (2022) and Ahmed *et al.* (2019). The trait cane diameter showed positive association with single cane weight (0.5395) and number of millable canes per clump (0.4339). Findings from Guddadamath *et al*. (2014) and Alam *et al*. (2017) indicated that cane diameter and single cane weight together had significantly contributed to cane yield improvement.

Cane yield had significant positive correlation with NS/C, brix percent at 10th and 12th months, SCW and NMC/C. Patra *et al.* (2022) concluded that the traits single cane weight, number of shoot and number of millable canes had strong association with sugar yield. Similar kind of observations were recorded by Anbanandan *et al*. (2020), Verma *et al*. (2021) and Kumar *et al.* (2022) in their experimental findings. The data presented above

Table 1. Phenotypic correlation coefficients of cane yield and its attributing traits in sugarcane seedlings

Source	PH	LL	NS/C	B (10th)	B (12th)	CD	SCW	NMC/C	CY/C
PH	**1.000**	-0.4248*	-0.0076	-0.5632**	-0.4914**	0.8263**	0.6398**	-0.0502	0.1324
LL		**1.000**	0.2489	0.1039	0.0263	-0.0508	-0.8237**	0.0808	-0.5677**
NS/C			**1.000**	0.7459**	0.7645**	0.5218**	0.2801	0.9774**	0.6295*
B (10$^{th)}$				**1.000**	0.9955**	-0.1450	0.1111	0.8284**	0.6718*
B (12th)					**1.000**	-0.0872	0.2050	0.8558**	0.7389**
CD						**1.000**	0.5395**	0.4339*	0.2927
SCW							**1.000**	0.3942	0.8103**
NMC/C								**1.000**	0.7678**

* 5 percent level of significance; ** 1 percent level of significance

Note: PH= Plant Height; NS/C= No. of Shoots per Clump; LL= Leaf Length; CD=Cane Diameter; SCW= Single Cane Weight; NMC/C= No. of Millable Canes/Clump; B (10th) = Brix in 10th month; B(12th) = Brix in 12th month; CY/C= Cane yield per Clump.

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indicates that a variety of characters impact cane yield, and the degree to which a particular character influences yield is determined by the degree of correlation between that character and yield. The selection of superior seedlings for subsequent clonal generations is aided by the higher contribution of the phenotypic correlation between yield and the traits that contribute to it. The graphical representation of correlation of cane yield and its related traits is shown in **Fig. 1**.

Path coefficient studies: The yield and its dependent variables were studied in the current research to obtain information on the indirect and direct effects. Although there may be a positive or negative relationship between yield and yield components, it is ultimately the outcome of that specific trait's direct influence as well as indirect effects through other traits which should be considered (Anbanandan *et al*., 2020). Therefore, it is essential to ascertain the path coefficients that divide the observed correlation into effects that are direct and indirect.

The result of path coefficient analysis of the present study at phenotypic level is presented in **Table 2**. The highest positive direct effect on the cane yield per clump was from brix percent at 12th month (1.0013) and the

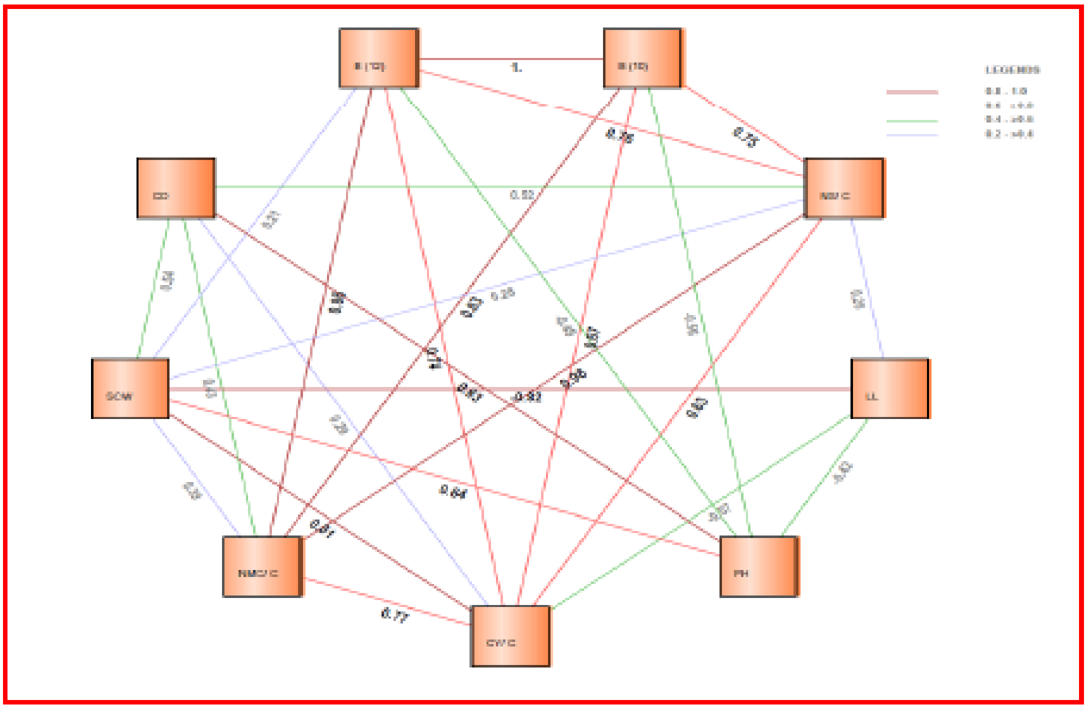

Fig. 1. Phenotypic correlation for yield and its related traits in sugarcane seedlings

Table 2. Phenotypic path coefficients of cane yield and its attributing traits in sugarcane seedlings

Source	PH	LL	NS/C	B (10th)	B (12th)	CD	SCW	NMC/C	CY/C
PH	**0.0008**	-0.0344	-0.0006	-0.0456	-0.0398	0.0670	0.0519	-0.0041	0.1324
LL	0.2235	**-0.5260**	-0.1309	-0.0547	-0.0138	0.0267	0.4332	-0.0425	-0.5677**
NS/C	0.0054	-0.1763	**-0.7083**	-0.5283	-0.5415	-0.3696	0.1984	0.6923	0.6295*
B (10th)	0.0005	-0.0001	-0.0006	**0.0810**	-0.0008	0.0001	-0.0001	-0.0007	0.6718*
B (12th)	-0.4920	0.0263	0.7655	0.9967	**1.0013**	-0.0874	0.2053	0.8569	0.7389**
CD	0.4399	-0.0270	0.2778	-0.0772	-0.0464	**0.5323**	0.2872	0.2310	0.2927
SCW	-0.1016	0.1308	0.0445	-0.0176	-0.0326	0.0857	**0.1588**	-0.0626	0.8103**
NMC/C	-0.0242	0.0390	0.4711	0.3993	0.4125	0.2092	0.1900	**0.4820**	0.7678**

RESIDUAL EFFECT = 0.031
* 5 percent level of significance; ** 1 percent level of significance
Note: PH= Plant Height; NS/C= No. of Shoots per Clump; LL= Leaf Length; CD=Cane Diameter; SCW= Single Cane Weight; NMC/C= No. of Millable Canes/Clump; B (10th) = Brix in 10th month; B(12th) = Brix in 12th month; CY/C= Cane yield per Clump.

lowest positive direct effect was contributed by plant height (0.0008). Cane yield also showed positive direct association with traits like brix at 10th month (0.0810), cane diameter (0.5323), NMC/C (0.4820) and SCW (0.1588) among which cane diameter had highest direct contribution towards the yield parameter. Consequently, these characteristics are considered to be the primary drivers of total yield. Similar trends of positive direct contribution towards brix , yield, SCW and NMC were reported by Ahmed *et al*. (2019). Somu *et al*. (2020) reported the highest direct contribution of brix percent towards cane yield per plot while cane diameter had lowest direct positive effect on yield trait. Therefore, to increase the yield, direct selection based on these traits could be made. The traits leaf length (-0.520), number of shoots per clump (-0.7083) contributed negative direct effect on cane yield.

NMC/C and brix percent at 12th month had contributed highest indirect effect which is consistent with the findings of Tabassum *et al*. (2023). The traits plant height had shown positive indirect effect with cane diameter (0.0670) and single cane weight (0.0519) and negative indirect effect with leaf length (0.0344), number of shoots per clump (-0.0006), brix percent at 10th (-0.0456) and 12th month (-0.0398). The positive indirect effect of cane height through SCW was also reported by Karpagam and Alarmelu (2019). Similarly, Parihar (2020) has reported that plant height had positive indirect effect with cane diameter. Leaf length showed positive indirect effect with plant height (0.2235), cane diameter (0.0267) and single cane weight (0.4332). The positive indirect effect of the leaf length through SCW was moderately higher as per the findings of Tena *et al*. (2016). Number of shoots per clump *via* SCW had indirect impact of number of millable canes per clump (0.6923) at a positive level. Whereas it had highest negative value *via* brix percent at 10th month (-0.5415). Kumar and Kumar (2014) observed the positive indirect effect of number of millable canes and negative indirect effect of brix percent *via* number of shoots. Brix percent at 12th month and cane diameter also showed indirect positive relation with same traits *i.e.,* single cane weight (0.2053, 0.2872) and NMC/C (0.8569, 0.2310) respectively. Palachai *et al.* (2019) and Masri *et al.* (2022) in their studies found similar results. Single cane weight had positive indirect effect *via* number of shoots per clump (0.0445), cane diameter (0.0857) except for NMC/C (-0.0626) and brix percent at 10th and 12th months (-0.0176, -0.0326). Karpagam and Alarmelu (2019) also provided similar results through SCW contributing negative indirect effect upon number of millable canes. Characters included in the path analysis explained 96.9% of the variability in cane yield through a residual effect of 0.031 at the phenotypic level, with the rest resulting from the contribution of other factors not included in the study on the dependent variable. The graphical representation of phenotypic path coefficient analysis of cane yield and its related traits is shown in **Fig. 2**.

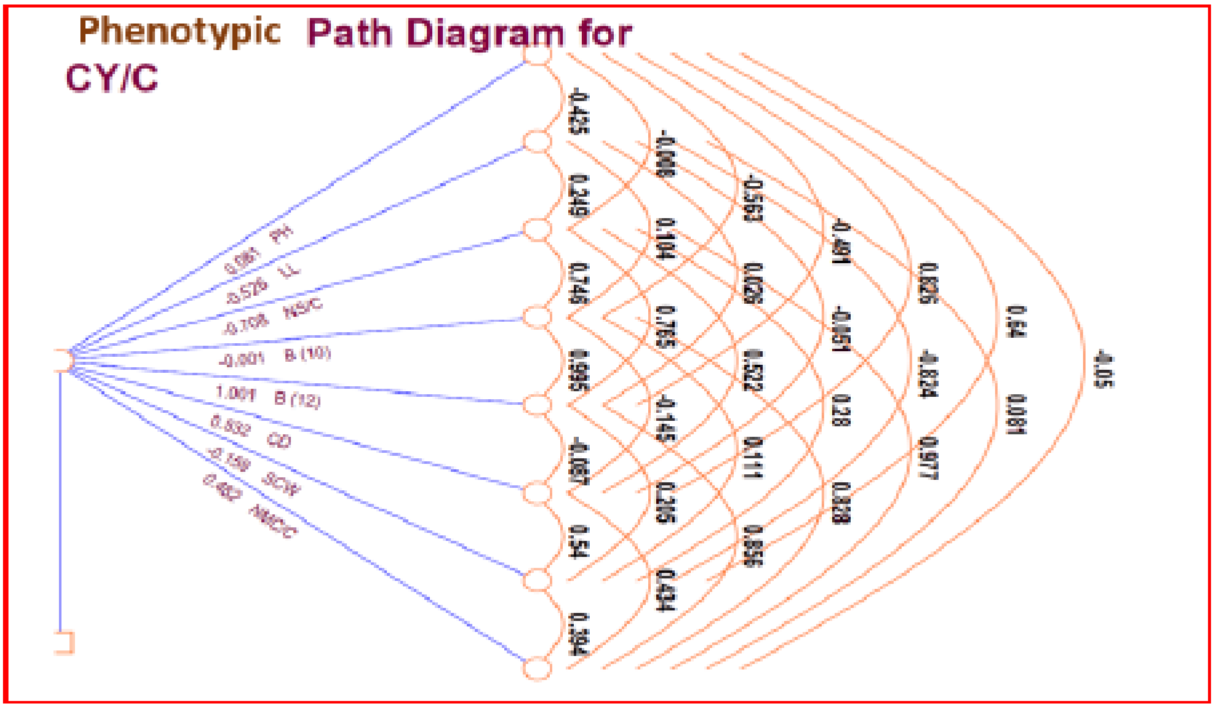

Fig. 2. Phenotypic path analysis of cane yield and yield related characters in sugarcane seedlings

The true relationship between yield and its traits is explained better by the means of direct effect by a particular trait on yield and choosing of these characters would benefit plant breeders for better selection efficiency. On the other hand, if the direct effect was small or negative, the indirect effects might be the source of the positive correlation. In that instance, the indirect effects could be taken into consideration concurrently with the selection process.

Thus it could be concluded that though cane yield per clump showed a highly significant and positive correlation with most of its component traits , plant height, brix at 10th and 12th months, cane diameter, number of millable canes per clump could be given more weightage in selection process for yield improvement in view of their favorable direct and indirect effects.

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REFERENCES

Ahmed, K.I., Patil, S.B., Moger, N.B., Hanumaratti, N.G. and Nadgouda, B.T. 2019. Correlation and path analysis in sugarcane hybrid clones of proven cross. *Journal of Pharmacognosy and Phytochemistry*, **8** (2): 781-783. [Cross Ref]

Alam, M.N., Nath, U.K., Karim, K.M.R., Ahmed, M.M. and Mitul, R.Y. 2017. Genetic variability of exotic sugarcane genotypes. *Scientifica (Cairo)*, **3**: 5202913. [Cross Ref]

Al-Ashkar, I., Ibrahim, A., Ghazy, A., Attia, K., Al-Ghamdi, A.A. and Al-Dosary, M.A. 2021. Assessing the correlations and selection criteria between different traits in wheat salt-tolerant genotypes. *Saudi J Biol Sci*., **28** (9): 5414-5427. [Cross Ref]

Anbanandan, V., Karthikeyan, P., Narayanan, R., Ranjith rajaram, S. and Pranay Reddy, J. 2020. Path coefficient analysis in sugarcane genotypes. *Plant Archives*, **20** (1): 1847-1848. [Cross Ref]

Devendra, K., Meena, L.R., Nirmal., Lalit, K., Meena, A.L., Meena, K.J., Raghavendra, C. and Arpan, B. 2022. Analysis of genetic diversity and correlation in sugarcane (*Saccharum spp.* L) clones in North-West zone of Uttar Pradesh. *Journal of Sugarcane Research,* **12**: 63-74. [Cross Ref]

Dewey, J.R. and Lu, K.H. 1959. Correlation and path coefficient analysis of components of crested weed crop seed corporation. *Agronomy Journal*, **51**: 515-518. [Cross Ref]

Falconer, D.S. 1964. *Introduction to quantitative genetics*. *Longmann*, 294-300. [Cross Ref]

Guddadamath, S.G., Sanjay., Patil, B. and Khadi, B.M. 2014. Relative contribution and associations studies among cane yield and their components in sugarcane (*Saccharum* spp. hybrid). *International Journal of Plant Sciences,* **9** (1): 21-26. [Cross Ref]

Kadian, S.P. and Mehla, A.S. 2006. Correlation and path analysis in sugarcane. *Indian Journal of Agricultural Research,* **40** (1): 47-51. [Cross Ref]

Karpagam, E. and Alarmelu, S. 2019. Character association and path analysis for cane yield and its components in interspecific hybrids of *Saccharum* spp. *Electronic Journal of Plant Breeding,* **10** (1): 30-38. [Cross Ref]

Kumar, D., Meena, L.R., Nirmal., Lalit, K., Meena., Raghavendra, K.J., Arpan, B. and Anjali. 2022. Assessment of genetic divergence and correlation analysis of sugarcane clones (*Saccharum spp.* L.) in North-Western plain zone of Uttar Pradesh. *Medicon Agriculture & Environmental Sciences*, **3** (1): 29-38. [Cross Ref]

Kumar, S., Paswan, A. and Panda, C.K. 2019. Adoption dynamics of improved package of practices on sugarcane cultivation by the farmers of East Champaran District of Bihar. *International Journal of Current Microbiology and Applied Sciences*, **8** (6): 1086-1091. [Cross Ref]

Kumar, S. and Kumar, D. 2014. Correlation and path coefficient analysis in sugarcane germplasm under subtropics. *African Journal of Agricultural Research*, **9** (1): 148-153. [Cross Ref]

Masri, M.I., El–Taib, A.B.A. and Abu-Ellail, F.F.B. 2022. Genetic and phenotypic correlation and path coefficient analysis for traits in sugarcane *SVU-International Journal of Agricultural Sciences,* **4** (2): 53-64. [Cross Ref]

Palachai, C.H., Songsri, P. and Jongrungklang, N. 2019. Comparison of yield components of sugarcane varieties grown under natural short- and long-term water-logged conditions in Thailand. *SABRAO Journal of Breeding and Genetics,* **51** (1): 80-92. [Cross Ref]

Parihar, R. 2020. Character association and path coefficient analysis for cane yield and quality characters in fourth clonal generation (C4) of Sugarcane (*Saccharum* sp. complex). *Journal of Crop and Weed*, **16** (1): 256-260. [Cross Ref]

Patra, D., Jagadev, P.N., Nayak, P.K. and Mohanty, S. 2022. Genetic variability, association and path coefficient studies in sugarcane. *The Pharma Innovation Journal,* SP-**11** (8): 559-563. [Cross Ref]

Praneetha, S., Muthuselvi. and Kousalya, R. 2024. Association studies on yield and yield components in snap melon (*Cucumis Melo. Var. Momordica*). *Madras Agricultural Journal,* **111**: 1-10. [Cross Ref]

Rakesh, G., Eswara Reddy, G., Swapna, N., Saicharan, M., Swathi, Y., Balaji Naik, B. and Vijay Kumar, M. 2023. Correlation and path analysis in sugarcane advanced clones. *The Pharma Innovation Journal*, SP-**12** (10): 415-422. [Cross Ref]

Ruggeri, G. and Corsi, S. 2019. An analysis of the Fairtrade cane sugar small producer organizations network. *Journal of Cleaner Production*, **240**: 118191. [Cross Ref]

Somu, G., Kanavi, M.S.P., Shashikumar, C., Shivaray, N. and Meena, N. 2020. Path coefficient analysis in first clonal stage of sugarcane (*Saccharum officinarum* L.). *International Journal of Current Microbiology and Applied Sciences,* **9** (9): 2682-2689. [Cross Ref]

Tabassum, Anand, S.J. and Rohit. 2023. Estimation of genetic variability, character association and path coefficient using sugarcane segregating population. *Electronic Journal of Plant Breeding,* **14** (2): 665-674. [Cross Ref]

Tena, E., Mekbib, F. and Ayana, A. 2016. Correlation and path coefficient analyses in sugarcane genotypes of Ethiopia. *American Journal of Plant Sciences,* **7**: 1490-1497. [Cross Ref]

Tena, E., Mekbib, F., Shimelis, H. and Mwadzingeni, L. 2016. Sugarcane production under smallholder farming systems: Farmers preferred traits, constraints and genetic resources. *Cogent Food & Agriculture,* **2**:1. [Cross Ref]

Verma, O.N., Santosh, K.S., Salam, J.L., Rastogi, N.K. and Sunil, K.N. 2021. Correlation and path coefficient analysis of cane yield and Bio-chemical and its components in sugarcane varieties (*Saccharum officinarum* L.) under three agro-climatic zones of Chhattisgarh. *The Pharma Innovation Journal*, **10** (11): 1772-1778. [Cross Ref]