Influence of Stale Cane Seed on Productivity of Sugarcane in Semi-Arid Climate

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Abstract

Sugarcane is an important sugar crop grown under diverse environmental conditions in Pakistan. This study was conducted to evaluate the comparative effect of sugarcane seed having different harvesting or stalling period on productivity of sugarcane. The experiment was laid out in randomized complete block design with split plot arrangement for two consecutive years. Three commercial sugarcane varieties viz. CPF 248, CPF 247 and CPF 246 were kept in main plots whereas cane setts staling; fresh, 3 days, 6 days & 9 days old stale cane setts were placed in sub-plots. Standard procedure was followed for recording all observations. Fisher’s analysis of variance technique by using Statistix 8.1 was used to analyzed data and least significant difference test was employed to compare treatment means at 5% probability level. Graphs were drawn through Microsoft Excel and SigmaPlot. The data revealed that sugarcane clones were differed significantly for most of biometric traits under study except cane yield whereas impact of cane setts stalling was also significant except sugar contents. The interactive effect of all treatment combinations for sugarcane clones and cane setts stalling was found significant except for commercial cane sugar (CCS%). It was found that clone CPF 247 exhibited highest cane and sugar yield by planting fresh cane setts as against lowest for CPF 248 when planted with 9 days old stale cane setts during both years of experimentation. Better growth and yield related traits were predominantly attributed to planting of fresh cane seed having better germination, tillering and cane density.

Keywords: Sugarcane, stale cane seed, cane yield, sugar contents, sugar yield

Introduction

Sugarcane (Saccharum officinarum L.) is an important cash crop of Pakistan that plays a pivotal role in boosting economic status of growers and country’s economy in terms of food security and employment. It provides basic raw material for sugar industry. In Pakistan, sugarcane has a 0.8 percent share in GDP and contributes 3.7 percent in agriculture value addition. It is cultivated on about 1260 thousand hectares with production of 88.6 million tons of canes by averaging 70.3 (TCH) (Govt. of Pakistan, 2022). Sugarcane is propagated by stalks (Yadav, 1991), also known as billets or setts. Due to vegetative propagation, health and vigor of cane setts or billets (cane seed) is of great importance and is directly affected by freshness or staleness of cane cuttings. Sugarcane planting might be delayed due to many reasons such as unavailability or shortage of labor and other inputs, unfavorable weather condition, over-cutting of seed, transportation problems and distant planting site etc. Apart from these, many intermediary processes during harvesting-to-planting, like cutting of sett (manual/mechanical), stripping, storage, transportation, chemical treatment, placement in furrows, soil covering etc. are also not only cause physical damage to buds of cane setts but also promotes staleness of seed-cane (Jain et al., 2009). Delay in planting and crushing of fresh cane after cutting can cause decrease in sucrose content, purity, stalk weight (Shrivastava et al., 2008; Liu et al., 2009), increase in reducing sugar (Deng et al., 2002) and fiber content (Qi & Jiang, 2006; Jiang, 2007) which leads to tremendous losses to both farmers and sugar mills. Moreover, the reduction in germination from staled cane-sets compared with using fresh seed-setts (Shrivastava et al., 2008; Liu et al., 2009) has an adverse impact on the crop. Aslam et al., (2001) reported that setts delayed for more than 16 hours are not considered good to plant. It is apparent that planting material has substantial influence on sprouting of sugarcane (Barnes, 1974). Thus, the selection of proper and suitable planting material is most important factor among various agronomic practices which require due attention in sugarcane agriculture. Age of the seed material, portion of a stalk, number of buds per sett, nutritional status of seed cane, duration between cutting and planting are known to have considerable effect on sprouting and subsequent growth of sugarcane (Barnes, 1974; Worku, 1992). Stalling impacts moisture of bud-sett and nutrients like sucrose and reducing sugar contents of seed cane/setts. With increase in stalling time, bud & sett moisture and sucrose percentage of juice decreases whereas total soluble solids and reducing sugars increases. Germination percentage and fresh weight of cane seeds decreased with increasing stalling time (Shrivastava et al., 2008). Aging of buds also attributes to lower percentage of sprouting in the bottom portion (Worku, 1992; Das, 2002).
Research findings in other countries also revealed that in aging buds the internal physiological conditions are liable to undergo changes affecting sprouting (Subbaro and Prasad, 2010). It is believed that aging of cane seed could cause internal change like accumulation of growth inhibitors (Das, 2005), metabolic and enzymatic depletion of essential food reserves, denaturation of proteins, damaging to synthesizing ability and increasing sensitivity to stress conditions and field pathogens (Sime, 2013). In view of the huge expenditure on cane growing particularly cost of seed sett/billet and its preparation, this circumstance could inflict a great financial loss on the sugar estate. Therefore, sufficient reliable information is needed to identify the effect of time gap between seed cane cutting and planting on productivity of sugarcane. Therefore, this study was conducted to determine maximum possible cutting–planting duration of cane seed without losing germination potential and other biometric traits of sugarcane.

**Materials and Methods**

**Experimental Location:** The experiment was conducted at Sugarcane Research Institute (SRI), Faisalabad, Pakistan located at Latitude of 31° 25’ N and Longitude of 73° 09’ E for two consecutive crop seasons, 2011-12 and 2012-13. During both years, physico-chemical analysis for soil of experimental site was carried out before planting of crop by taking composite soil samples from depth of 15-30 cm. The soil analysis was conducted at Soil and Water Testing Laboratory, Ayub Agricultural Research Institute (AARI), Faisalabad and results are shown in Table 1. The climatic data for study duration of experimental site for both crop years is given as Figure 1.

**Table 1.** Physico-chemical examination of soil of experimental location for both years of sugarcane cultivation

| Determination          | 2011-12 | 2012-13 |
|------------------------|---------|---------|
| Texture                | Loam    | Loam    |
| Saturation (%)         | 34      | 36      |
| pH                     | 7.2     | 7.6     |
| EC (dS m⁻¹)            | 2.13    | 2.08    |
| Organic matter (%)     | 0.83    | 0.96    |
| Total N (g kg⁻¹)       | 0.58    | 0.51    |
| Available P (mg kg⁻¹)  | 7.02    | 7.85    |
| Available K (mg kg⁻¹)  | 151     | 155     |

Notes. EC, electrical conductivity. N, nitrogen. P, phosphorous, whereas K, potash.

**Figure 1.** (a & b) Weather data during both crop seasons of sugarcane cultivation  
**Source:** Observatory of Plant Physiology Section, Agronomic Research Institute-AARI, Faisalabad

**Treatments and Design:** Three sugarcane clones developed and released by SRI, Faisalabad viz. CPF 247, CPF 248 and CPF 246 were tested against cane setts staling viz. fresh (check), 3 days stale cane setts, 6 days stale cane setts and 9 days stale cane setts. Replicated three times, the trial was laid out in RCBD under split plot arrangement keeping plot size of 12 m × 9.6 m. Sugarcane clones were kept in main plots whereas cane setts staling were placed in sub plots.  

**Experimental Material and Planting:** The sugarcane seed of all three clones was prepared as per treatment plan. For this purpose, cane seed from nine months old healthy
plant crop was harvested at 3, 6 and 9 days before planting of experiment, respectively, trashed manually and placed under shade. Whereas, fresh seed was harvested and prepared at the time of planting. The whole experiment was planted in spring on 28 and 29 February, 2011 and 2012, respectively in each year at recommended 1.2 m apart dual row trench planting method. Recommended seeding rate of 50,000 TBS ha\(^{-1}\) was used and fertilizers were applied @ 168-112-112 NPK Kg ha\(^{-1}\). All other Agronomic practices were applied according to recommendation and kept uniform for all the experimental units.

**Data Collection of Biometric and Qualitative Traits:** Data regarding germination percentage and tillers plant\(^{-1}\) were recorded at 50 and 90 days after planting (DAP), respectively while millable canes, cane yield, CCS % and sugar yield were computed at final harvest. Standard procedures were adopted to record all the observations. Total germinant were counted from each experimental unit and were converted to germination percentage and similarly all tillers in each plot were counted to work out tiller plant\(^{-1}\). During both years, the trials were harvested in the month of February of 2012 and 2013 after achieving crop age about more than 11 months. At harvesting, all the mature canes in each experimental unit were counted to work out millable canes ha\(^{-1}\). Whole of each plot was harvested and canes were topped, stripped and weighed in Kg by using floor balance and then expressed as cane yield in tons of canes ha\(^{-1}\) (TCH). Ten randomly taken stripped canes from each experimental plot were taken to the Sugarcane Technology Laboratory, SRI, Faisalabad for quality analysis of cane juice. Canes were crushed with electric cane crusher (having about 70% extraction) for juice extraction and brix% were recorded with the help of hydrometer standardized at 20°C, Pol% were determined with Horn’s dry lead sub-acetate method of sucrose analysis (Anonymous, 1970). Commercial Cane Sugar (CCS%) was calculated by employing formula:

\[
\text{CCS\%} = \frac{3P}{2 \times (F + 5)} - \frac{B}{2} \times \frac{1 - (F + 3)}{100}
\]

(P stands for pol%, F for fibre% and B for Brix%)
Sugar yield was calculated by the formula:
Sugar yield (CCS tons ha\(^{-1}\)) = CCS% / 100 \times stripped cane yield

**Statistical Analysis:** The recorded data were statistically analyzed by using Fisher’s analysis of variance technique (Freed, 1990) through Statistix 8.1 and least significant difference test was used to compare treatment means 5% level of probability (Steel et al., 1997). The Microsoft Excel and SigmaPlot were used for drawing graphs of weather data and cane & sugar yield, respectively.

**Results**

The perusal of table 2, 3 & 4 illustrated that germination percentage in sugarcane was not only significantly affected by clones and cane setts stalling period but their interaction was also found significant during both years. In 2011-12, the highest germination percentage was recorded in V$_3$S$_1$ when fresh cane setts of CPF 247 were used for planting whereas lowest germination percentage was recorded in V$_3$S$_4$ by planting 9 days old cane setts of CPF 246. The same trend was exhibited during 2012-13 and germination percentage was varied from 56.8 to 36.6% depending upon varietal and stalling period difference. The tillering potential of the varieties was also differed among them depending upon stalling period during the course of study. In 2011-12, more tillers plant\(^{-1}\) was recorded in treatment combination of planting CPF 247 using fresh cane setts which was statistically at par with CPF 248 with fresh cane setts. Whereas, CPF 246 planted with 9 days stale cane setts showed lowest tillers plant\(^{-1}\) during 1$^{st}$ year of study. A similar trend in tiller production was observed during second year of experimentation.

Millable canes ha\(^{-1}\) is a major yield contributing factor and it was found significantly affected by different sugarcane genotypes and cane setts stalling period and also their interactive effect was also significant during both years (Table 2, 3 & 4). Millable cane ha\(^{-1}\) was found maximum during both years when sugarcane variety CPF 247 was planted with fresh cane setts and it was closely followed by V$_1$S$_1$ (CPF 248 + fresh cane setts). However, lowest number of millable cane ha\(^{-1}\) were recorded in V$_3$S$_4$ (CPF 246 + 9 days stale cane setts) in each year (Table 4). The data indicated that sugarcane clones did not differed significantly with respect to final cane yield while it was significantly affected by cane sett stalling period.

Whereas, the interactive effect of both factors was significant and highest cane yield was recorded in treatment V$_2$S$_1$ (CPF-247 + fresh cane setts) during both crop seasons but it was statistically at par with V$_3$S$_1$ (CPF-246 + fresh cane setts). On the other hand, CPF 248 showed lowest cane yield when planted with 9 days old stale cane setts during both years of experimentation (Table 2, 3 & 4). The results also indicated strong dependence of cane yield on the freshness of cane setts used as seed (R$^2$= 0.99) during the course of study (Figure 2).

Sugar recovery is a percentage of sugar production in metric ton to the strip cane production per unit area and is generally considered as a genetic character of any sugarcane cultivar. So, the varietal difference showed a significant effect on sugar recovery but it was not affected significantly by stalling period of cane setts and their interaction during both years of study (Table 2, 3 & 4). Among varieties, maximum sugar recovery was recorded for CPF 246 for both crop seasons. Sugar yield is a bench mark to determine the profitability and productivity of any sugarcane production system. The sugarcane genotypes
and cane setts stalling singly as well as the interactive effect of both factors had significant effect on sugar yield during each year. The perusal of data presented in Table 4 showed that highest sugar yield was produced by CPF 247 when planted by using fresh cane setts in 1st year and was found statistically at par with V₁S₁ (CPF 246 + fresh cane setts). During 2nd year of study, sugar yield was maximum in V₃S₁ (CPF 246 + fresh cane setts) but it was closely followed by other two varieties when planted fresh (V₁S₁ and V₃S₁). While, the lowest sugar yield was noted in CPF 248 when 9 days staled setts were used for planting (V₁S₁) during both years. The data (Fig. 3) also depicted the impact of cane sett stailness on overall sugar yield (R² = 0.98 & 0.99) during both years, respectively.

Table 2. Biometric traits as influenced by sugarcane clones

| Variety/clone (V) | Sprouting (%) | Tillers plant¹ | Millable canes (000 ha⁻¹) | TCH | Sucrose contents (CCS%) | Sugar yield (CCS t ha⁻¹) |
|------------------|---------------|----------------|---------------------------|-----|------------------------|-------------------------|
| CPF 248 (V₁)    | 47.2A         | 2.28AB         | 90.5A                     | 81.5| 13.6 B                 | 11.0B                   |
| CPF 247 (V₂)    | 47.8A         | 2.37A          | 91.5A                     | 84.2| 13.9AB                | 11.7A                   |
| CPF 246 (V₃)    | 43.1B         | 2.10B          | 86.2B                     | 82.1| 14.2A                 | 11.7A                   |
| LSD at 5%       | 3.118         | 0.1963         | 3.875                     | N.S | 0.5555                | 0.3166                  |

Means sharing different letters in a column, statistically differ from each other

Notes: TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference

Table 3. Biometric traits as influenced by sugarcane seed (sett) stalling age

| Seed/sett stalling (S) | Sprouting (%) | Tillers plant¹ | Millable canes (000 ha⁻¹) | TCH | Sucrose contents (CCS%) | Sugar yield (CCS t ha⁻¹) |
|------------------------|---------------|----------------|---------------------------|-----|------------------------|-------------------------|
| Fresh (control)        | 54.0A         | 2.68A          | 102.7A                    | 94.9A| 13.9                   | 13.2A                   |
| 3 days old             | 49.6B         | 2.45B          | 95.1B                     | 88.0B| 14.1                   | 12.4B                   |
| 6 days old             | 43.2C         | 2.11C          | 84.2C                     | 78.1C| 13.7                   | 10.7C                   |
| 9 days old             | 37.4D         | 1.76D          | 75.6D                     | 69.6D| 13.9                   | 9.6D                    |
| LSD at 5%              | 1.886         | 0.1715         | 1.983                     | 1.90 | -                     | 0.4451                  |

Means sharing different letters in a column, statistically differ from each other

Notes: TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference

Table 4. Biometric traits as influenced by sugarcane clone and seed (sett) stalling

| Interaction (V x S) | Sprouting (%) | Tillers plant¹ | Millable canes (000 ha⁻¹) | TCH | Sucrose contents (CCS%) | Sugar yield (CCS t ha⁻¹) |
|---------------------|---------------|----------------|---------------------------|-----|------------------------|-------------------------|
| V₁S₁                | 55.3a         | 2.75a          | 103.3ab                   | 94.0a| 13.3                   | 12.5b                   |
| V₁S₂                | 51.5b         | 2.55a          | 97.0c                     | 86.8b| 13.8                   | 12.0b                   |
| V₁S₃                | 44.3c         | 2.20cd         | 86.1e                     | 77.6cd| 13.5                   | 10.5cd                  |
| V₂S₁                | 37.8de        | 1.64f          | 75.5gh                    | 67.9e| 13.6                   | 9.24e                   |
| V₂S₂                | 55.6a         | 2.76a          | 104.7a                    | 96.5a| 14.0                   | 13.52a                  |
| V₂S₃                | 51.5b         | 2.54ab         | 97.2c                     | 89.7b| 14.1                   | 12.6b                   |
| V₃S₁                | 45.1c         | 2.19cd         | 86.1e                     | 80.0c| 13.6                   | 10.8c                   |
| V₃S₂                | 39.1d         | 1.98cd         | 77.8fg                    | 70.7e| 14.0                   | 9.90de                  |
|          | V1S1 | V1S2 | V1S3 | V1S4 | V2S1 | V2S2 | V2S3 | V2S4 | V3S1 | V3S2 | V3S3 | V3S4 |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|
|          | 51.2b | 2.53ab | 99.9bc | 94.4a | 14.3 | 13.5a |
|          | 45.8c | 2.25bc | 91.2d | 87.3b | 14.4 | 12.6b |
|          | 40.1d | 1.95de | 80.3f | 76.6e | 14.2 | 10.9c |
|          | 35.4e | 1.66ef | 73.6h | 70.2e | 13.9 | 9.80de |
| LSD at 5%| **3.267** | **0.2971** | **3.435** | **3.29** | - | **0.771** |
|          |      |      |      |      |      |      |      |      |      |      |      |      |
| 2012-13  |      |      |      |      |      |      |      |      |      |      |      |      |
|          | 55.7ab | 2.77ab | 99.8b | 92.1bc | 14.1 | 13.3ab |
|          | 52.5bc | 2.59abc | 95.8bc | 85.7ef | 13.7 | 11.9cd |
|          | 45.4d | 2.21de | 88.0d | 79.7g | 13.8 | 10.7ef |
|          | 38.4e | 2.16def | 79.8e | 71.1h | 13.5 | 9.15g |
|          | 56.8a | 2.82a | 104.2a | 96.7a | 13.4 | 12.9abc |
|          | 51.8c | 2.54bc | 97.5b | 89.6cd | 13.4 | 12.1c |
|          | 44.8d | 2.26de | 87.0d | 82.1fg | 13.4 | 10.72ef |
|          | 39.4e | 1.92fg | 78.6ef | 71.8h | 13.8 | 9.77fg |
|          | 52.6bc | 2.58abc | 99.8b | 94.9ab | 14.5 | 13.6a |
|          | 46.8d | 2.35cd | 93.1c | 87.1de | 14.3 | 12.5bc |
|          | 40.0e | 2.03efg | 81.2e | 78.8g | 14.4 | 11.0de |
|          | 36.6e | 1.85g | 75.0f | 74.2h | 14.4 | 10.2ef |
| LSD at 5%| **3.463** | **0.2602** | **4.047** | **3.816** | - | **0.9914** |

Means sharing different letters in a column, statistically differ from each other

**Notes.** TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference

**Figure 2.** (a & b) Variation in total final cane yield ha\(^{-1}\) to changing stalling time of sugarcane seed (billets/setts) during both crop seasons
The findings of this study indicated that biometric traits varied both with sugarcane clones and length of cane seed stalling period, which suggested negative impact of time lag on seed quality mainly due to varietal differences and ability for resistance to loss in moisture, decrease in sucrose and increase in reducing sugars (Bhatia et al., 2009). Germination depends heavily on viability of buds of cane seed. Difference in germination trend is mainly due to the difference in genetic potential of sugarcane cultivars and length of stalling cane setts. As CPF 247 has genetically better sprouting vigor than both of other cane cultivars. More germination in treatment V₂S₁ was also helped by better vigor of fresh seed setts having more moisture contents and other readily available food supplies in the form of simple sugar. Aslam et al. (2001) also observed similar trend is germination while comparing fresh and stale cane seed in sugarcane. The delay in harvest to planting could decrease buds viability of cane seed, thus, can cause failure or exhibit poor sprouting (Jain et al., 2009). Shrivastava et al. (2008) also reported gradual and significant decrease in germination of stalled seed-setts of cane. Zhao et al. (2012) also reported sprouting in sugarcane genotypes was significantly lowered with stalled cane seed. Tillers plant⁻¹ depends a lot on growth of seedlings that is negatively effected by increasing stalling period (Zhao et al., 2012). Therefore, more tillers plant⁻¹ is attributed to good germination percentage which helped to produce healthier and better establishment of cane seedlings. Similar trend was observed by Shrivastava et al., (2008).

Better germination percentage and early establishment of seedlings and tillers plant⁻¹ were responsible for higher number of millable of canes in sugarcane. As buds from stale cane tend to accumulate more phenols which may plausibly be associated with in situ toxicity due to secondary metabolites resulting in poor sprouting (Jain et al., 2009). It was also observed that sugarcane clones which matures most of their produced tillers in millable canes would ensure better crop stand than others. Similar trend was observed in case of CPF 247 as it has the characteristic to mature its maximum tillers in millable canes. These results are in line with the findings of Jiang (2007) who reported comparable results. Increase in cane yield for treatment V₂S₁ than others is due to genetic potential of CPF 247 and its improved growth and yield contributing factors due to better germination, seedling establishment, tillering and millable canes, achieved with freshness of cane billets (Hussain et al., 2011). Ali et al., (2002) investigated in a varietal trial that a variety with highest tillering capacity gave more cane yield when planted with fresh seed cane sett. Similar phenomenon was also explored by Deng et al., (2002).

The difference in sugar recovery is basically dependent upon genetic potential of sugarcane clones and a rapid decline in sugar contents during late crushing period in sugarcane crop was also reported by Singh and Solomon (2003). The variation in sugar yield is attributed to higher sugar contents for CPF 246 along with better cane yield due to freshness of cane billets. Genetically, the clone CPF 246 has better sugar contents than other genotypes. A similar trend in CCS (t ha⁻¹) was also revealed by (Atta et al., 1992) in his studies. The difference in bud viability, height of seedlings, number of sprouted setts and seedlings varied not only due to length of stalling period but also with sugarcane clones, thereby providing breeders an option to select sugarcane clones with better stalling-resistant ability for plant growth.
Conclusion

Increasing staleness of cane seed had negative effect on agronomic traits, cane and sugar yield of sugarcane. It is therefore suggested that cane seed should be fresh or with minimum time lag of less than 3 days for harvesting-planting to get better cane productivity owing to improved germination, tilling and ultimately their contribution towards final cane yield and qualitative characteristics.

References

Ali, F. G., Iqbal, M. A., Chattha, A. A. & Afghan, S. (2002). Performance of some sugarcane varieties at different seeding densities under Faisalabad (Pakistan) condition. Pak. Sugar J. 21(6): 22-23.
Anonymous. (1970). Laboratory Manual for Queensland Sugar Mills. (5th Ed.), Watson, Ferguson and Co., p. 94-150.
Aslam, M., Javaid, M. A., & Chattha, A. A. (2001). Effect of seed staling on germination and yield of sugarcane. Proceeding of 46th Annual Convention of Pak. Society Sugar Tech., August 27-28, Avari Hotel, Lahore.
Atta, M. R., Ali, Z., & Hussani, K. H. (1992). Adaptability of new sugarcane varieties to Karore, Layyah zone of Punjab (Pakistan). Pakistan Sugar Journal, 5(1): 25-31.
Barnes, A. C. (1974). The sugarcane. 2nd edition, Leonard Hill Ltd., London.
Bhatia, S., Jyoti, Uppal, S.K., Thind, K.S. and Batta, S.K. (2009). Post-harvest quality deterioration in sugarcane under different environmental conditions. Sugar Tech., 11(2): 154-160.
Das, S. D. (2005). Influence of aging of seed cane on germinability and vigor of seedlings of sugarcane. Seed Research, 9(2): 162-166.
Deng, Z. Y., Zhu, Q. A., Wang, W. Z. & Wang, B. H. (2002). Deterioration of harvested stalk of several new sugarcane varieties. Sugarcane. 3: 19-23.
Freed, R. D. (1990). MSTATC Ver. 1.2. Michigan State Univ., Michigan, USA.
Govt. of Pakistan, (2022). Pakistan Economic Survey: Agriculture, p. 20.
Hussain F., M. A. Sarwar, S. Ahmad, M. A. Ali, N. Fiaz, A. A. Chattha. (2011). Effect of stale and fresh cane sets (seed) on yield and quality of sugarcane (Saccharum officinarum L.). Int. J. Agric. Applied Sciences. 3(1): 35-37.
Jain, R., Solomon, S., Shrivastava, A. K., Singh, P., Prajapati, C. P., Singh, P. K. & Lal, P. (2009). Impact of harvest to planting delays on the sprouting of seed cane. Sugar Tech., 11(2): 231-233.
Jiang, Y. (2007). Effect of outdoor stalk of millable sugarcane cultivar on processing qualities and fresh weight. Sugar Crops of China, 1: 13-15.
Liu, J. Y., Wu, C. W., Chen, S. K., Zhao, J., Zhao, P. F. & Yang, H. C. (2009). Post-harvest quality deterioration of two promising sugarcane clones CYZ02-588 and CYZ02-1826 developed at Yunnan, P. R. China. Sugar Tech., 11(2): 225-227.
Qi, R. & Jiang, Y. (2006). Study on the effect of pilling up under outdoor conditions on processing qualities and fresh weight of millable sugarcane. Sugarcane and Cane sugar. 3: 12-15.
Shrivastava, A. K., Solomon, S., Srivastava, K., Shukla, S. P., Sawrani, A., Darash, R., Prajapati, C., Singh, P., Priyanka, S., Rai, R. K., Jain, R., Srivastava, P., Chatterjee C. & Dube, B. K. (2008). Influence of progressive staling on germination of sugarcane. Sugar Tech, 10(2): 137-142.
Sime, M. (2013). The Effect of Different Cane Portions on Sprouting, Growth and Yield of Sugarcane (Saccharum spp. L.). Int. J. Sci. Res. Pub., 3(1): 1-3.
Singh, I. & Solomon, S. (2003). Post-harvest quality loss of sugarcane genotypes under sub-tropical climate: Deterioration of whole stalk and billets. Sugar Tech., 5(4): 285-288.
Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). Principles and Procedures of Statistics: A biometrical approach. 3rd edn. McGraw Hill Book Comp., New York. p. 400-428.
Subbarao, M. S. & Prasad, R. B. (2010). Studies in India on the germination of sugarcane. Indian J. Plant Physiology. 3(2): 181-194.
Worku, B. (1992). The influence of different portions of the stalk cuttings and number of buds per set on sprouting, tilling and yield of sugarcane. M.Sc. thesis, Alemaya University of Agriculture, Ethiopia.
Yadav, R. L. (1991). Sugarcane Production Technology: Constraints and Potentialities. Oxford & IBH Publishing Co. (Pvt.) Ltd. New Delhi.
Zhao, P., Liu, J., Yang, K., Xia, H., Zhao J., Li, F., Chen, X., & Wu, C. (2012). Impact of staling on cane quality and sprouting, and the possibility of selecting for staling-resistant ability, Int. Sugar J. 114(1): 101-106.