E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(5): 425-429
Received: 19-02-2024
Accepted: 24-03-2024

Roohi
CCS Haryana Agricultural University, Regional Research Station, Karnal, Haryana, India

Kanika Pawar
CCS Haryana Agricultural University, Regional Research Station, Karnal, Haryana, India

Vijay Kumar
Maharana Pratap Horticultural University, Karnal, Haryana, India

Kiran K Khokhar
CCS Haryana Agricultural University, Krishi Vigyan Kendra, Karnal, Haryana, India

Corresponding Author:
Vijay Kumar
Maharana Pratap Horticultural University, Karnal, Haryana, India

Organic cultivation of sugarcane varieties and its effect on cane yield and quality jaggery production

Roohi, Kanika Pawar, Vijay Kumar and Kiran K Khokhar

DOI: https://doi.org/10.33545/2618060X.2024.v7.i5f.713

Abstract
The field experiment was conducted at the Regional Research Station, CCS Haryana Agricultural University, in Karnal, Haryana, during 2018-19. The objective was to assess the impact of organic cultivation on two spring-planted sugarcane varieties, CoH 160 (early) and CoH 167 (mid-late), in terms of cane yield and quality jaggery production. The trial consisted of five distinct treatments, involving varying levels of Farm Yard Manure (FYM) application at 10 t/ha (T_1), 20 t/ha (T_2), and 30 t/ha (T_3) at the time of sowing. Additionally, organic practices such as biofertilizers and green manuring of *Sesbania* in inter-row spaces, along with the control of insect pests and diseases, were implemented in three treatments (T_1, T_2, and T_3). Treatment T_4 involved the application of Natural Formulation I on setts, complemented by three sprays of Natural Formulation II during April, May, and June, following natural farming principles. Treatment T_5 applied the recommended dose of NPK fertilizers (150-50-50 kg/ha) and relied on chemical methods for pest and disease control. The application of FYM @ 30 t/ha at the time of sowing + biofertilizers (BF)+green manuring of *Sesbania* in inter row space (GM) (No inorganic fertilizers) was at par with RDF through inorganic application of fertilizer (69.43 t/ha and 70.10 t/ha) and produced significantly higher cane yield compared to application of FYM @10 (55.99 t/ha) or 20 t/ha + BF + IPM (61.33 t/ha) or Setts treatment with *beejamrit* + three sprays of jeevamrit during the months of April, May and June in natural farming technique (36.08 t/ha). Furthermore, organic jaggery was prepared from both sugarcane varieties, with CoH 160 demonstrating superior quality attributes such as sucrose content exceeding 70% and reducing sugars below 20%. This variety also received high sensory acceptance ratings, being described as "extremely liked" on the hedonic scale, and exhibited a light golden-yellow color, indicating its potential for quality jaggery production.

Keywords: Sugarcane, organic farming, jaggery, green manuring

Introduction
Sugarcane (*Saccharum officinarum* L.) is one of the most important cash crops globally, contributing significantly to the sugar and renewable energy industries. However, continuous cropping with imbalanced fertilizer usage, as well as the use of exclusively inorganic fertilizers, has resulted in depletion of organic carbon and available nutrients in the soil (Sinha *et al.*, 2024) [16], posing a danger to long-term soil productivity (Khan *et al.*, 2024) [6]. The frequent use of synthetic chemical pesticides as crop protectants has presented major risks to humans and the environment, harmed natural enemies and resulted in pest resistance to insecticides. With increasing concerns about environmental sustainability and human health, there is a growing interest in organic farming practices as an alternative to conventional methods. Organic cultivation emphasizes the use of natural inputs, biodiversity conservation, and soil health management, aiming to minimize chemical inputs and environmental impact while promoting sustainable agricultural practices (Adeyemo *et al.*, 2019) [1].

In recent years, organic cultivation of sugarcane has garnered attention due to its potential benefits in enhancing soil fertility, reducing environmental pollution, and producing healthier agricultural products (Roohi *et al.*, 2022) [9]. Organic farming practices typically involve the application of organic manures, biofertilizers, and green manures, along with the avoidance of synthetic pesticides and fertilizers (Antonious, 2018) [2]. These practices not only promote soil health and biodiversity but also contribute to the production of high-quality agricultural commodities.

One area of interest in organic sugarcane cultivation is its effect on cane yield and jaggery quality. Jaggery, a traditional sweetener derived from sugarcane juice, is widely consumed in many parts of the world due to its distinct flavor and perceived health benefits (Shivashenkaramurthy *et al.*, 2021; Guddadamath *et al.*, 2014) [13, 5]. Organic cultivation practices have the potential to influence the yield and quality of sugarcane, thereby impacting the characteristics of jaggery produced from organic sugarcane varieties.

Despite the growing interest in organic sugarcane cultivation, there is still a need for comprehensive research to evaluate its effects on cane yield and jaggery quality. Understanding the impact of organic farming practices on sugarcane production can provide valuable insights for farmers, policymakers, and consumers interested in sustainable agriculture and healthy food choices. Therefore, this study aims to investigate the organic cultivation of sugarcane varieties and its effect on cane yield and quality jaggery production, contributing to the growing body of knowledge on sustainable agriculture and organic farming practices.

Materials and Methods

A field experiment was conducted during 2018-19 at research farm of the CCS Haryana Agricultural University, Regional Research Station, Karnal (latitude of 29º 43'42.19" N, longitude of 76º 58'49.88" E and at an altitude of 253 meters above mean sea level) on clay loam soils. The aim was to study the effect of organic cultivation of two sugarcane varieties *viz.* an early maturing variety CoH 160 and midlate CoH 167 on cane yield and jaggery production in different treatments of organic inputs. The experimental site used for the study was an undisturbed piece of land which was never being cultivated before. The field was prepared and layout was done for the cultivation of sugarcane and then representative soil samples were collected from depth of 0-15 cm. The initial soil physico-chemical properties of the experimental field are presented in the table 1 and all the treatment details are given in table 2. These treatments were applied in plant crop of two sugarcane varieties (CoH 160 and CoH 167) in factorial randomized block design (RBD) design.

Table 1: The physico-chemical properties of the soil of experimental field

Texture	Clay loam
pH (1:2 Soil:Water)	8.0
Electrical Conductivity (dS m^{-1})	1.25
Organic carbon (%)	0.30
Available phosphorus (kg ha^{-1})	10
Available potassium (kg ha^{-1})	384

Table 2: The treatment details of the study

	Treatment details
T_1	10 t FYM ha^{-1} at the time of sowing + Biofertilizers (BF) + Green manuring of *Sesbania* in inter row spaces (GM) + control of insect pests and diseases through organic practices (IPM)
T_2	20 t FYM ha^{-1} at the time of sowing +BF+GM+IPM
T_3	30 t FYM ha^{-1} at the time of sowing +BF+GM+IPM
T_4	Natural farming: Seed treatment with natural formulation I* and three sprays of natural formulation II** @ 200 L/acre during the months of April, May and June at 21 days interval upto growth phase + control of insect pest with natural pesticides
T_5	Chemical farming: Recommended dose of NPK (RDF)*** + control of insect pests and diseases through chemical practices

Note: *Natural formulation I was prepared by mixing 5 kg indigenous cow dung, 5 L of cow urine, 50 g lime, handful of undisturbed soil and 20 L water. Sugarcane setts were treated with this formulation for 30 minutes.

**Natural formulation II was prepared by mixing 10 kg of indigenous cow dung, 10 L of cow urine, 1.5 kg of gram flour, 1.5 kg of jaggery and handful of undisturbed soil in 200 L of water

***Recommended dose of NPK (RDF): 187.5-62.5-62.5 kg/ha

Farm yard manure was applied at the time of sowing before opening the ridges. No inorganic fertilizers were applied in treatments from 1 to 4. The setts were treated with biofertilizers *viz*. *Azotobacter/Acetobacter* + PSB (Phosphorus solubilizing bacteria) and *Trichoderma viridae* before sowing for enhancing nitrogen and phosphorus availability to the crop in treatment 4. Sowing was done with 75 cm row to row spacing by half ridge irrigation method of planting. *Sesbania* (Dhaincha) was grown in inter row space in organic treatments. All ecological based insect pest's management practices (Table 3) were adopted for organic cultivation of sugarcane except in T_5 which was chemical farming-based treatment.

CoH 160 is early maturing variety, non-lodging, good-ratooner resistant to red rot, smut and frost, solid juicy cane and thick stems while CoH 167 is mid maturing variety, tolerant to red rot, smut and frost resistant, non-lodging, solid juicy cane and thick stems. The crop was harvested at maturity and cane yield per plot was recorded. For the purpose of comparison of Jaggery made of these two sugarcane varieties i.e CoH 160 and midlate CoH 167 and grown with organic inputs. Sugarcane samples were collected from the treatment of highest input of organic i.e 30 t FYM ha^{-1} at the time of sowing + Biofertilizers and green manuring of *Sesbania* in inter row spaces along with control of insect pest and diseases through organic practices.

After the harvesting of the sugarcane crop, organic jaggery was produced in jaggery manufacturing unit. The technical process of making jaggery from sugarcane juice involves several precise steps to ensure optimal quality and efficiency. Initially, freshly harvested sugarcane is crushed to extract the juice, which is then strained to remove any solid particles. The extracted juice undergoes clarification to remove impurities and is then transferred to large, shallow pans or evaporators for heating. The juice is boiled at high temperatures until it reaches a thick, syrupy consistency, with continuous stirring to prevent burning. During this process, the water content evaporates, leaving behind concentrated sugar syrup. Once the syrup reaches the desired thickness, it is poured into molds or trays to cool and solidify. After solidification, the jaggery blocks are demolded and allowed to further air dry, ensuring proper curing and solidification. The resulting jaggery is rich in natural sugars and retains the distinctive flavor and aroma of sugarcane, making it a popular choice for various culinary applications. The jaggery manufacturing process involves the following steps as mentioned below (Figure 1): The organic jaggery prepared from the two sugarcane varieties were analyzed for their quality traits such as sucrose (on dry basis), reducing sugar (on dry basis), moisture, water insoluble matter (on dry basis), sulphated ash (on dry basis) and ash insoluble in dilute HCL (on dry basis) which were measured as per the standard methods of FSSAI, 2017 [4].

Table 3: Ecological based insect pest's management practices for organic farming of sugarcane

Crop stage	Pests	Control measures
Before planting	Termite and white grub	Deep ploughing before planting of crop
Selection of crop for seed	Borers and mealy bug	Healthy seed free from insect-pests incidence
Seed selection	Borers and scale insect	Setts showing borer damage will be discarded
Planting time	Termite and shoot borer	Application of Amritguard 0.03% (neem formulation) @ 1.5 litre/acre in 600 litre of water
April-January	Shoot borer, top borer and stalk borer	Pheromone traps for monitoring and control of shoot borer, top borer and stalk borer
April- June	Shoot borer, termite and root borer	Irrigating crop during formative phase at 8-10 days interval
April- October	Shoot borer, top borer and *Pyrilla*	Collection and destruction of egg masses of top borer shoot borer and *Pyrilla.* Removal of dead hearts and top borer infested shoots and their destruction
April- November	Shoot borer, top borer and stalk borer	Installation of light trap for shoot borer, top borer and stalk borer
May-June	Shoot borer and stalk borer	Light earthing up at initial stage and final earthing up of the crop soon after completion of tillering
July-August	Stalk borer	Propping of cane stalks
July-October	*Pyrilla*	Conservation, colonization and release of nymphal, nymphal-adult parasitoid cocoons of *Epiricania melanoleuca* and egg parasitoid, *Tetrastichus pyrillae* egg masses
July-October	Top borer and stalk borer	Release of egg parasitoid, *Trichogramma* sp. @ 20000/acre at 10-15 days interval
August-September	Whitefly	Clipping up and disposal off 2 to 3 affected leaves with nymphs and pupal stages of whitefly and drainage of field if waterlogged and conservation of nymphal parasitoid, *Encarsia* sp.
October -December	Stalk borer	Detrashing of dried leaves 2 times at 30 days interval. Removal and destruction of late shoots at 15 days intervals.

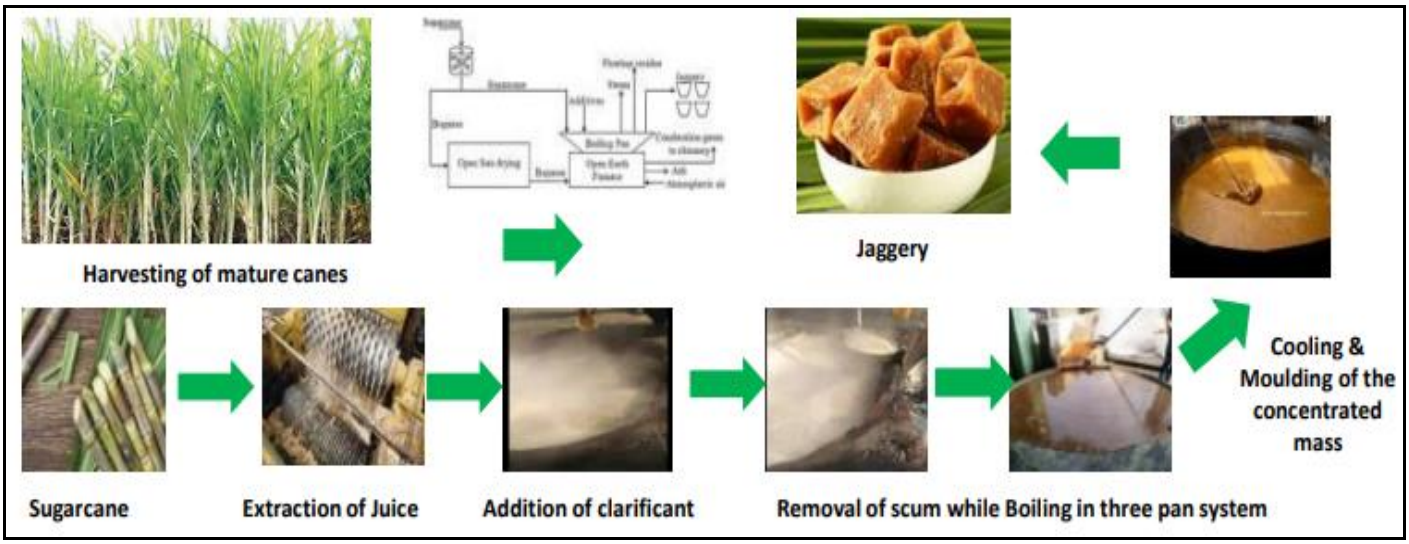

Fig 1: Process flow diagram of the organic jaggery production

Results and Discussion

Effect of application of organic manure along with bio-fertilizer and green manuring on cane yield

Perusal of the data in table 4 reveal that organic cultivation treatment of maximum FYM application @ 30 t/ha at the time of sowing + BF + GM of *Sesbania* in inter row space was *at par* with chemical farming through inorganic application of fertilizer (69.43 t/ha and 70.10 t/ha, respectively). Both the treatments produced significantly higher cane yield compared to treatments of application of FYM @10 (55.99 t/ha) or 20 t/ha + BF + IPM (61.33 t/ha) or seed treatment with *beejamrit* (natural formulation I) + three sprays of cow urine based products (natural formulation II) during the months of April, May and June i.e., in Natural farming (36.08 t/ha). This could be attributed to the use of FYM and biofertilizers, which increased the organic matter content of the soil and the availability of all essential nutrients to the plant throughout its life cycle, allowing all physiological processes in sugarcane to function smoothly.

On an average CoH 167 (63.16 t/ha) produced higher cane yield as compared to CoH 160 (54.01 t/ha). Natural farming gave lowest cane yield which might be due to lack of other essential nutrients, which has lowered photosynthesis rate and ion translocation compared to other treatments (Roohi *et al.,* 2022) [9].

Table 4: Effect of application of different treatments on cane yield

Manure and Fertilizers (A)	COH167	COH160	Cane Yield (t/ha)
T_1: 10 t FYM* + BF* + control of insect pest and diseases through organic mode practices	59.21	52.77	55.99
T_2: 20 t FYM + BF + control of insect pest and diseases through organic mode practices	66.78	55.88	61.33
T_3: 30 t FYM +BF + control of insect pest and diseases through organic mode practices	74.15	64.71	69.43
T_4: Natural farming	41.35	30.82	36.08
T_5: Chemical (RDF* 150:50:50; N, P_2O_5 and K_2O kg/ha) (Chemical farming)	74.29	65.90	70.10
CD ($p \leq 0.05$)	3.01		
Varieties (B)			
CoH 167	63.16		
CoH 160	54.01		
CD ($p \leq 0.05$)	1.90		
CD ($p \leq 0.05$) A x B	NS		

*FYM= Farm Yard Manure, BF= Biofertilizer, RDF= Recommended Dose of Fertilizers

Several field experiments had been researched to study the impact of organic cultivation on the crop yield, quality, economies and soil nutrient content in several crops (Sankar *et al.*, 2007, Shivakumar *et al.*, 2012, Patra and Sinha, 2012) [12, 10 16]. Soomro *et al.*, 2013 [17] studied integrated nutrient effect of inorganic and organic fertilizers and reported higher cane yield and quality with saving of 25 per cent inorganic fertilizers by using of FYM and/or press mud at 20 t/ha. Bokhtiar and Sakurai, 2005 [3] studied the effect of organic manure and chemical fertilizers on fertility of soil and productivity of sugarcane crop. A cane yield (108.4 t/ haand 96.8 t/ha) in plant and ratoon crop was observed with application of FYM at 15 t ha^{-1} along with chemical fertilizer. They also reported 25 per cent reduction in fertilizer application if FYM or press mud at 15 t/ha was used in sugarcane plant and ratoon crops. Similar research studies by Sankar *et al.*, 2007 and Rakkiyappan *et al.*, 2001 [10, 8] observed a positive correlation of the effects of organic biocompost (FYM, Pressmud etc) on the cane yield and quality of different sugarcane varieties. The reason could be due to the increased improvement in the availability of soil nutrients (available N, P, K, S and total nitrogen content), organic carbon which has an additive effect on the microbial activity and mineralization of native nutrients which ultimately lead to increase in cane yield. Shilpa *et al*. (2017) [11] also documented 5-10% increase in sugarcane yield with the addition of biofertiliser in integrated nutrient management programme in sugarcane crop.

Effect of application of organic manure along with bio-fertilizer and green manuring on jaggery production

Out of the two organically cultivated varieties, jaggery prepared from CoH 160 was found to be superior to CoH 167 in terms of its quality, sensory acceptance and also acceptable light golden yellow color. Guddadamath *et al.*, 2014 [5] also observed that organic jaggery prepared from sugarcane varieties (SNK 07337 and SNK 07680) were superior and of highly acceptable golden yellow color over the commercial sugarcane varieties. In this study, CoH 160 was found to have 85.69% sucrose, 9.36% reducing sugar, 7.75% moisture, 0.25% water insoluble matter, 2.46% sulphated ash and 0.14% ash insoluble in dilute hydrochloric acid while CoH 167 was found to have 85.27% sucrose, 7.80% reducing sugar, 9.27% moisture, 0.18% water insoluble matter, 3.10% sulphated ash and 0.13% ash insoluble in dilute hydrochloric acid (Table 5). The various quality parameters of jaggery are in the range as depicted by FSSAI, 2017 [4], Shweta *et al.*, 2021 [14] and Singh *et al.*, 2018 [15]. However, the enhanced cane yield and better juice quality leads to the good organic quality jaggery production. Shweta *et al.*, 2021 [14] screened different early and mid-late sugarcane varieties and prepared jaggery from five different sugarcane varieties. The jaggery prepared from early sugarcane varieties (Co 89003 and CoH 160) had better sensory acceptability and quality as compared to jaggery made from all other mid-late varieties.

Table 5: Quality parameters of the organic jaggery prepared from two different sugarcane varieties

Parameters	CoH 160	CoH 167	Permissible Limits (As per FSSAI, 2017) [4]
Sucrose (on dry basis), %	85.69	85.27	70.0 (percent by mass, min)
Reducing Sugar (on dry basis), %	9.36	7.80	20 (percent by mass, max)
Moisture, %	7.75	9.27	7.0 (percent by mass, max)
Water insoluble matter (on dry basis), %	0.25	0.18	2.0 (max)
Sulphated ash (on dry basis), %	2.46	3.10	4.0 (percent by mass, max)
Ash insoluble in dilute HCL (on dry basis), %	0.14	0.13	0.5 (percent by mass, max)

Several field experiments had been researched to study the impact of organic cultivation on the crop yield, quality, economies and soil nutrient content in several crops (Sankar *et al.*, 2007, Shivakumar *et al.*, 2012, Patra and Sinha, 2012) [10, 12, 7]. Soomro *et al.*, 2013 [17] studied integrated nutrient effect of inorganic and organic fertilizers and reported higher cane yield and quality with saving of 25 per cent inorganic fertilizers by using of FYM and/or press mud at 20 t/ha. Bokhtiar and Sakurai, 2005 [3] studied the effect of organic manure and chemical fertilizers on fertility of soil and productivity of sugarcane crop. A cane yield (108.4 t/ haand 96.8 t/ha) in plant and ratoon crop was observed with application of FYM at 15 t ha^{-1} along with chemical fertilizer. Organic manure enhanced the organic carbon, total N, and available P, K & S contents of soils increased slightly due to incorporation of organic manure. They also reported 25 per cent reduction in fertilizer application if FYM or press mud at 15 t/ha was used in sugarcane plant and ratoon crops. Similar research studies by Sankar *et al.*, 2007 and Rakkiyappan *et al.*, 2001 [10, 8] observed a positive correlation of the effects of organic biocompost (FYM, Pressmud etc) on the cane yield and quality of different sugarcane varieties. The reason could be due to the increased improvement in the availability of soil nutrients, organic carbon which has an additive effect on the microbial activity and mineralization of native nutrients. Shilpa *et al.* (2017) [11] also documented 5-10% increase in sugarcane yield with the addition of biofertiliser in

integrated nutrient management programme in sugarcane crop.

Conclusion

The organic cultivation of sugarcane varieties was effectively carried out using diverse treatments and specific conditions. Notably, the application of FYM at a rate of 30 t/ha during sowing, combined with biofertilizers, *Sesbania* green manuring in inter-row spaces, and IPM practices, yielded cane crops comparable to those from conventionally recommended fertilizer applications. This approach significantly enhanced cane yield compared to natural farming methods or the application of FYM at lower rates (10 or 20 t/ha) alongside biofertilizers, green manuring, and IPM techniques. CoH 167, a mid-late maturing sugarcane variety, exhibited superior cane yield at 63.16 t/ha compared to the early maturing variety CoH 160, which yielded 54.01 t/ha. In terms of jaggery quality, sensory attributes, and desirable light golden yellow color, jaggery produced from the CoH 160 (early maturing) variety surpassed that from CoH 167 (mid-late maturing), highlighting its superiority in organic cultivation outcomes.

Acknowledgment

Authors acknowledged the timely financial assistance and support provided by the CCS Haryana Agricultural University, Hisar, Haryana.

References

1. Adeyemo AJ, Akingbola OO, Ojeniyi SO. Effects of poultry manure on soil infiltration, organic matter contents and maize performance on two contrasting degraded alfisols in southwestern Nigeria. International Journal of Recycling Organic Waste in Agriculture. 2019;8:73-80.
2. Antonious GF. Biochar and animal manure impact on soil, crop yield and quality. In: Aladjadjiyan A, editor. Agricultural Waste and Residues. London, UK: Intech Open Limited; c2018. p. 45-67.
3. Bokhtiar SM, Sakurai K. Effects of organic manure and chemical fertilizer on soil fertility and productivity of plant and ratoon crops of sugarcane. Archives of Agronomy and Soil Science. 2005;51(3):325-334.
4. FSSAI. Standards for Gur or Jaggery, Sodium Saccharin and Calcium Saccharin. In: Food Safety and Standards (Food Products Standards and Food Additives) Amendment Regulations; Press Note. c2017. p. 1-8.
5. Guddadamath SG, Patil SB, Khadi BM, Chandrashekar CP. Genetic Enhancement of Sugarcane for the Production of Organic Jaggery. Sugar Tech. 2014;16:86-91.
6. Khan A, Gillani SW, Jiang H, Wei Y, Li M, Yu Z, *et al.* Combine application of N and biofertilizers improved plant morphology and soil environment via regulating rhizosphere bacterial community under sugarcane monocropping. Industrial Crops and Products. 2024;210:118074. ISSN 0926-6690.
7. Patra PS, Sinha AC. Studies on organic cultivation of groundnut (*Arachis hypogaea*) in Cooch Behar. Indian Journal of Agronomy. 2012;57(4):386-389.
8. Rakkiyappan P, Thangavelu S, Malathi R, Radhamani R. Effect of biocompost and enriched pressmud on sugarcane yield and quality. Sugar Tech. 2001;3:92-96.
9. Roohi, Khokhar KK, Kumar V, Pawar K. Effect of organic manure and zero budget technique on soil fertility and productivity of sugarcane plant and ratoon crop. Annals of Plant and Soil Research. 2022;24(3):378-383.
10. Sankar BMV, Mastan RC, Subramanyam A, Balaguravaiah D. Effect of integrated use of organic and inorganic fertilizers on soil properties and yield of sugarcane. Journal of the Indian Society of Soil Science. 2007;55(2):161-166.
11. Shilpa V, Chogatapur V, Reshma S. Organic Sugarcane: A Review. International Journal of Current Microbiology and Applied Sciences. 2017;6(12):1729-1738.
12. Shivakumar BS, Dharmatti PR, Channal HT. Effect of organic cultivation of papaya on yield, economics and soil nutrient status. Karnataka Journal of Agricultural Sciences. 2012;25(4):488-492.
13. Shivashenkaramurthy M, Nayak GV, Rajakumar GR, Channabasappa KS, Patil SB. Effect of nutrient management and cultivars on quality of sugarcane juice and liquid Jaggery. Journal of Pharmacognosy and Phytochemistry. 2021;10(2):1502-1510.
14. Shweta, Pawar K, Gehlot R, Kumar R, Sharma S. Screening and Physico-chemical Study of Quality Jaggery Prepared from Different Early and Mid Season Sugarcane Varieties. Asian Journal of Dairy and Food Research. DOI: 10.18805/ajdfr. DR-1680. 2021.
15. Singh P, Bhatnagar A, Singh MM, Singh A. Validation of Elite Sugarcane Varieties for quality jaggery production in Subtropical India. Sugar Tech; c2018. DOI: 10.1007/s12355- 018-0647-6.
16. Sinha SK, Kumar Dr A, Kumari A, Singh AK. The Integrated Effect of Organic Manure, Biofertilizer and Inorganic Fertilizer on Soil Properties, Yield and Quality in Sugarcane Plant-ratoon System under Calcareous Soil of Indo-gangetic Plains of India. Journal of Scientific Research and Reports. 2024;30(5):193-206.
17. Soomro AB, Tunio S, Oad FC, Raiper I. Integrated effect of inorganic and organic fertilizers on the yield and quality of sugarcane (*Saccharum officinarum* L.). Pakistan Journal of Botany. 2013;45(4):1339-1348.