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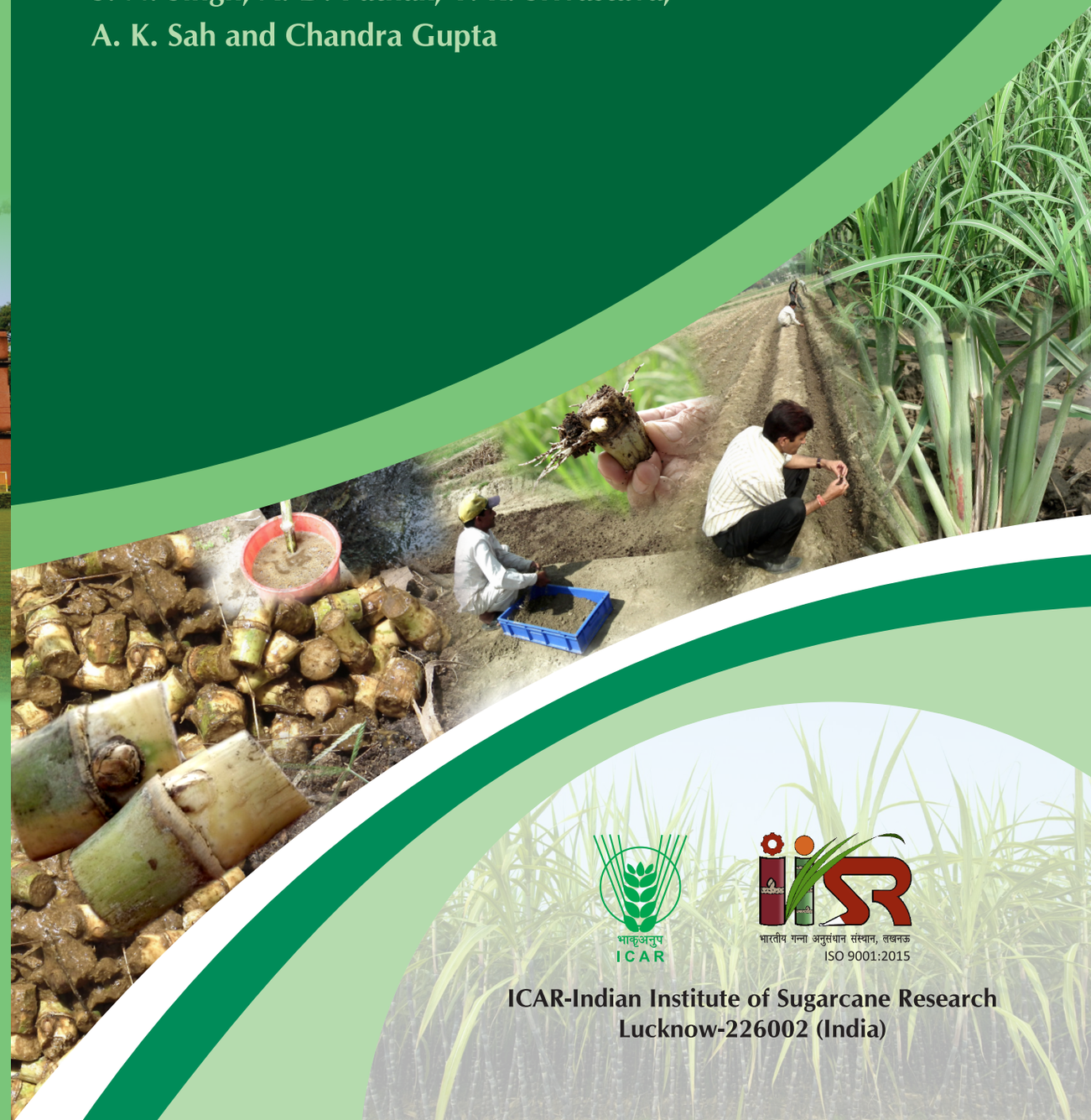
army printing press
www.armyprintingpress.com
Lucknow (0522) 6565333

Cane Node Technology for Sugarcane Planting

S. N. Singh, A. D. Pathak, T. K. Srivastava,
A. K. Sah and Chandra Gupta



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भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001:2015

ICAR-Indian Institute of Sugarcane Research
Lucknow-226002 (India)

IISR Tech Bulletin No : 01/2020

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Published by :

Director
ICAR-Indian Institute of Sugarcane Research
Lucknow-226002 (India)

Citation :

S. N. Singh, A. D. Pathak, T. K. Srivastava, A. K. Sah and Chandra Gupta 2020. Cane Node Technology for Sugarcane Planting for Higher Yield with Reduced Cost. ICAR-Indian Institute of Sugarcane Research Lucknow, Page 44.

Year of Publication :

2020

Printed at : Army Printing Press, 33 Nehru Road, Sadar Cantt, Lucknow Ph. 2481164

भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान
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Foreword

Sugarcane (*Saccharum* sp. complex) is one of the most efficient converters of solar energy into sugars and other forms of energy. In India, it is cultivated in an area of 5.042 m ha with a total production of 411 m tonnes of sugarcane and 32.48 m t of sugar at an average cane productivity of 81.5 t/ha. It is cultivated commercially by planting portions of cane stalk known as seed pieces, cane setts or seed cane. The true seed of sugarcane is called fluff and used for raising seedlings under conventional breeding programme for the development of new sugarcane varieties. Economic viability of sugar sector in India hinges on cost effective sugarcane cultivation, as sugar mills incur more than 66% of sugar production cost on the purchase of raw material. Sugarcane, with harvestable stalk yield of 100 t (tonnes), on an average, produces 10 t of sugar, 4 t of molasses (ethanol production), 3 t of press mud (organic manure production), 30 t of bagasse (co-gen of 1500 kW electricity and manufacturing of paper *etc*.) besides 30 t of cane tops and leaves (for cattle feed and trash mulching *etc*.). Maximization of sugarcane productivity with reduced cost of cultivation is an outcome of adequate and appropriate agronomic management practices. Efficient use of precious farm resources (seed cane amongst others) has always been targeted under new agronomic interventions in sugarcane agriculture. Accurate and healthy seed cane placement (preferably in least quantity) in soil not only helps in ensuring good initial plant population in the field but also reduces the cost of production by optimizing use of available farm inputs.

As we know that planting of sugarcane in one ha area requires 60-80 quintals of seed cane depending upon the cane variety and planting methods used. Sugarcane (*Saccharum* spp. hybrid) is commercially planted by using stalk cuttings or setts of about 25-30 cm stalk pieces having 2-3 buds that accounts for about 20-25 percent of the total cost of production, which is gradually becoming uneconomical since nearly 10% of total produce is used as planting material. This large mass of planting material poses a great problem in transport, handling and storage of seed cane and prone to rapid deterioration thus reducing the viability of buds and subsequently their sprouting. To overcome the problem of voluminous requirement of seed cane material, an alternative method of economized seed cane use and planting technique was very much needed. Based on this, a technique called "Cane Node Technology for Sugarcane Planting" was developed and experimented over the years assessing its utility and feasibility in reducing the seed cane quantity without compromising cane yield in addition to rapid multiplication of newly released varieties of sugarcane in real farming situations. I am sure the present form of this technical bulletin will be of much use to the various stakeholders engaged in sugarcane agriculture. I heartily congratulate the authors of this bulletin for extending their intellectual, scientific and editorial skills in bringing out this unique publication in the interest of addressing the concerns mainly of rising cost of cultivation in sugarcane growing.

Date : 4 March 2020
Lucknow

(A.D. Pathak)

Preface

In the past, various sugarcane researchers have reported that a small volume of tissue and a single root primordium adhering to the bud are enough to ensure germination in sugarcane. They have also stated that under favourable growing conditions, a sett or stalk with only one bud did well as seed cane material for good germination of sugarcane. Extensive work has also been done to assess the effect of using different types of seed cane materials such as single bud settlings, bud chip raised seedlings, 1-3 bud setts for crop establishment and then determining the effect of the planting material on growth and yield of sugarcane in India. It has been observed that, due to saving in seed cane material, the highest net returns can be obtained with settlings raised from single-bud setts. Earlier studies have established that about 80% (by weight) of seed material can be saved by planting single-bud setts over the conventional 3-bud setts planting. The single-bud sett seed material has relatively low food reserves (1.2-1.8 g sugar/single-bud sett) compared to conventional 3-bud setts (6.0-8.0 g sugar/3-bud setts). The food reserves and moisture content in the single bud setts deplete at a faster rate compared to 2 or 3 bud setts, therefore sufficient soil moisture and nutrients are pre-requisite for viability of single bud setts as planting material. In view of the benefits of using single-bud setts for sugarcane planting, extensive field experiments were carried out at ICAR- Indian Institute of sugarcane Research, Lucknow and its validation was also done at the farmers' fields in different sugar factory zones of Uttar Pradesh.

It was long felt imperative to develop an efficient agro-technique for faster multiplication of healthy and quality seed cane of newly released varieties in sugarcane cultivation with reduced cost. Several techniques have been developed for rapid multiplication of seed cane of promising varieties at a faster rate. Few to mention here are poly-bag technology of settlings raising, tissue culture technique for rapid multiplication of disease free planting material, spaced transplanting technique (STP), sustainable sugarcane initiative (SSI) technology, bud chip method of developing sugarcane seedlings *etc*. These technologies though proved potential in sugarcane cultivation, but being applied only in location specific agro-climatic and soil conditions across the states in India. To address this gap of wider adoptability and also to make it practically feasible by the farmers, a package of simple agricultural innovations popularly known as “Cane Node Technology” has been developed by ICAR-Indian Institute of Sugarcane Research, Lucknow for commercial cultivation of sugarcane using less seed cane material in the form of single node of cane with priming techniques and seed cane treatments to enhance germination and establishment of adequate plant population in the field. The results obtained in field experimentation (on-station and farmers' fields) hold great promise in economizing seed cane use and faster multiplication of newly released varieties of sugarcane besides enhancing cane yield.

Date : 4 March 2020
Lucknow

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Cane Node Technology for Sugarcane Planting

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Economic viability of sugar sector in India hinges on cost effective sugarcane cultivation, as sugar mills incur more than 66% of sugar production cost on the purchase of raw material. Sugarcane,with harvestable stalk yield of 100 t (tonnes), on an average, produces 10 t of sugar, 4 t of molasses (ethanol production), 3 t of press mud (organic manure production), 30 t of bagasse (co-gen of 1500 kW electricity and manufacturing of paper *etc*.) besides 30 t of cane tops and leaves (for cattle feed and trash mulching *etc*.). Exploiting the full production potential of sugarcane is of utmost importance for maximizing its production as well as productivity, which is an outcome of adequate and appropriate agronomic management practices. Efficient use of precious farm resources (seed cane amongst others) has always been critical for sustainable growth of sugarcane agriculture. Accurate and healthy seed cane placement (preferably in least quantity) in soil not only helps in ensuring good initial plant population in the farm but also reduces the cost of production by optimum utilisation of available farm inputs. In addition to many inputs involved in sugarcane production, focus on the seed cane saving technology is needed to effectively check its increasing cost of cultivation.Sugarcane (*Saccharum* spp. hybrid) is commercially planted by using stalk cuttings or setts that accounts for about 20-25 percent of the total cost of production. This method of cultivation is gradually becoming uneconomical. In conventional system of sett planting about 6 – 8 tonnes/ha of seed cane (nearly 10% of total produce) is used as planting material, which comprises of about 25-30 cm stalk pieces having 2-3 buds. This large mass of planting material poses a great problem in transport, handling and storage of seed cane and prone to rapid deterioration thus reducing the viability of buds and subsequently their sprouting. One alternative to reduce the quantity and improve the quality of seed cane would be to plant pre-sprouted single bud cane segments, popularly known as cane nodes. These cane nodes are less bulky, easily transportable and more economical as seed material. The cane node technology holds great promise in rapid multiplication of newly released varieties of sugarcane. Moreover, it improves uniformity within row spacing and provides room for decreased competition among plants.

In the past, various sugarcane researchers have reported that a small volume of tissue and a single root primordium adhering to the bud are enough to ensure germination in sugarcane. They have also stated that under favourable growing conditions, sett or stalk with only one bud did well as seed material for good germination of sugarcane. Indian sugarcane experts have showed the feasibility of eliminating the inter-nodal part of the seed cane piece and using only buds for commercial planting. Extensive work has been done using different types of seed cane materials such as single bud settlings, bud chip raised seedlings, 1-3 bud setts for crop establishment and then determining the effect of the planting material on growth and yield of sugarcane in India. It has been observed that, due to saving in seed material, the highest net returns can be obtained with seedlings raised from single-bud setts. Earlier studies have established that about 80% (by weight) of seed material can be saved by planting single-bud setts over the conventional 3-bud setts planting. The single-bud sett seed material has relatively low food reserves (1.2-1.8 g sugar/single-bud sett) compared to conventional 3-bud setts (6.0-8.0 g sugar/3-bud setts). The food reserves and moisture in the single bud setts deplete at a faster rate compared to 2 or 3 bud setts, therefore sufficient soil moisture and nutrients must be available at the time of planting. In view of the benefits of using single-bud setts sugarcane planting, extensive research work has been carried out at ICAR- Indian Institute of sugarcane Research, Lucknow on this aspect besides its validation at the farmers' fields in different sugar factory zones of Uttar Pradesh.

The cane growers may have to pay even more for the newly released varieties due to scarcity of high quality seed cane. Therefore, it becomes imperative to develop an efficient agro-technique for producing a sufficient quantity coupled with optimum quality of healthy seed cane for planting sugarcane under such conditions. Several techniques have been developed for multiplication of seed cane of promising varieties at a faster rate, but could not be applied due to several problems. To solve these problems, scientists at the Institute proposed a method of raising polythene bag nursery from young buds located in the spindle region of sugarcane stalk and transplanted the plantlets into the field. Planting single-bud setts in polythene bags provides an opportunity for faster multiplication of newly released varieties of sugarcane over the conventional system where the average germination rate of 35-40% from 37000 three-bud cane setts (6-8 t/ha) results into wastage of precious seed material. Further, the bulky cane cuttings used for planting harbour many pests and diseases thereby decreasing cane yield and quality drastically. Accumulation of diseases over vegetative cycles leads to further decline in yield and quality over the years. In fact, poor seed cane quality is a major constraint in sugarcane

production. Development of tissue culture technology for rapid multiplication of disease-free planting material has greatly facilitated mass production of quality seed in sugarcane, but due to some technical problems and increasing cost, it could not be carried forward further for commercial sugarcane production. To address these aforesaid problems, a package of simple agricultural innovations popularly known as "cane node technology" has been developed by ICAR-IISR, Lucknow for sugarcane farming using less seed cane material in the form of single bud cane node with priming techniques and seed cane treatments to enhance germination and establishing adequate plant population in the field.

Concerns of conventional 3-bud setts sugarcane planting

- Huge seed cane requirement (60-80 q/ha)
- Entails significant investment in seed cane : 22-25% of the total cost of cultivation
- Slow and low bud germination restricts early vigour of cane crop
- Narrow multiplication ratio (1:10) of sugarcane seed
- Irregular germination in time and space (about 10-15% bud setts fail to sprout) creates 20-25% gaps in crop stand, resulting in low cane yield
- Transportation of huge quantity of seed cane reduces the seed quality and makes adoption of packaging and seed certification procedures difficult

Cane node technology: the background

- To reduce the quantity of seed cane requirement from 6-8 to 1.5-2.0 tonnes per hectare, ICAR-Indian Institute of Sugarcane Research, Lucknow developed STP (Spaced transplanting technique) method of planting wherein single-bud stem cuttings are first raised in nursery bed then transplanted in the field. However, for transplanting and better establishment of settlings two additional irrigations are required over the recommended practice which favours prolific weed growth and that adds to the cost of cultivation. Therefore, the technique was not in much favour for its adoption at large.
- Recently, 'bud-chip technique' has also been tried, but in this technique also transplanting is required. Bud-chips are not planted directly in the field. However, this technique also suffers with the requirement of transplanting.
- The cane-node technology is a novel technique for priming of sugarcane planting material, its packaging, transportation, certification and field placement for faster germination and higher cane yield.

- Through priming of sugarcane planting material, we aim to accelerate bud germination so that cane germination period in field conditions could be reduced effectively from 45 days required in conventional 3- bud setts planting.

Description of the cane-node technology

- For seed cane priming, a stem cutting having a bud along with root band and attached an inch length of internode on both sides is taken as planting material (Fig. 1a).
- This planting material is treated first with 0.10 – 0.75% liquid solution of *carbendazim* for at least 30 minutes (Fig. 1b) followed by treatment for 15-20 minutes in a liquid organic formulation made up of cattle dung and cattle urine in a ratio of 1:1 to 1:5.
- This organic formulation in a container is diluted 5-10 times with water and stirred for 5-10 minutes to make it as organic slurry for priming the planting material (Fig. 1c).
- The planting material (cane nodes) is immersed in the slurry (Fig. 1d) for 15-20 minutes.
- After that seed material is incubated in a solid organic formulation made up of decomposed farmyard manure and soil in the ratio of 1:1 to 1:5; in a corner of field where these cane nodes are to be planted or any other desired place or in perforated plastic crates (Fig. 2).
- For incubation, the planting material is to be kept in layers on a bed with 2-5 cm thick solid organic formulation between each two layers.
- In this fashion, 3 such layers of planting material and solid organic material formulation, having 20-30% moisture content, is placed vertically one after other.
- After three layers of solid organic formulation and planting material, it must be covered by 1-5 cm thick layer of dry soil, followed by sprinkling of chlorpyriphos at the concentration of 10 ml/L of water to safeguard against termites.
- After covering, the swelling of buds starts which may be checked in the field itself after 5-7 days under 25-35^{0}C temperature.

- If the planting of cane node segments are to be planted in some other fields/ places, then these 5-7 days may be utilized for transportation of such seed cane material from nursery site to actual planting site.
- A minimum period of 5-7 days is required for completion of priming of seed in the above mentioned temperature range.
- Once the packaged planting material reaches the destination (the period may vary from 0-7 days depending upon the distance and mode of transportation) the primed buds with discernible roots on conjoined root band are planted in furrows.
- Emergence of shoots from such primed buds takes about 7-10 days depending on soil moisture and temperature of the atmosphere, thus the total period required for shoot emergence is 12-16 days against 45 days required with the conventional practices. The germination percentage is more than 90% against 35-40% under conventional methods of planting.

Modus operandi under field conditions

Cane nodes preparation

Cutting of healthy cane nodes (4-5 cm long) having viable buds along with root bands

Treatment of cane nodes

(a) Dipping of cane segments in 0.10-0.75% liquid solution of *carbendazim* at least for 30 minutes

(b) Preparation of liquid organic formulation made up of cattle dung and cattle urine in a ratio of 1:1 to 1:5

(c) The above solution is diluted 5-10 times with water and stirred for 5-10 minutes to make it an organic slurry

(d) Planting material is immersed in the above slurry for 30 minutes

Preparation of soil mixture for use in nursery bed

(a) Mixture of field soil and decomposed FYM/SPMC in the ratio of 1:1 to 1:5 maintaining moisture content of 20-30%

(b) Sprinkling of chlorpyriphos solution (10 ml/L of water) on the soil mixture to safeguard against termite

Photographs showing sequential methodology of cane node technology of sugarcane growing

Fig. 1 (a): Cane node segments

Fig. 1 (b): Cane nodes treatment

Fig. 1 (c): Priming of cane nodes

Fig. 1 (d): Cane nodes' treatment in organic slurry

Fig. 2: Cane nodes ready for planting in nurserry

Fig. 3: Establishing nursery for cane nodes plantation

Fig. 4: Status of cane nodes after 5-6 days of incubation

Fig. 5: View of a cane node after incubation

Fig. 6: Cane nodes kept in the plastic tub for planting in the field

Fig. 7: Planting of incubated cane nodes in the field planted crop

Fig. 8: Tillers production of cane nodes

Fig 9: Growth of sugarcane planted by cane node method

Selection and preparation of nursery

(a) Corner of a field on the planting site

(b) Nursery size should be 5.0 m × 0.60 m to accommodate planting material for 1 ha field

(c) Layering of 2 cm soil mixture from the base of nursery bed

Placement of cane nodes in nursery

(a) Placing of cane nodes on the nursery bed just like a mat

(b) Layering of 2 cm soil mixture over the cane nodes

(c) Placing second layer of cane nodes and covering with 2 cm soil mixture

(d) Covering of nursery bed with dry sugarcane leaves

(e) Sprinkling of water over nursery bed on alternate day basis to maintain 20-30% soil moisture

Incubation period

(a) Primed cane nodes are kept in incubation for 5-7 days

(b) Buds start swelling after 2 days of implantation

(c) Sprouts of 0.2-0.4 cm length emerge on buds after 5-7 days

Field plantation

(a) Planting of sprouted buds at 75 cm × 30 cm distance (spring planting season) or as per planting geometry to be adopted in accordance with the planting seasons or as per requirement.

(b) Follow up of normal agronomical practices as is done in conventional planting (Fig. 3 to Fig. 9)

Table 1: Conventional *versus* cane node planting in sugarcane cultivation

Sr. No.	Parameters	Conventional planting material (3- bud setts)	Cane node planting material (stem cutting having a bud alongwith roots band only)
1.	Seed cane quantity	60-80 q/ha	15-17 q/ha
2.	Length of planting material	25-30 cm	4-5 cm
3.	Weight of planting material	125-150 g / segment	20-25 g / segment

4.	No. of planting material required	44,400/ha (75 cm × 30 cm spacing)	44,400/ha (75 cm × 30 cm spacing
5.	No. of buds required	1,33,200/ha	44,400/ha
6.	Expenses on the total cost of cultivation	20-25%	5-6%
7.	Buds germination	Slow (35-38% at 45 DAP)	Quick (85-90% at 45 DAP)
8.	Plant vigour	Slow, on account of late emergence of leaves and less leaf area	Early, on account of early emergence of leaves and more leaf area
9.	Seed cane multiplication ratio	1:10	1:40
10.	Extent of plant population	10-15% buds fail to sprout and thus create 20-25% gaps, and reduces yields of cane and ratoon subsequently	Almost gapless initial planting density
11.	Scope of enhancing planting density	Sub-optimum, thus difficult	Optimum, and can be enhanced further by manipulating planting geometry and nutrition level
12.	Transportation of seed cane	A cumbersome job due to huge quantity	Can be done easily
13.	Maintaining genetic purity and mixing of seed cane and during transportation	Difficult due to unfair mixing in open truck, and farmers remain suspicious	No chance of mixing due to less seed cane quantity and genetic purity maintained
14.	Seed cane packaging	Difficult due to bulk quantity and mechanical damage to buds due to truck loading	Easier due to less quantity

15.	Seed cane certification	Not possible due to unpacked planting material	Possible due to packing
16.	Suitability for intercropping	Not very good	Good, because of uniform planting density
17.	Gap filling, weeds management and late planting	Not very easy	Easier, sprouted planting materials get ready in advance

On-station experimental results

An experiment on "Cane node technology of sugarcane planting" was initiated at ICAR-Indian Institute of Sugarcane Research, Lucknow for two crop seasons during 2014-2015 and 2015-16 consisting of the treatments namely, T_1 : Cane node (a stem cutting having a bud along with root band) only, T_2 : Cane node + 2 cm internode (both side of the cane), T_3 : Cane node + 2 cm internode (upper side of the cane only), T_4 : Cane node + 2 cm internode (lower side of the cane only), T_5 : Conventional planting of 1-bud setts, T_6 : Conventional planting of 2-bud setts and T_7 : Conventional planting of 3-bud setts. On the basis of results obtained, it was observed that the cane node technology may be useful in reducing the seed cane quantity in sugarcane cultivation in addition to rapid multiplication of newly released varieties of sugarcane germination of cane buds.

Experimental data indicated that the germination of cane buds counted at 25, 35 and 45 days after planting (DAP) under cane node planting treatments (T_1, T_2, T_3 and T_4) was maximum and it was, on an average, 67.69, 71.35 and 82.50% as against 23.79, 32.99 and 39.00% under conventional planting by 3-bud setts, respectively. Higher germination percent in cane node planting treatments also produced significantly more number of tillers and millable canes than that of conventional planting methods (T_5, T_6 and T_7). Cane yield also exhibited almost the same trend as the number of tillers and millable canes under different treatments, and it was significantly higher under cane node planted treatments producing 8.72% more cane yield than that obtained under conventional 3-bud planting method (75.31 t/ha). CCS% cane did not differ significantly due to different treatments in the test.

Off-station experimental results

The results of cane node technology experiment done at ICAR-IISR, Lucknow were validated at the different farmers' fields under sugar mills zone areas (east, central and west) of Uttar Pradesh. This experiment was carried out in two farmers'

fields each at two villages in east, central and western sugar factory zones separately. Experimental results indicated that the cane yield obtained in different farmers' fields of all the three sugar factory zones exhibited almost the same trend with that of germination %, tillers and millable cane numbers (Table 2). On an average, the cane yield of 95.11 t/ha obtained under cane node planting from all the three sugar factory zones, and it was higher by 8.88% than that of conventional method of planting (86.66 /ha). The technology of sugarcane planting by cane node method is becoming popular among sugarcane farmers in the state, since it gives not only good cane yield but also saves precious seed cane planting material and thereby reduces cost of cultivation. Sugarcane farmers are also preferring this technology and using it for rapid multiplication of newly released varieties of sugarcane (Fig. 10).

Table 2. Germination percent, number of tillers, number of millable canes and cane yield obtained under cane node and conventional planting techniques in different sugar factory zones of Uttar Pradesh

Sugar factory zone/ village / farmer	Germination (%)		Tillers ('000/ha)		Millable canes ('000/ha)		Cane yield (t/ha)	
	Cane Node	Conven-tional	Cane Node	Conven-tional	Cane Node	Conven-tional	Cane Node	Conven-tional
(A) *Hata* (East U.P.)								
(1) Village : 1								
(i) Farmer 1	79.64	38.73	168	159	120	100	103.6	80.55
(ii) Farmer 2	72.30	39.74	164	152	110	105	75.35	67.94
Mean	75.97	39.24	156	156	115	103	89.21	74.25
(2) Village : 2								
(i) Farmer 1	79.70	39.20	159	145	104	100	88.00	80.34
(ii) Farmer 2	78.80	40.83	160	147	108	99	91.51	81.67
Mean	79.25	40.02	160	146	106	99	89.76	81.01
Mean of Eastern U.P.	77.61	39.63	163	151	111	101	89.49	77.63
(B) *Biswan* (Central U.P.)								
(1) Village : 1								
(i) Farmer 1	85.3	42.7	189	179	127	110	105.92	93.95
(ii) Farmer 2	88.6	41.5	182	169	128	112	109.96	96.78
Mean	86.9	42.1	186	174	128	111	107.94	95.37
(2) Village : 2								
(i) Farmer 1	87.3	43.2	183	165	130	118	107.30	98.15
(ii) Farmer 2	89.4	39.6	188	171	125	117	101.90	90.74
Mean	88.4	41.4	186	172	128	118	104.60	94.45
Mean of Central U.P.	87.65	41.75	186	173	128	115	106.27	94.91

(C) *Ramala* (West U.P.)								
(1) Village : 1								
(i) Farmer 1	92.3	45.8	206	205	139	130	95.30	92.30
(ii) Farmer 2	86.7	42.3	207	202	130	127	88.71	86.41
Mean	89.5	44.05	206	203	135	129	92.01	89.36
(2) Village : 2								
(i) Farmer 1	85.9	40.9	208	207	136	134	90.08	88.70
(ii) Farmer 2	89.4	39.7	210	200	129	125	84.14	82.31
Mean	87.7	40.3	209	203	133	130	87.11	85.51
Mean of Western U.P.	88.6	42.18	207	203	134	130	89.56	87.44
Mean of Uttar Pradesh	84.63	41.20	185	176	124	115	95.11	**86.66**

Table 3: Details of cost of cultivation of sugarcane under conventional and cane node planting techniques based on average data of sugarcane growing in east, central and western zones of Uttar Pradesh (2017-18)

Sr. No.	Particulars	Conventional	Cane node
1.	**Field preparation**		
	a) Disc ploughing: 3 hrs		
	b) Harrow – 2: 5 hrs		
	c) Cultivator – 2: 4 hrs		
	d) Planking - 1: 2 hrs		
	14 hrs	8400	8400
	e) Labour - 2	348	348
		----------	----------
		8748	**8748**
2.	**Seed cane and its preparation**		
	a) Seed cane: 70 qtl (conventional): 17 qtl (cane node)	26600	6460
	b) Harvesting: 12 labour (conv.): 04 (cane node)	2088	696
	c) Sett cutting: 08 labour (conv.): 06 (cane node)	1392	1044
	d) Seed transportation: 1 hr (conv.): 0.5 hr (cane node)	600	300
	e) Establishment of cane node nursery: 05 labour	---	870
		----------	----------
		34480	**9370**

3.	**Seed cane treatment and planting**		
	a) Seed cane treatment: 112g bavistin + 2 labour	728+348=1076	728+348=1076
	b) Furrow opening: 2 hrs	600	600
	c) Sett placement: 8 labour (conv.), 4 labour (cane node)	1392	696
	d) Covering + Planking: (1 pair bullock and 2 labour)	425+348=773	425+348=773
		---	---
		3841	**3145**
5.	**Irrigation:**		
	a) 07 (01 pre-planting + 06 growth period) (15 hrs/irrigation)	26250	26250
	b) Labour: 2 (pre-planting) + 12 (growth period)	2436	2436
		---	---
		28686	**28686**
6.	Manure, fertilizer & application		
	a) FYM @ 100 q/ha	7000	7000
	b) Transportation of FYM:2 hr	1200	1200
	c) Spreading: 4 labour	696	696
	d) 150 kg N + 80 kg P + 60 kg K	3600	3600
	e) SSP: 500 kg	2297	2297
	f) Urea: 300 kg	1400	1400
	g) MOP: 100 kg	1320	1320
		---	---
		17513	**17513**
7.	**Plant protection**		
	a) Chlorpyriphos @ 6.25 lit/ha	1484	1484
	b) Labour: 3	522	522
	c) Coragen: 0.375 lit	4750	4750
	d) Labour: 3	522	522
		---	---
		7278	**7278**
8.	**Inter-culture operation**		
	a) Hoeing with *kassi* – 2 @ 25 labour/hoeing	8700	8700
	b) Hoeing with cultivator: 2 (1 pair bullock + 2 labour) / hoeing	850+348=1198	850+348=1198
	c) Earthing: 2@ 30 labour	11440	11440
	d) Propping : 3@ 20 labour	10440	10440
		---	---
		31778	**31778**
9.	**Harvesting @ Rs. 40/q**	28000	28000
10.	**Supervision**	8000	8000
Total cost of cultivation (Rs./ha)		**1,68,324/-**	**1,42,518/-**

Fig. 10: Activities pertaining to priming of cane nodes at farmers field of Hata sugar factory (East U.P.)

Prevailing market rate of inputs:

Sugarcane (seed cane):	Rs. 380/ q	MOP:	Rs. 1400/q
Tractor:	Rs. 600/ hr	Bavistin:	Rs. 650/kg
Labour	Rs. 174/ day		
One pair bullock:	Rs. 425/ day	Coragen:	Rs. 12668/lit.
FYM:	Rs. 70/ q	Urea:	Rs. 696/q
Chloropyriphos	Rs. 295/lit.		
SSP:	Rs. 720/q	Irrigation	Rs. 250/hr

The components of cost of cultivation as indicated above (Fig. 11) clearly indicate that seed cane and preparation accounts for 22% of the total cost of cultivation. This cost can be reduced significantly with the adoption of cane node technology as it needs only 15-17 q/ha of seed cane quantity as against 60-80 q/ha under conventional 3-bud setts of sugarcane planting.

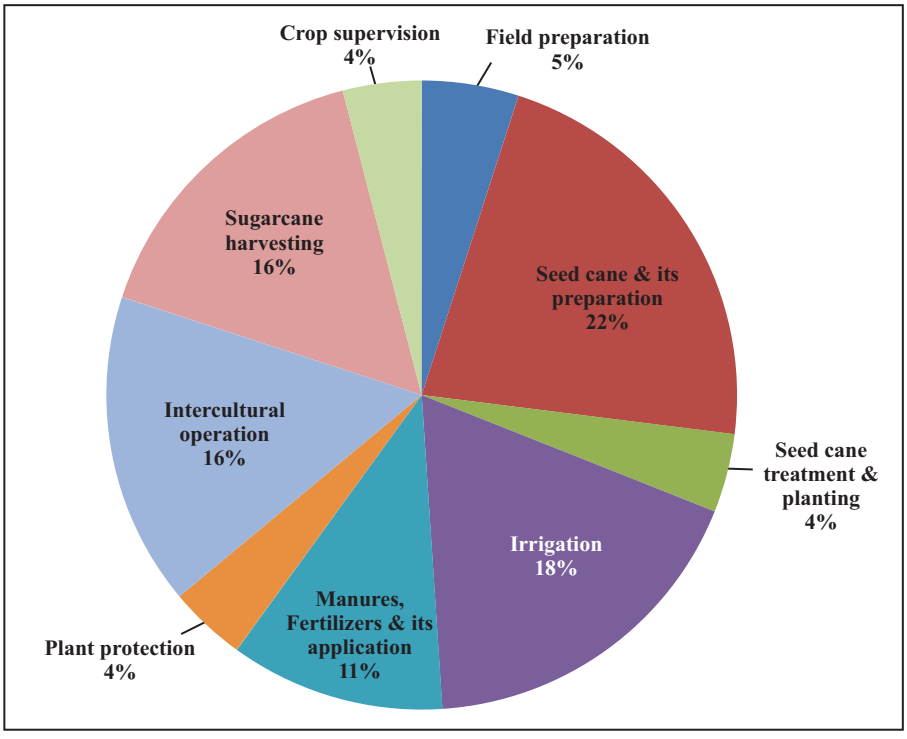

Fig. 11: Component wise cost of cultivation of conventional sugarcane

Table 4: Economic returns from both the methods of sugarcane cultivation

Sl. No.	Items	Pooled mean of 03 years data (Farmers' fields)	
		Cane node technology	Conventional 3 bud setts
1	Cane yield (t/ha)	88.00	81.70
2	Cost of cultivation (Rs/ha)	1,42,518	1,68,324
3	B:C ratio	2.01	1.58

The benefit cost ratio was higher in case of cane node method of sugarcane planting (2.01) compared to conventional 3 bud setts (1.58) (Table 4). The technology of sugarcane planting by cane node method is becoming popular among sugarcane farmers in different zones of the state since it gives not only good cane yield but also saves precious seed cane planting material and thereby reduces cost of cultivation. Sugarcane farmers are also preferring this technology and using it for rapid multiplication of newly released varieties of sugarcane.

Benefits of cane node technology

1) The seed cane quantity requires for this method is 15-17 quintals as against 60-80 quintals/ha in conventional planting, and thus reduces cost of cultivation.

2) Benefit: cost ratio worked out for sugarcane planting by cane node technique was 2.01 as against 1.58 under conventional method of sugarcane planting.

3) Seed cane multiplication ratio: 1:40 as against 1:10 in conventional method of planting.

4) It leads to quicker germination by planting of sprouted cane nodes in the field.

5) Uniform plant population that leads to higher yield of cane by way of maximizing initial crop stand.

6) An excellent tool for rapid multiplication of newly released varieties of sugarcane.

7) Easier packaging, transportation and seed cane certification because of smaller seed cane quantity required for sugarcane planting by cane node method.

8) Mechanization in sugarcane agriculture and intercultural operations (inter and intra) can easily be done on account of uniform stand establishment of initial plant population of sugarcane.

9) Disease management is easier under cane node technology method since smaller quantity of seed cane material can be well treated than that of a huge seed cane quantity required for conventional method of sugarcane planting.

10) Settlings developed through cane node technology can be used appropriately for gap filling after germination of conventionally planted sugarcane crop.

11) Sugarcane planting by cane node technology can be a very good option for late planting situations after harvest of scented varieties of rice in November (eastern Uttar Pradesh and north Bihar) and wheat in April-May (western Uttar Pradesh and parts of Haryana and Punjab) since it reduces the time to be taken for emergence of cane buds planted in the field.

12) Selection of viable cane buds for planting is easier due to smaller seed cane quantity since the same operation becomes quite difficult and time taking too in case of huge seed cane quantity required for conventionally planted sugarcane crop. Mechanical damage of cane buds during harvesting of sugarcane and also the damage caused by various insect pests occur usually.

13) Seed cane preparation and also the planting of sugarcane can easily be done by women farmers as it reduces drudgery in various operations involved in it.

14) It gives a very good scope for the development of cane node planter, so that the smaller quantity of seed cane material could be loaded easily in the machine and planting in the field subsequently.

15) In case if we do not have land for the establishment of a nursery for cane nodes priming and sprouting during incubation then the same operation can be done using plastic crates or gunny bags suitably.

16) Leftover sugarcane material after cutting of cane node segments can be well utilized for jaggery making or supplied to local cane juice venders / sugar mills.

Limitations and future line of work in cane node technology

1) The technology is undoubtedly useful in reducing the seed cane planting material and rapidly multiplying the newly released varieties of sugarcane besides enhancing the yield of cane up to some extent.

2) As per our observations, the best time for its planting in subtropical climatic conditions is in autumn (September – October) and early spring (February) seasons owing to less loss of soil moisture.

3) But when the planting is extended beyond February the available soil moisture depletes at faster rate due to blowing of desiccating westerly winds. This is the major bottleneck in obtaining good germination of cane nodes besides limiting the proper establishment of emerged plantlets thereafter.

4) Moreover, nutritional aspect is also an important factor to look into since food materials available in cane nodes is certainly less than that in 30 cm long 3-bud setts used in conventional planting.

5) There is a need to address the soil moisture constraints and nutrition aspects for accelerating cane buds germination and early vigour of emerged plantlets *vis-à-vis* maximized plant population in main planting season.

6) Cutting of sugarcane stalks for planting with traditional method is costly, time-consuming, requires great human force and high volume of sugarcane stalk per hectare. Also the existing (traditional) tools used for bud cutting of sugarcane are unsafe, messy and need skill and training. The risk of injury is also too high. This necessitates the development of a node cutting machine for sugarcane. Now-a-days seed cane cutting machines (1 HP) with the cutting efficiency of 4500 buds per hour have been developed/fabricated commercially (Fig 12) to reduce the human force and time. However, these machines may not have control on cutting location. Sometimes, cut may appear on the bud as well, which results into no germination of the bud and we lose the precious seed cane material. In addition to proper controlled cutting of stalk, it is necessary to identify any disease in the node as it affects the yield and quality of the sugarcane.

Fig. 12 : Cane Node Cutting Machine

7) To reduce the human effort required for sugarcane planting by developing automated sugarcane node cutting machine, it is required to have proper control on cutting location so that cut can not appear on node besides cutting of maximum nodes at minimum time for enhanced efficiency of the desired operation.

Common package of practices for sugarcane raised through cane node technology and conventional planting method

Planting Seasons

Since Sugarcane requires about 25-32°C for good germination, and this temperature requirement is met twice in Uttar Pradesh *i.e.* in the month of October and also in the months of February-March. The planting schedule of sugarcane in the state is illustrated here as under:

(A) Autumn planting: 15 September-30 October

(B) Spring planting:

(ι) Eastern zone: 15 January – end of February

(ii) Central zone: 15 February – end of March

(iii) Western zone: 15 February – end of March

(C) Late planting after harvest of wheat: April – 15 May (western zone of the state)

Sugarcane Varieties Recommended for Uttar Pradesh

Sugarcane varieties recommended for general cultivation in Uttar Pradesh are given in Table 5.

Table 5: Sugarcane varieties for general cultivation in Uttar Pradesh

Particulars			Name of Sugarcane varieties	
			Early	Mid late
1. State as a whole	All Areas of the state	All sugarcane producing districts of the state	Co S 8436, Co S 88230, Co S 95255, Co S 96268, Co S 03234, UP 05125, Co Se 98231, Co S 08272, Co Se 95422, Co 0238, Co 0118, Co 98014, Co S 13231 and Co S 13235	Co S 767, Co S 8432, Co S 97264, Co S 96275, Co S 97261, Co S 98259, Co S 99259, Co Se 01434, UP 0097, Co S 08279, Co S 08276, Co S 12232, Co Se 11453, Co 05011, Co S 09232 and Co S 13452

2. Western zone	Meerut, Saharanpur	Meerut, Ghaziabad, Hapur, Bulandshahr, Baghpat, Saharanpur, Muzaffarnagar, Shamali	Co J 64, Co S 03251, Co Lk 9709, Co 0237, Co 0239, Co 05009, Co Pk 05191, Co Lk 11203 in addition to varieties mentioned at row number -1	Co S 94257, Co S 96269, UP 39, Co Pant 84212, Co S 07250, Co H 119, Co Pant 97222 Co J 20193, Co 0124 , Co H 128, Co Lk 09204, Co Lk 11206, in addition to varieties mentioned at row number -1
3. Central zone	Lucknow, Bareilly, Moradabad	Lucknow, Lakhimpur-Kheri, Sitapur, Hardoi, Raebareli, Kanpur, Kanpur-Dehat, Farrukhabad, Unnao, Bareilly , Pilibhit, Shahjahanpur, Badaun, Aligarh, Etah, Mathura, Muradabad, Sambhal, Amroha, Rampur and Bijnor	Co J 64, Co Se 01235, Co Lk 9709, Co 0237, Co 0239, Co 05009, Co Pk 05191, Co Lk 12207 in addition to varieties mentioned at row number -1	Co S 94257, Co S 96269, UP 39, Co Pant 84212, Co H 119, Co Pant 97222, Co J 20193, Co 0124 and Co H 128, Co Lk 12209 in addition to varieties mentioned at row number -1
4. Eastern zone	Deoria, Gorakhpur, Devipatan, Faizabad	Deoria, Kushinagar, Azamgarh, Mau, Ballia, Gorakhpur, Maharajganj, Basti, Siddharthnagar, Santkabirnagar, Gonda, Balrampur, Shravasti, Behraich Faizabad, Varanasi, Bhadohi, Jaunpur, Ghazipur, Barabanki, Ambedkar Nagar, Sultanpur, Amethi, Prayagraj, Mirzapur *etc*.	Co Se 01235, Co 87263, Co 87268, Co 89029, Co Lk 94184, Co 0232, Co 01421, Co Lk 12207 in addition to varieties mentioned at row number -1	Co Se 96436, Co 0233, Co Se 08452, Co Lk 12209 in addition to varieties mentioned at row number -1
5. Approved varieties for waterlogged areas			-----	U.P. 9530, Co Se 96436, Co Se 1039 and Co S 08272

Preparatory Tillage / Field Preparation

For higher sugarcane yields, providing optimum soil environment is an essential pre-requisite since the crop remains in the field for about 2 to 3 years due to the practice of raising ratoon crops. Further intense mechanization involving traffic of heavy machinery from planting to harvesting and transporting to the sugar mill or distillery, can cause the deterioration of soil physical conditions. This translates into soil compaction with a cohort of harmful side effects viz., reduction in storage & movement of air and water, mechanical difficulty for root growth and difficulty in absorption of nutrients from the soil itself and from the fertilizer. Therefore, a through land preparation every time a new crop is planted is absolutely essential to bring the soil to fine tilth for proper germination of the sets and field emergence and root growth.

Objectives of Land Preparation

- To prepare a seed bed which permits optimal soil water air relations
- Good physical conditions for early root penetration and proliferation
- To incorporate preceding crop residues and organic manures
- To destroy weeds and hibernating pest & disease organisms
- To facilitate proper soil chemical and microbial activity

In alluvial soils of Uttar Pradesh, tillage operations through tractor drawn implements are most ideal and quick. For initial ploughing use either mould board plough or disc plough to a depth of 20-25 cm. Subsequently, depending upon soil types, 3-6 crosswise ploughings to a depth of 10 cm by *deshi* plough or tractor drawn disc harrow/cultivator are also done. After each ploughing, the field is levelled by running a heavy wooden plank to break the clods for making the soil pulverised and to compact the soil lightly in order to conserve soil moisture. For clayey soils the use of rollers is also suggested. Organic manures like FYM, compost press mud cake *etc*. if to be applied should be evenly spread and mixed thoroughly in the soil at the time of field preparation. Before opening planting furrows, soil should be clod free and well pulverised. Whenever, soil turning is desired, a mould board plough should be used. On the other hand, when the soil is hard, uneven and composed of crop stubbles, a disc plough is preferable. Ploughing at optimum soil moisture content is very essential to achieve tilth. Too wet soil interrupts movement of machinery and causes destruction of soil structure. On the other hand too dry soil will not allow tynes to penetrate deep and results in frequent mechanical breakdowns, increased power requirement and cloddy soil surface affecting soil water air relations.

The secondary tillage operations are carried out using disc harrows, tyned harrows or rotavator. The rotavator is a very useful multipurpose implement, which cuts the crop residues, shred them and incorporates in the soil in one pass. Use mechanical methods (sub-soiling or chiselling or deep ploughing) or biological means (green manuring between last ratoon harvest and start of a new crop) to destroy the compacted layer and to allow roots to develop normally. Sub-soiling has also shown to reduce fuel consumption, working time and facilitate optimum plant population.The adequacy of moisture is very much necessary for sprouting of sett-buds. In this state care is taken to conserve as much moisture in the soils as possible, so that planted cane is able to germinate satisfactorily. As the planting is necessarily done during the comparatively dry season, considerable loss of moisture from the soil and setts/cane nodes takes place, and usually only 30 to 40% of the buds germinate in case of conventional 3-bud setts sugarcane planting.. Therefore, optimum soil moisture at the time of sugarcane planting should be 20-30% in alluvial soils of Uttar Pradesh.

Fertilizer /Manures

Sugarcane is a heavy feeder of nutrients. A crop of sugarcane producing 100 tons/ha of biomass removes approximately 205 kg N, 55 kg P, 275 kg K and 30 kg S besides 3.5 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2kg Cu from the soil. Adequate manuring, therefore, is essential for sustaining high yields. Generally soils of Uttar Pradesh are deficient in N except in some parts of north eastern region. Further nearly 50% soils are deficient in P and 20% in K. At present, in most areas sugarcane-crop is inadequately fertilized. So, adoption of location specific judicious and balanced nutrient management practices is required for enhancing cane yield.

The nitrogen requirements of sugarcane depend upon the soil and climate. In U.P sugarcane crop requires 150 kg N/ha. In vicinity of sugar mills, sulphitation press-mud is also used as manure. Recommended doses of N, P and K @150, 60 and 60 kg/ha should be applied, of which 1/3rd of total N + full doses of P and K are given as basal dressing before placing of setts/nodes in the furrows, while rest of N is top-dressed in two equal splits at the tillering phase before the onset of monsoon. Now-a-days, deficiency of sulphur is constantly increasing in Indian soils and it has become a limiting factor in sugarcane cultivation. In marginally deficient soil, the application of 30 kg S/ha has been useful. Foliar application of micro-nutrients has been found effective in increasing cane yields in U.P.

Integrated use of various sources of nutrients in sugarcane is becoming imperative for maintaining soil fertility and to improve crop productivity. Different

components of integrated nutrients management include use of legumes in sequential or intercropping system, organic manures, crop residues, factory by-products or effluents and bio-fertilizers in combination with inorganic fertilizers. At the IISR, Lucknow, the use of farmyard manure alone or with urea maintained the organic matter content of the soil at higher level than urea alone up to the fourth ratoon. However, the higher yield of plant as well as of ratoon occurred with combined application of fertilizer and farmyard manure. The application of farmyard and green-manure in sugarcane established their beneficial effects in improving production efficiency of fertilizer-N, especially at the optimal level of 150 kg N/ha (358 kg cane/kg N applied).

Planting Methods

Sugarcane setts are planted as two or three bud setts in furrows / trenches made at distance varying according to seasons and methods of planting. Distance between furrows vary from 75 cm in spring planting, 90 cm in autumn planting, 60 cm in late planting and 120 cm in trench method of planting. Prominent methods of planting prevalent in Uttar Pradesh are given below.

(A) Flat Planting

The field is prepared in a fine tilth by one or two deep ploughing followed by harrowing and planking. Shallow furrows of 10-15 cm depth at a distance of 90 cm in autumn and 75 cm during spring season are opened. Setts are placed in furrows end to end taking care that one 3 - bud sett falls in each running 30 cm length of furrow following either head to head or bud to bud alignment and compacted with heavy wooden plank to conserve soil moisture. Sugarcane cutter planter developed by ICAR-IISR, Lucknow effectively reduces the time and labour required for flat sugarcane planting. Only 05 man days are required by this planter in place of 30-40 man days in manual planting.

(B) Trench Method

In this method, farmers realize high input use efficiency and it provides ample scope for accommodating inter-crops between sugarcane rows. Trenches, 30 cm wide and deep are made with centre to centre distance of 120 cm and sugarcane setts are placed along both the walls of trench (30:90 cm). This method is suitable for mechanized operations, lesser requirement of labours with enhanced water use efficiency. In this method farmers obtain cane yield of 110 t/ha with cost benefit ratio of 2.15.

(C) Paired row sugarcane planting

- Ridge and furrow are made at a distance of 45 or 60 cm and a gap of 120 cm is left after every two rows
- Setts are planted in the paired rows
- Irrigation and fertilization is done in the planted paired rows
- In the skipped area intercropping of potato or any legume can be taken

(D) Raised bed seeder-cum sugarcane planting

Raised bed seeder-cum-sugarcane cutter planter (RBS) has been developed at ICAR-IISR, Lucknow to plant two rows of sugarcane in furrows and drill two rows of wheat or any other crop as companion crop on the main raised beds. It has effective capacity of 0.20-0.25 ha/hr and saves approximately 60% of the cost of operation.

Irrigation /Water Management

In sugarcane, maintenance of optimum soil moisture during all stages of crop growth is one of the essential for obtaining high yield. The crop should, therefore, be grown in areas of well-distributed rainfall or under assured and adequate irrigation. Therefore, in the absence of rains, the cane is irrigated every 25-30 days during its growing period. In dry areas and in sandy-loams soils, irrigation is needed at an interval of as short as 8 days. In deep clay loams irrigation can be withheld for longer periods, up to 2 or 3 weeks. Frequent light irrigation, each of 40 to 50 mm, adjusted to suit growing period of the crop and to the prevalent weather conditions are very useful. Towards the time of harvesting, the irrigation frequency is reduced and just before harvest, irrigation is withheld for about a month.

Summer is dry and hot, the crop needs water more frequently. In canal-irrigated areas, frequency of irrigation depends entirely on the running of the canals. The severity of these conditions is slightly mitigated by high water-holdings capacity of the alluvial loam soil. In central and western U.P., 4 to 6 irrigations are usually given, which help crop to tide over summer. In eastern Gangetic plains cane subsists almost entirely on subsoil moisture and rainfall and receives 2-4 irrigation at the most. In post-monsoon season, the crop receives only 1 or 2 irrigation or none at all; however, these post-monsoon irrigations only help keep crop in a good conditions. In areas where frosts occur, irrigation is applied to save crop from them. Sugarcane responds to irrigation and it is profitable to apply frequent light irrigation to crop during hot weather. There are 3 methods of irrigation in sugarcane culture, i.e. flood,

furrow and skip-furrow methods. Skip-furrow irrigations save water up to 36.5% and increases water-use efficiency (WUE) by 64%. Where irrigation facilities are scarce in summer, trash-mulching in inter-row spaces is done for conserving soil moisture.

The tillering phase of sugarcane in Uttar Pradesh comes in between March and June, and the crop is in emergent need of water to enhance the growth of sugarcane. Critical stages of growth and tillering are given here as under.

i. Germination phase: 45 days after planting

ii. First phase of tillering: Last week of April

iii. Second phase of tillering: 10-15 May

iv. Third phase of tillering: Last week of May to first week of June

Moreover, sugarcane crop needs much water during formative phase in July-August, but sufficient water demands of the crop is met through rains in this period. Water saving technologies is given here as under.

i) Skip furrow method of irrigation

In this method of irrigation, instead of irrigating all the rows and inter-row spaces, one row is skipped and irrigation is given in alternate rows. With this technique, limited water may be used to irrigate larger area. In this method, sugarcane is planted in flat bed as usual and after germination, 45 cm wide and 15 cm deep furrows are made in alternate inter-row spaces. At the time of irrigation, the furrows thus made are irrigated. Irrigating sugarcane with this method results in 36.5 per cent water saving and 64 per cent increase in water use efficiency (Fig. 13).

Fig. 13: Skip-furrow method of irrigation

ii) Trash mulching

Sugarcane trash is a waste material available after harvesting of the crop. Trash is spread @ 10 t ha^{-1} in the alternate inter-row spaces in ratoon crop at the time of its initiation (Fig. 14). Because of trash mulching, effectiveness of irrigation is increased as the evaporation losses of moisture from soil surface reduced considerably. Sugarcane crop yield and water use efficiency increases by 26 and 40 per cents, respectively, due to trash mulch as the trash mulch keeps the soil moisture at a higher level for a longer time as compared to uncovered soil surface. Increase in sugarcane yield due to trash mulch is attributed to favourable moisture condition, increased microbial activities and addition of water-soluble nutrients from the trash. In the long run, soil organic carbon content is also improved.

Plate 14: Trash mulching in cane rows and drip method of irrigation

iii) Irrigation at critical growth stages

In the areas of limited water supply, ensuring irrigation at critical period of water need of the crop and deferring the same at somewhat less critical period, improves yield and irrigation water use efficiency. These critical stages for sugarcane are emergence, first order of tillering, second order of tillering and third order of tillering. Depending upon the availability of water, the crop is irrigated at these stages. If two irrigations are available, then the irrigations are provided at second and third order of tillering. If three irrigations are available, then the irrigations are provided at all three orders of tillering. If four irrigations are available, then the irrigations are provided at all the four critical stages.

iv) Drip irrigation

Micro-irrigation is the frequent application of small quantities of water on, above or below the soil surface, by surface drip, subsurface drip, micro sprayers or micro sprinklers. Water is applied as discrete or continuous drops, tiny streams or miniature sprays through emitters or applicators placed along a water delivery line near the plant. Micro-irrigation is characterized by low rate, frequent irrigation;

water being applied near or into the root zone of plants and low-pressure delivery systems. In drip irrigation, water is supplied directly to the root zone using a network of tubes and dippers/emitters nozzles placed along the water-delivery line. This involves precise control and manipulation of soil moisture temporally and spatially, which improves water economy, growth and ultimately crop yield. The uniformity of water application in drip irrigation would be as high as 95% if the system is properly planned, designed and operated.

Intercultural Operations

The first hoeing and weeding is given to the crop, 3-4 weeks after planting. But in U.P., shoots usually take a long time to emerge. Weeds particularly nut grass comes up rapidly in the planted field. This rapid infestation of the planted field calls for one blind hoeing and is given within 1 or 2 weeks. After germination, depending on the field conditions and the frequency of irrigations, 2 or 3 more hoeings and weedings are needed during first 3 months after planting. Tedious, cumbersome and time-consuming nature of manual weed-control methods and scarcity of human labour have rendered this practice less effective and impractical. Alternatively, chemical weed control through pre-emergence application of Atrazine @ 2 kg *a.i.* / ha, followed by 2, 4-D spray @ 1 kg *a.i.*/ha (post-emergence at 60 days after planting) has been found to provide good weed control. The final earthing-up is completed before monsoons and is generally synchronized with application of the final dose of nitrogen. Good care in weeding and inter -culture help clumps tiller early and form millable canes thereafter. The crop is managed to grow rapidly to form a canopy over inter-spaces. This helps keeping down the weeds, and reduces cost of weeding and inter-cultural operations and also reduces the moisture loss from the soil surface.

Weed Management in Sugarcane

Results of experiments at different sugarcane growing areas in Uttar Pradesh, it is estimated that weeds take away about 160 N, 25 P_2O_5 and 200 K_2O kg ha^{-1} in the sugarcane system if not checked and controlled. A species of morning glory (*Ipomoea hederacea*) causes around 25 per cent loss in case yield in eastern Uttar Pradesh and Bihar by twining round the clumps. Orobanche (*Aeginetia indica*), a root parasite is capable of producing certain enzymes that cause degeneration of sucrose in cane plant to the extent of 75 per cent. According to an estimate, collective crop losses due to weeds, insect pests and plant pathogens in 2006-07 in India is to the tune of Rs. 14 lakh million. The weeds are notorious in being responsible for major part of this losses (about 40%). Weed management is the application of certain principles and suitable methods that will improve the vigor and uniform stand of the crop. At the same time avoid or discourage the invasion and growth weeds. Weed control is an essential part of all crop production systems. Weeds reduce yields by competing

with crops for water, nutrients and sunlight and may directly reduce profits by hindering harvest operations, lowering crop quality and producing chemicals which are harmful to crop plants (alleopathy). Left uncontrolled, weeds may harbor insects and diseases and produce seeds, rootstocks, stolons, rhizomes or stem cutting which infest the field and affect future crops.

Damage / losses caused by weeds in sugarcane

- In India, the reported cane yield losses range from 12 to 72 per cent. If weeds are not properly controlled in the initial stages, the yield loss could go up to 17.5 t/ha. Twining weeds which sprout at later stages and twine around clumps affect cane growth and cause around 25 per cent loss in yield. The total cane yield loss in the country per annum is around 25 million tonnes (equivalent to 2.5 million tonnes of sugar) valued around Rs. 1500 crores.
- Poor growth of sugarcane resulting from weed infestation also causes quality depression in sugarcane. Weeds harbor certain disease and insect pests that attack sugarcane and thus lead to indirect losses.
- Bermuda grass (*Cynodon dactylon*) the cogan grass (*Imperata cylindrica*) and other graminacious weeds are known to be alternate hosts to Ratoon Stunting Disease (RSD) of sugarcane.
- Twining weeds like Ipomoea spp. are becoming a problem in many sugarcane growing areas, escalating cost of cultivation besides decreasing cane yields. The twining weeds also cause serious harvesting problem.

Critical Period of weed Competition

In sugarcane fields, weeds get adequate time and space to germinate and establish well before the crop is able to compete. Hence, weeds pose tough competition to crop until the grand growth phase (150 days after planting) sets in. Generally, sugarcane is the most sensitive to weeds infestation during tillering. Sugarcane crop should be kept weeds free during its tillering phase, which under north Indian conditions falls between 60 and 120 days after planting for spring planted crop. Autumn planted cane crop in central, eastern and western parts of Uttar Pradesh requires weed free environment from November to June. Sugarcane, in general, requires weed free environment for the first 90 to 100 days before the rapid close in of the cane canopy.

Cultural Management

Deep summer ploughing and inclusion of short duration crops in intensive cropping systems are effective in minimizing the weeds infestation. Inclusion of

lowland rice in sugarcane based cropping systems can effectively check the *Cyperus rotundus*. Hand weeding, digging with spades and intercultivation using three-tyned cultivator are commonly used for weed control in sugarcane crop. Removal of weeds by hand at 30, 60 and 90 DAP is the best among all the cultural and mechanical methods of weed control. Sugarcane trash mulch at 7.5 to 10 t ha^{-1} to an average thickness of 10 cm over the soil surface is effective against many weeds besides soil moisture conservation. Optimum stage for trash mulching is 45 DAP which does not create hindrance to germination and tillering of sugarcane and also suppress excessive tillers. Intercropping of vegetables (potato, cauliflower, cabbage, knol-khol, turnip, radish etc.), spices (garlic, onion, fenugreek, coriander etc.), legumes (pea, Bengal gram, French bean etc.), oilseeds (*toria*, mustard, linseed etc.), flowers, medicinal plants etc. in autumn and green gram, black gram, cow pea etc. in spring planted crops not only reduces competition from weeds, but also enhances the income per unit area and time.

Use of Herbicides

Most commonly used herbicide is pre-emergence spraying of Atrazin 50 % WP @ 2 kg *a. i.* ha^{-1} mixing in 1150 litres of water upto 72 hours of sugarcane planting at sufficient soil moisture followed by 2,4-D Sodium salt 80% WP @ 1.25 kg *a.i.* ha^{-1} mixed with 1150 litres of water at 60 DAP. This controls almost all the weeds and provide weed free environment for required duration.

Integrated Weed Management (IWM)

Integrated weed management, therefore, focuses on the control of sugarcane weeds through judicious use of mechanical, cultural, biological and chemical methods at different stages of weed and crop growth to get the effective and economical results.

Plant cane

(i) Weeds should be controlled during most critical period (planting-120 days) of crop growth.

(ii) Under manpower availability, three manual hoeings or intercultural operations at 30, 60 and 90 days after planting should be done.

(iii) Under limitations of manpower availability, pre-emergence application of either atrazine 50% WP (@ 2.0 kg *a.i.* ha^{-1}) or metribuzin (1.0 kg ha^{-1}) in 1150 litres water ha^{-1} followed by either post-emergence spray of (Na salt) 1.0 kg ha^{-1} (1150 litres water ha^{-1}) or one manual hoeing at 60 days after planting can successfully be done.

(iv) Under heavy infestation of *Cyperus rotundus*, a blanket sprays of glyphosate (1 kg *a.i.* ha^{-1}) in 625 litres water ha^{-1} after 15-20 days of cane planting (before emergence of cane) followed by one hoeing at 60 days of planting should be done.

(v) After 150 days, earthing-up should be done to suppress the weeds.

(vi) The physical removal of weeds by manual labour implements like *khurpi*, *kassi*, spade, hand hoe, etc. are very effective in controlling weeds at early stages of crop growth. However, in mechanized cane cultivation bullock or tractor-drawn cultivators, harrows and rotavators could be used for the control of weeds.

(vii) Artificial mulches have been used for intercepting sun-light reaching the soil surface and thus starve out weed seedling as they emerge. Uniform spread of 5 to 10 cm thick trash blanket in-between the rows, as also in the inter-plant spaces help in suppressing weeds. The trash keeps all weeds suppressed and the fields remain almost free from weeds. It is necessary to give a thorough hoeing and weeding in the field before spreading the trash, particularly if the field has been weedy. In places, where obnoxious grass weeds are in abundance the trash cover has to be a little thicker, say 10 cm to 15 cm thick. This is indeed a very potent and useful way of suppressing weeds in sugarcane fields. Beside weed control, trash mulching saves water, labour and costs, and gives higher yields of cane. Spreading the black polythene film (Solarization) in interspaces suppresses the growth of weeds and conserves soil moisture.

Ratoon cane

(i) Weeds in ratoon crop should be controlled within 60 days of crop initiation.

(ii) With the availability of manpower, three hoeings at 1, 4 and 7 weeks after ratoon initiation should be adopted for effective control of weeds.

(iii) Under limitations of manpower availability, pre-emergence application of either atrazine 50% WP (2.0 kg *a. i.* ha^{-1}) or metribuzine 70% WP 1.0 kg *a. i.* ha^{-1} (1150 litres water ha^{-1}) followed by either spray of 2, 4-D 80% WP(Na salt) at 1.0 kg *a. i.* ha^{-1} (1150 litres water ha^{-1}) or hoeing at 45 days after ratoon initiation should be practiced.

(iv) Trash mulching in alternate rows and hoeing in unmulched rows at 1 & 6 weeks after ratoon initiation is also a good option.

(v) In the standing crop, during or after monsoon, weeds should be removed manually.

(vi) Crop should be given earthing-up at 120 days to suppress the weeds.

Management of binding weeds

In sugarcane, application of atrazine 50% WP @ 2 kg *a.i.*/ha or metribuzine 70% WP @ 1.25 kg *a.i.*/ha as pre-emergence followed by DICAMBA @ 350 g *a.i.*/ ha at 75 DAP is effective for controlling binding weeds in sugarcane.

Hoeing & Earthing-up

Hoeing and earthing-up are two main operations in sugarcane cultivation. Hoeing is done with the help of shovel or cultivators. It starts just after one week of planting (blind hoeing), the second about 3 weeks after planting and subsequent hoeing after every irrigation. Blind hoeings helps in breaking the hard crust at surface, which might create problems to the sprouting of seedlings. Besides covering the exposed setts, it also helps in uprooting the weeds, and replacing the damaged setts by diseases or insects. The hoeings are necessary for better aeration, moisture conservation and control of weeds. Hoeing is done first in a week or so after planting in order to break the surface crust, else light irrigation is followed by the same period in order to help emergence of sprouts. After the sprouts are out, the hoeing by bullock drawn implements is followed to control weeds as well as for loosening surface soil. If the weeds are more, the hoeing is followed by hand weeding. One to two hand weedings and one hoeing are given within 6–8 weeks after planting by which time first top dressing of nitrogen fertilizer is given. Before next nitrogen, fertilizer application (12-16 weeks after planting), one more hand weeding followed by hoeing is usually necessary. Earthing-up is also required in sugarcane cultivation. It is done to suppress the growth of excess tillers facilitate irrigation and economize water, to drain out the excess water from the field, to control weed infestation and to protect the crop from lodging.

Propping/ Detrashing

Propping is also a general practice in which canes are tied up so that they may not sway during winds and lodge. The best way is to bring stalks together from adjacent rows and tie them up with their own trash and old leaves. Earthing is recommended in July while tying in August and September when sugarcane of about 5 feet height. Do not tie upper leaves. It is done to prevent lodging, economize water use efficiency, control weeds and draining excess water. Detrashing refers to removal of unwanted bottom dry and green leaves at regular intervals.

Propping

The operation of tying the leaves together using the bottom dry and green leaves is known as propping.

- It is done to check the lodging of cane.
- Usually the trash without removing from the cane is twisted to form a sort of rope and cane stalks are tied together. This is known as trash-twist propping. Propping can be either done for each row or two rows can be brought together and tied.
- In some parts of western Uttar Pradesh, bamboo poles are used and propping is done but it is too expensive. In areas where cane top growth is heavy and wind velocities are high, propping is necessary to prevent lodging. It reduces cane breakage and loss of stalk number at harvest and thus reduces loss of cane yield.

Advantages of Detrashing

- Helps in maintaining clean field
- Enhances air movement and enriches CO_2 within the crop canopy providing an ideal micro-climate for unrestricted growth of cane
- More food material is made available for stalk growth
- Reduces the problem of infestation of several insect-pests like scales, mealy bug, white flies etc
- Reduces bud sprouting due to accumulation of water inside the sheath in some varieties.
- Bud sprouting is not desirable as it would reduce main stalk growth and affect sugar accumulation
- Facilitates easy entry and movement in the field, for inspection of the crop
- A clean field minimizes rodents, rats, squirrels in the field which may otherwise cause damage to the crop
- Facilitates easy and economy in harvesting besides clean canes for crushing
- Detrashed trash can be used as a mulch for moisture conservation
- Such detrashed leaves can be used for composting

Intercropping in autumn planted sugarcane

Intercropping refers to growing of two or more crops simultaneously on the same piece of land with a definite row-planting pattern to obtain higher productivity per unit area and time. Rapidly increasing population, increased demand for food, limited scope for extension of cultivation to new areas, diversified needs of small

farmers for food and cash, etc. have necessitated the adoption of intercropping systems. In long duration crops like sugarcane, intercropping holds much promise. Due to slow establishment of sugarcane during the first 90-120 days, the greatest scope for complementary effect lies in the addition of annual intercrops to the temporal system to improve resource use efficiency in the early crop growth. Intercropping offers an opportunity for profitable utilization of available space. Sugarcane growers take advantage of this and grow various short duration crops like cereals, pulses, vegetables and spices as intercrops to obtain interim return. Small sugarcane growers need not wait until the harvest of the sole crop to obtain financial returns. Intercropping of economically important short duration crops with sugarcane through utilization of the present limited land resources would help to sustain sugarcane cultivation and provide interim return to marginal and small farmers, besides meeting the ever-increasing demand for vegetables and pulses. Great potential exists in India for increasing crop production and productivity through wider use of multiple cropping in cereals, millets, oilseeds, legumes and fibre crops. Legume intercrops in cropping systems enhance soil fertility through the excretion of amino acids into the rhizosphere. The nitrogen fixed by the legume intercrop may be available to the associated sugarcane in the current season itself, as sugarcane remains in the field for over nine months after the harvest of the legumes.

A further possibility of soil fertility improvement is through addition of crop residues, which on decomposition adds to the fertility of the soil. Since considerable addition of nutrient occurs through intercrops, there is a possibility of reducing N application through fertilizer. The intercrops and cultivars selected should be of dwarf type with compact canopy and short duration. In general, the optimum row spacing recommended for autumn planted sugarcane is 90 cm which is widely followed in sub-tropical India, although there is a possibility to adopt wider row spacing. Such wider row spacing permits intercropping without adversely affecting the cane yield and thus increases the overall productivity and profitability of the system. Wider row spacing now becomes an important agronomic consideration to adopt mechanization on account of non-availability of labourers in sugarcane cultivation.

In the sub-tropical region, sugarcane is normally planted in autumn (September-October), *i.e.* before the onset of winter or after the cessation of winter. This planting of sugarcane invariably yields 15-20% higher sugarcane as also 0.5 units more sugar recovery than spring planted cane. The cane planted in the autumn season germinates before the onset of winter and remains in the field without much growth until the spring sets in. During this period, the cane does not make much demand for the growth resources. This facilitates rising of any *rabi* crop as intercrop with autumn planted sugarcane. Several studies demonstrated that the total productivity

of crops in sugarcane + *rabi* crops intercropping system is substantially higher than the total productivity of sole *rabi* crop in winter followed by sole sugarcane planted in spring season. Dwarf type crops with compact canopy including legumes, oilseeds, cereals, spices and vegetables are suitable as intercrops in autumn planted sugarcane. Potato has been reported to be a promising intercrop in autumn planted sugarcane in sub-tropical India. Therefore, cultivation of short duration spices and vegetables as intercrops in sugarcane can be a successful package as it provides the needed income during the early stages and increases the total productivity without affecting the cane yield in the system. There is a higher demand for vegetables in the market now-a-days since the consumption of vegetables is increasing at faster rate in modern time as these are supplementary items in human diet.

Recently, Hon'ble Union Minister of Agriculture and Farmers Welfare, Govt. of India while addressing a seminar on 'Hundred Year of Sugarcane Varieties', said that the government has set a target of doubling farmers' income by 2022 and is taking various steps to achieve this objective. The Minister stressed that the sugarcane farmers should be encouraged to adopt intercropping to boost their income. To boost income of cane farmers, the Minister called upon the farmers to go for intercropping and grow pulses, oilseeds or vegetables along with sugarcane. Moreover, Progressive farmers in certain areas of Punjab have improved their earning three times what they did earlier after they started inter-cropping their cane with garlic, potato and turmeric. In inter-cropping, cane rows are sown three to four feet apart and this space is used for the other crops. According to estimates of the cane department of Govt. of Punjab, around 40 to 50 per cent of the farmers are already growing autumn cane with suitable intercrops. At a few places, up to 80 per cent farmers have gone for intercropping with autumn planted sugarcane. In autumn planting seed requirement is reduced and yet gives a high yield, besides bringing in an additional income from inter crops. Alongwith vegetables and spices , the under mentioned *rabi* crops can be grown successfully as intercrop with autumn planted sugarcane (Table 6) in Indian sub-tropics for enhanced yields and net returns.

Table 6: Suitable intercrops for autumn planted sugarcane

Cereals	Wheat
Legumes	Pea, French Bean, Chickpea, Lentil
Oilseeds	Mustard, Toria, Linseed, Sunflower, Sesame
Flowers	Gladiolus, marigold
Medicinal and aromatics	Mentha, Ginger
Spices	Chillies, Onion, Garlic, Coriander, Fennel, Cumin, Fenugreek, Nigella, Turmeric
Vegetables	Potato, Tomato, Carrot, Turnip, Cauliflower, Cabbage, Knoll Kohl, Lettuce, Radish , Lady's Finger, Cucurbits

Package of practices for vegetables intercropping with autumn planted sugarcane

Vegetable crops *viz*., cauliflower, cabbage, knol-khol, turnip, carrot, radish and potato are suitable for intercropping with autumn planted sugarcane (Fig. 15). Agronomic practices adopted for raising different intercrops are given in Table 7. Sugarcane is planted in furrows 90 cm apart keeping one-three budded setts @ 30 cm row length in the first fortnight of October. Sugarcane is fertilized with 150 kg N/ha (1/3 at planting as basal dressing + 2/3 in two equal split doses as top dressing after harvesting of intercrops at proper moisture) while, intercrops are given one-third of the total N + full doses of P_2O_5 and K_2O at their respective sowing times and remaining half of N is top dressed after 30 days of sowing as per Table 7.

Table 7: Details of variety, row arrangement, date of sowing / harvesting, seed rate and fertilizer application for different intercrops

Intercropped Vegetables	Variety	No. of intercrop rows in between two cane rows	Date of sowing	Date of harvesting	Plant To Plant Distance (cm)	Seed Rate (kg/ha)	Application of Fertlizer (kg/ha)		
							N	P	K
Cauliflower (*Brassica oleracea var. botrytis L.*)	PSB-16	Two	First Fortnight of November	First Fortnight of November	45	0.350 (for nursery)	80	40	40
Cabbage (*Brassica oleracea var. Capitata F.alba)*	Pride of India	Two	First Fortnight of November	First Fortnight of November	45	0.400 (for nursery)	80	40	40
Knol-khol (*Brassica oleracea var. Caulorapa O.C. Linn.)*	King of North	Three	First Fortnight of November	First Fortnight of November.	20	0.450 (for nursery)	60	30	30
Turnip (*Brassica rapa* L.)	PTWG	Three	First Fortnight of November	First Fortnight of November	20	0.800 (for nursery)	40	20	20
Carrot (*Daucus Carota L.)*	Pusa Keshar	Three	First Fortnight of November	First Fortnight of November.	10	3.50	60	30	30
Radish (*Raphanus sativus L.*)	Janupuri	Three	First Fortnight of November.	First Fortnight of November.	10	7.00	40	20	20
Potato (*Solanum tuberosum* L.)	C-3797	Two	First Fortnight of November	Second Fortnight of February	20	2200	160	80	80

Sugarcane + Potato

Sugarcane + Cabbage

Sugarcane + Knol-khol

Sugarcane + Radish

Sugarcane + Garlic

Sugarcane + Cauliflower

Sugarcane + Sugarbeet

Sugarcane + Coriander

Fig. 15: Intercropping of *rabi* / winter crops with autumn planted sugarcane

Management of Insect pests in Sugarcane cultivation

Sugarcane is a long duration crop of approximately 12 months duration in sub-tropical India, and is attacked by a number of insect pests and diseases. According to an estimate, sugarcane production declines by 20.0 and 19.0 % by insect pests and diseases, respectively. To increase the crop productivity, management of insect-pests and diseases is of great significance. Due to diversity in agro-ecological conditions across the state of Uttar Pradesh, the incidence of insect pests and diseases varies and therefore, management strategy should be adopted accordingly. Sugarcane is infested by about 288 insects of which nearly two dozen causes heavy losses to the quality as well as quantity of the crop. The scenario of insect pests and diseases varies both in sub-tropical and tropical belt of sugarcane growing. Top borer and stalk borer are found pre-dominantly in sub-tropical areas whereas internodes borer and early shoot borer are prevalent in tropical region. Based on feeding habits, the major pests infesting sugarcane may be broadly classified as borers, sucking pests, sub-terranean pests, defoliators etc.

1) **Borers:** include shoot borer, top borer, stalk borer, Internodes borer, gurdaspur borer, plassey borer and root borer.

2) **Sucking pests:** includes pyrilla, white fly, thrips, scale insects, mealy bug and wooly aphid.

3) **Subterranean pests**: include termites and white grub.

4) **Defoliators**: include grasshopper and army worm.

Several management strategies have been developed as a result of research and development work. In order to save environment from chemical pollution, use of bio-control has been given utmost attention. The management technologies have been integrated as per need for increasing the efficiency. The details pertaining to management of prominent insect pests are given below.

(i) Shoot borer (*Chilo infuscatellus snell.*)

Control measures

- Irrigation and light earthing during summer months also reduce the incidence.
- Destruction of infested shoots along with larvae and pupae from April to June.
- Installation of 10-11 pheromone trap/ha for collection of male moth.
- Spraying of chlorpyriphos 20 % EC @ 5 litre + 1600 litres of water/ha over the seed cane setts in the trenches/furrows followed by 4-5 cm covering with

soil. However, drenching of chlorantraniliprole (coragen 16.5 % SC) @375 ml + 800 litres of water may be done using water can along the base of cane rows in the month of April if the incidence is seen repeatedly.

- Release of *Trichogramma chilonis* @ 50,000 parasitized eggs /ha from March to May at 15 days intervals.

(ii) Top borer (*Scirpophaga excerptalis* Walk.)

The top borer, *Scirpophaga excerptalis* Wlk., Infests sugarcane during all the stages of crop growth, and is the major pest in the sub tropical region.

Control measures:

- Collection and destruction of top borer egg masses during February to March (First brood) and April to May (Second brood).
- Removal and destruction of affected shoots along with larvae and pupae during April (First brood) and June (Second brood).
- Installation of 10-11 Pheromone traps/ha for moth collection.
- Soil application of Carbofuran 3G@1.00 Kg *a. i.* /ha (33Kg) at the soil surface along cane rows in the last week of June. Sufficient soil moisture should be there at the time of application.
- 2 Drenching of Coragen 20% SC @150 ml/acre dissolved in 400 lit of water at the base of plant during last week of April with the help of Knap-sac sprayer followed by irrigation effectively control Second and Third brood of top borer. However, drenching of chlorantraniliprole (coragen 16.5 % SC) @375 ml + 800 litres of water may be done using water can along the base of cane rows.
- Release of *Trichogramma japonicum* @50000 parasitized eggs /ha from July to September.

(iii) Stalk borer (*Chilo auricilius* Dudgeon.)

Control measures

- Application of balance fertilizer, proper drainage, destruction of water shoots and detrashing of dry leaves in August and September.
- Earthing up of canes during June and July and binding of canes during July and August.
- Release of *Trichogramma Chilonis* @ 50000 parasitized eggs / ha from July to September at 15 days intervals

- *Cotesia flavipes* is a natural parasitoid of larvae. About 40-60% parasitisation is recorded after monsoon.

(iv) Root Borer (*Emmealocera depressella*, Swinhoe)

Control Measures

- Stubbles shaving practices should be adopted in affected areas
- Crop rotation should be adopted in affected areas.
- Spraying of chlorpyriphos 20 % EC @ 5 liter/ ha after dissolving in 1875 liter of water at the time of planting, and drenching of Imidacloprid 17.8 % SL @ 500 ml/ha in the mid of August if the symptoms of the pest are visible in standing cane crop.
- In the case of difficulties in drenching/spraying in standing cane crop, then Imidacloprid 17.8 % SL @ 500 ml/ha and chlorpyriphos 20 % EC @ 5 liters/ ha mixing with 25 Kg of soil should be applied along cane rows after flooding in field in August-September.
- Released of *Trichogramma chilonis* @ 50,000 egg parasitoids/ ha from July to September at 15 days interval.

(v) Internode borer (*Chilo sacchriphagus indicus*)

Control measures

- The control measures applied for stalk borer will be equally effective for this borer also.
- Removal of dry leaves of sugarcane from fifth to nine months age of the crop.
- Removal of water shoots of the crop at eighth and nine months age of the crop.
- Nitrogen fertilizers should be applied at the recommended dose only.
- Proper drainage of water should be ensured.
- Chemical and biological control measures should be adopted as per recommendations given for stalk borer treatment.

(vi) Pyrilla (*Pyrilla perpusilla*)

Control Measure

- Cane trash should be completely removed from the field after harvesting and may be utilized as compost.

- Irrigate the field to conserve the *E. melanoleuca*
- The eggs may be destroyed after the collection of egg masses during March and May.
- If the incidence of the pest is seen epidemic in July-August then the spraying of Quinalphos 25% EC @1.0-1.2 litre + 500 litres of water /ha may be done.
- Release of nymphal adults ectoparasitoid, *Epiricania melanoleuca* @ 4000-5000 cocoons and 4-5 lakh eggs/ha during July-August reduces the pest build up.

Note: There should be no application of insecticides if the *Epiricania* population appears in the affected field, but the ratio should be 3:1 in *pyrilla* and *Epiricania*.

(vii) Termite (*Odontotermes obesus* Rambur)

Control Measures

- Irrigation of field reduces the incidence.
- Application of Chlorpyriphos 20% EC @ 5 lit./ha or Imidacloprid 17.8% SL @ 400 ml/ha dissolved in 1875 lit in water over cane setts at the time of planting.

Application of *Metarrhizium anisopliae* / *Baeuvaria bassiana* (10^9 cfu/gm) @ 5 kg/ha mixed with farm yard manure over cane setts at the time of planting.

(xi) White grub (*Holotrichia consanguinea* Blanch.)

Control measures

- Ploughing of the field up to 15-20 cm depth for exposing the different stages of white grub.
- Spraying of 2% Imidacloprid insecticide on host trees.
- Installation of the light trap and pheromone trap (Methoxy benzene) to attract the beetle.
- Application of clothianidin 50 WDG @ 250 gm dissolved in 1875 lit of water before onset of monsoon in cane planted rows and irrigate the field.
- Application of *B. bassiana* @ 5 kg/ha mixed with 1 quintal of press mud cake or compost in cane planted rows and irrigate the field.

Sugarcane diseases and their management packages

Red rot, smut, rust (fungi), grassy-shoot disease (mycoplasma) and ratoon-stunting disease (bacteria) are the important diseases of sugarcane, transmitted through seed-cuttings (seed). They are, to a great extent, responsible for lowering cane yield, its quality or both. The planting of vigorous and diseases free healthy seed-canes from a well-nourished, short-duration nursery crop of sugarcane helps to eliminate diseases; and secondary infection through other sources is prevented. The raising of seed cane nurseries from heat-treated canes offers the best scope for eliminating primary diseases infection of ratoon stunting and grassy shoot diseases. The moist hot air treatments can be done through equipment developed at the IISR, Lucknow. Full-length detrashed canes are loaded in the treatment chamber. For the treatment, the temperature inside the chamber is brought to 54^{o}C with a relative humidity of 99%. Injection of steam into the chamber creates required humid condition. Priming time of 2 hr is required to reach the desired level of temperature and humidity. Thereafter another 2.0-2.5 hr are needed for the actual treatment. Thus total period of operation including initial heating period, becomes 3.5-4 hr and at a time 0.5-0.6 tonnes of cane can be treated. Description of major diseases in sugarcane is given below.

(i) Red rot (*Colletotrichum falcatum*)

Management

Management of red rot has been a challenging work for the pathologist. The deep-seated nature of infection within the stalk, the hard nature of the cane rind and the nature of the pathogen, all the therapy have been found to be ineffective in the control of red rot. The use of resistant sugarcane varieties is the most effective method of prevention and control. Healthy cultural practices, clean nursery programme, clean cultivation, roguing of diseased plants, biological control (*Trichoderma* and *Pseudomonas*), crop rotation and chemical treatment should be adopted. There is a need for restricting transport of cane from an infected zone to disease free zones.

(ii) Smut (*Ustilago scitaminea*)

Disease management

The use of resistant sugarcane varieties is the most effective method of prevention. Seed selection and rouging of infected clumps is more beneficial to manage the spread of smut disease. Smut teliospores lack dormancy and hence could not survive in soil or debris in the absence of buds. Removal and destruction of the

smutted clump should be collected as whips in a thick cloth bag/polythene very carefully. Hot water treatment for 52^0 C for 2 hours or MHAT for 50 for 2.30 hours is to be effective in controlling the smut pathogen residing in the planting setts. Collected whips bag should be immerse in boiling water for 1 hr to kill the spores. IDM should be follow for management. Sett dipping with 0.2% Bavistin before planting the setts is also useful to this disease.

(iii) Wilt (*Cephalosporium sacchari)*

Disease management

Seed material should be selected from the disease-free plots, disease free stalk and should be dipped in Bavistin 0.2% before planting. The practice of ratooning should avoided from diseased fields, burn the trashes and stubbles in the field. Crop rotation with coriander or mustard as a companion crop in the early stages is more beneficial to manage this disease. Dip the setts in 40 ppm Boran or Manganese for 10 minutes or 0.1% carbendazim for 15 minutes are useful. Dipping the setts in 40 ppm of boron or manganese, or spraying the plants with either of these minor elements reduces the disease intensity. Use of Borax @ 15 Kg/ha is also used through soil treatment. *Trichoderma* culture (10 Kg/ha) is also used as a biological control of this disease.

(iv) Grassy shoot disease/Albino (GSD)

Disease management

Selection of setts should be avoided from diseased area. Rouging of infected clumps is more beneficial. Hot water treatment for 52^0 C for 2 hours or MHAT for 50 for 2.30 hours is to be effective to control. Vector should be controlled by spraying insecticide to prevent secondary infection.

(v) Pokkah boeng

Pokkah boeng is an air-borne fungal disease and caused by various species of *Fusarium* fungus (*Fusarium sacchari, Fusarium verticilloides*, *F. moniliforme*). The earliest symptom of pokkah boeng is a chlorotic condition towards the base of the young leaves. Frequently, a pronounced wrinkling, twisting and shortening of the leaves accompanied the malformation or distortion of the young leaves and rotting of spindle leaves. In severe cases, one or two or even more transverse cuts in the rind of the stalk in such a uniform manner as if, the tissues are removed with a sharp knife called knife-cut stage. In these cases yield losses can occur.

Disease management

Spraying of 0.1% Bavistin or 0.2% Blitox-50 or 0.2% Copper oxychloride or 0.3% Mancozeb are most effective fungicides to reducing the pokkah boeng disease at an interval of 15 days in a month.

Ripening

The maturity of sugarcane is generally recognized by the gradual withering of lower leaves and presence of fewer green leaves at the top if the growers can keep and use a hand refractometer which indicates the total soluble sugars in juice, the testing of maturity would be easier. If samples of juice taken from the middle portions of the stalks show, on the average, the hand- refractometer reading of 20, the cane crop may be considered to have reached stage of maturity. The Fehling's test for glucose provides a better technological assessment of quality of the canes, the glucose content usually reaching values of less than 0.5% in juice at peak maturity.

In U.P. sugarcane ripens by early December in a normal season, but the sugar content of juice continues to rise till end of March. After that the temperature rises very high and the canes standing in the field gradually dry up. Early duration varieties ripen 2 to 3 weeks earlier but in the latter part of the crushing season the differences in juice quality narrow down. Sugarcane reaches its peak maturity during the months of December to March. Sugarcane requires bright clear sunny days and cool nights for attaining higher levels of recovery. Maturity is delayed by late rains, warm weather in the late season and high amount of fertilizer-nitrogen. Quality of the juice gets deteriorated. When winters are harsh, frost may damage the crop seriously, leading to rotting of buds and drying of leaves, rendering cane unfit for gur or sugar-making.

Maturity and Harvesting

Sugarcane crop matures within 10-12 months in north India depending upon the season of the crop. The crop should be harvested when sucrose contents value reaches to minimum 16.5% with 85% juice purity. Thus impurities of sucrose in total dissolved solids are most important factor which governs the maturity of crop. Usually this stage arrives during December-January when atmospheric temperature is about or below 20^0C. Under high temperature conditions, the sucrose gets converted into glucose resulting in poor quality of produce. The yellowing of leaves, emergence of arrows, cane become brittle & breaks easily can produce metallic sound and swelling out of buds from nodes are the other indicators of crop maturity. The sucrose content in waterlogged condition increases suddenly after receding of water

and drops again after a few days. It has also been observed that canes of waterlogged areas start drying at a faster rate after receding of water in comparison to normally grown canes. It is, therefore, revealed that sugarcane matures earlier in waterlogged areas. So, cane should be harvested as early as possible after water recession, so that the maximum amount of sucrose is obtained. To ensure maximum yield of sugarcane and ultimately sugar from the crop, it would be necessary to have proper harvesting to achieve higher sugar recovery, which naturally increases sugar production per unit area. Stalks are cut at the ground level, preferably at least 3 to 5 cm above the ground level. The dried leaves are stripped off up to the top-most mature internodes, where stalks usually break easily. The harvested canes should always be crushed quickly. In U.P during the cold season the harvested canes kept in shade for 1 or 2 days may help in quality of juice but canes loses its weight unless kept moist. In the late season quick processing of the harvested cane is essential to avoid deterioration in the quality due to activity of *Leuconostoc* bacteria.

Notes

Notes