



अखिल भारतीय समन्वित गन्ना अनुसंधान परियोजना
All India Coordinated Research Project on Sugarcane
Salient Research Achievements

**During
XII Plan Period
(2012-17)**



ICAR-Indian Institute of Sugarcane Research
Post-Dilkusha, Raebareli Road, Lucknow-226 002



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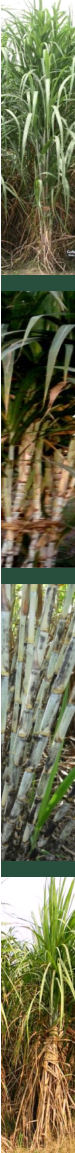
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Research Achievements made under AICRP on Sugarcane during XII Plan

Sugarcane is cash *cum* industrial crop and grown in both tropical and sub-tropical regions of the country. Productivity and production of the crop influence livelihood of sugarcane growers in the country. It is grown in an area of 5.0 million hectares and average cane yield is about 70.0 t/ha at national level. Nearly six millions farmers are directly or indirectly engaged in its cultivation. Similarly, sugar recovery from sugarcane varieties is major concern for sugar-millers in the country. At present, around 762 sugar-mills are functional in the country and sugar recovery is 10.62%. Now, the country has achieved self-sufficiency in sugar production and has started exporting sugar to other developing countries.



Fig. 1: Regular centres



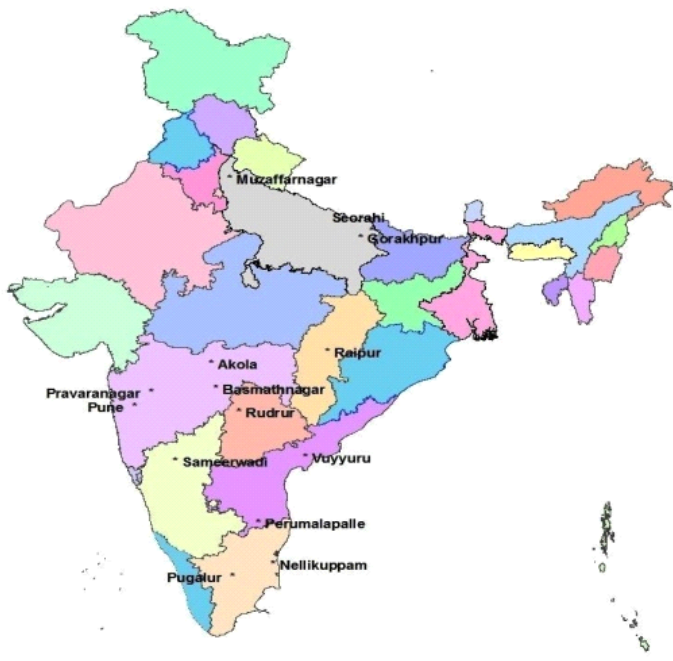


Fig., 2: Voluntary centres

During XII-Plan, various programmes were undertaken under All India Coordinated Research Project on Sugarcane to cater the needs of the nation and fulfilling demands of sugarcane growers and sugar-mills. These programmes encompass crop improvement for developing high yielding and high sugar varieties, crop production and crop protection technologies to enhance cane productivity, sugar recovery and to sustain soil fertility while protecting our environment. These research programmes were conducted at 22 regular and 14 voluntary centres in the country (Fig. 1 & Fig. 2).

a) Very specific and technologically validated output/outcome -

1. Crop Improvement

Twenty sugarcane varieties have been identified by AICRP(S) during 12th five year plan. However, sixteen sugarcane varieties of different maturity groups have been released and notified by Central Varietal Release Committee (CVRC). The salient features of these varieties are being given below.

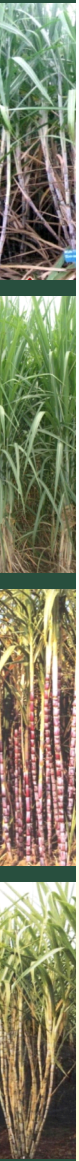


Table 1: Sugarcane varieties released and notified during XII-Plan

Sugarcane producing zone (s) for which recommended	Name of variety	Year of release & notification	Key characteristics (like duration, yield level, quality characteristics etc.)		
			Maturity	Cane Yield (t/ha)	Sucrose (%)
			Peninsular Zone (Gujarat, Maharashtra, Karnataka, Kerala, Interior of Tamil Nadu & Andhra Pradesh, Madhya Pradesh & Chattisgarh)	Co 0403	2012
	Co 06027	2013	Midlate	110.56	19.18
	CoSnk 05103	2014	Early	105.97	17.21
	CoSnk 05104	2014	Midlate	106.86	17.52
	Co 09004	2017	Early	109.85	18.94
East Coast Zone (Coastal Tamil Nadu & Andhra Pradesh and Odisha)	Co 06030	2013	Midlate	103.33	16.60
North West (Punjab, Haryana, Rajasthan, Central and Western Uttar Pradesh and Uttarakhand)	CoH 128	2012	Midlate	76.23	17.70
	Co 0237	2012	Early	71.33	18.78
	Co 05011	2012	Midlate	81.87	18.00
	CoPK 05191	2013	Early	81.12	17.06
	Co 05009	2013	Early	75.89	17.44
	Co 09022	2017	Midlate	83.59	17.49
North East Zone (Assam)	CoSe 01421	2013	Early	65.87	17.36
	CoP 06436 (CoP 2061)	2015	Midlate	74.25	17.35

"Photos of some promising sugarcane varieties released during 12th five year plan



Sugarcane Variety-CoPb 08212



Sugarcane Variety-CoP 09437



Sugarcane variety-CoSnk 05103



Sugarcane variety-CoSnk 05104



Sugarcane variety-CoH0128



Sugarcane Variety-Co 0237





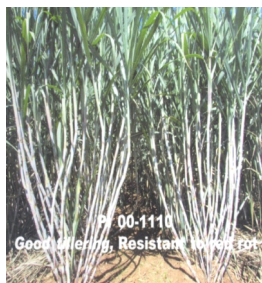
Sugarcane Variety-Co 05011



Sugarcane Variety- Co 06030



Sugarcane Variety- Co 06027



Sugarcane Variety- PI 07131



Sugarcane Variety-Co 09004



Sugarcane Variety-Co 09022

2. Crop Production

Sugarcane crop is perennial in nature and cane productivity and sugar content are important characteristics for growers and scientists. Injudicious use of inorganic fertilizers and agro-chemicals affected soil fertility adversely and polluted environment. Enhanced use of chemical fertilizers without due considerations for soil health and supplementing micro-nutrients has resulted yield plateau in sugarcane producing regions of the country. The water economy in sugarcane has also drawn attention of the researchers and policy makers recently in tropical region of India like Maharashtra, Karnataka, Gujarat and other states.

With the expansion of irrigation, scheduling of irrigation became main focus and legumes went out of the cultivation and cereal- cereal cropping became predominant. Spread of rice- wheat cropping system in Indo-Gangetic Plain region is the glaring example of this. Due to this cereal-based crop rotation, natural resources started degrading and weeds developed resistance to herbicides. Factor productivity started declining. Presently these are our cultivation practices i.e. our convention, which is chemical based and input intensive, this we wished to change to bring bio-intensive agronomic practices, which included massive use of biomanures, biofertilizers and biopesticides. The

research on rhizospheric engineering and carbon sequestration was strengthened to improve the soil health and nutrient use efficiencies. Rhizospheric engineering refers to bringing changes in root architecture by modifying planting methods and crop geometry and also improving root zone soil profile through rhizodeposition. In irrigated ecosystem, where legumes could not be introduced due to their sensitivity to water, sugarcane is to be brought in the system, because several beneficial microorganisms are associated with its roots, which mobilizes soil materials. Also, large quantity of root mass of sugarcane upon decomposition adds substantial quantity of organic matter to the soil. Thus in order to provide user-friendly technology to the growers in sugarcane and make profitable sugarcane agriculture, these issues have been addressed in research programmes taken under All India Coordinated Research Project in discipline of crop production.

A. Nutrient Management

- **Plant nutrients in varied agro- ecological situations :** Application of Zn @ 5 kg/ha and S @ 40 kg/ha along with NPK every year to sugarcane plant crop was recommended for subtropics, while for tropics, the recommendation of Zn @ 10 kg/ha and S @ 60 kg/ha along with NPK was found appropriate.
- **Fertilizer requirement for promising sugarcane genotypes:** There is great deal of genetic variations in cane yield and quality across the zone. Hence, superior clones were recommended to substitute old/inferior varieties. In NWZ/NEZ/NCZ/ECZ, sugarcane crop fertilized with the recommended dose of fertilizer resulted the highest sugarcane and sugar yields, whereas in peninsular zone, sugarcane crop responded up to 25% higher doses of NPK than the recommended.
- **Sustaining sugarcane production and soil health through integration of nutrient sources in sugarcane based cropping system:** For sustaining higher sugarcane yield and better soil health, sugarcane plant and ratoon crops be fertilized with 75% of recommended NPK through in-organics + 25% of recommended N through organics (FYM/PSM) along with furrow application of *Azotobacter* + PSB @ 12.5 kg/ha each and bio-pesticide (*Trichoderma*) inoculated @1kg/ha mixed with one quintal FYM, apart from trash mulching and green manure of legumes (*Sesbania*) in alternate rows in ratoon crop.
- **Nutrition for improving productivity of winter initiated ratoon:** Sulphitation press mud cake (SPMC) @ 20 t/ ha at ratoon initiation is



recommended for improving bud sprouting and cane yield in winter initiated sugarcane ratoon. Alternatively, 10 t/ha SPMC + 25 kg ZnSO₄/ha is also recommended.

- Application of 20 t/ha FYM/ compost along with inorganic fertilizers applied on the basis of soil test crop response for targeted yield or on the basis of general recommendation for the region has shown positive effect on sugarcane growth and yield both in plant and ratoon crops. Response of bio-fertilizers (*Azotobacter/Gluconacetobacter/Acetobacter/Azospirillum/PSB*) was more pronounced in peninsular zone. Use of organic sources of nutrients in plant-ratoon system brought forth substantial enhancement of soil health parameters in most of the sugarcane growing soils.
- **Sub-soiling:** Development of a hard pan beneath the plough soil in sugarcane growing areas causes yield stagnation and crop lodging. To improve upon soil physico-chemical characteristics and sugarcane productivity sub-soiling especially cross sub-soiling at 1.0 m is recommended for enhancing cane yield and sustaining soil health.
- **Compatibility of zinc application with sources and levels of phosphorus in sugarcane:** Single super phosphate and Di-ammonium phosphate were found equally effective as sources of phosphorus. In North West, North East and East Coast Zones, sugarcane crop be fertilized with 60 kg P₂O₅/ha. However, in Peninsular Zone, DAP was superior to SSP and sugarcane crop be fertilized with 60-80 kg P₂O₅/ha. As regards, zinc nutrition, 20-30 kg ZnSO₄/ha was found appropriate.

B. Water management

- Surface and sub-surface drip irrigation in sugarcane effectively saves water (up to 40%) and raises the crop productivity (20-25% higher than the conventional). Fertigation with drip resulted in 25% saving of nitrogen compared with surface irrigation. However, with the application of 100% recommended N in drip irrigation, cane productivity could be further raised. Drip irrigation system once installed can be effectively used for five years up to fourth ratoon.

C. Weed management in sugarcane ratoon crop

- Three hoeings, at 1, 4, and 7 weeks after ratoon initiation should be adopted for effective control of weeds in sugarcane ratoon crop. However, under limitations of manpower-availability, cost etc., pre emergence application of either atrazine @ 2.0 kg a.i./ha or metribuzin @ 1.0 kg qa.i./ha (800- 1000 litres water/ha) followed by either 2,4 D Na salt @ 1.0 kg/ ha (600-800 litres

water/ha) or hoeing at 45 days after ratooning was successfully practised. Further, trash mulching in alternate rows as well as hoeing in unmulched furrows at 1 and 6 weeks after ratoon initiation was also found good alternative option.

D. Binding weed is a perpetual problem in sugarcane ratoon particularly under water-logged conditions.

Application of Atrazine @ 2 kg ai/ha or metribuzine @ 1.25 kg ai/ha as pre-emergence followed by Dicamba @ 350 g ai/ha at 75 DAP is recommended for controlling binding weeds in sugarcane.

3. Crop Protection

- Chemicals identified for the management of binding weeds (*Convolvulus arvensis*, *Ipomoea* spp., *Cardiospermum hispidum*, *Cocciniagrandsis*, *Rhynchosia minima* and *Merremimarginita*) were controlled by the application of atrazin @ 2.0 kg a.i./ha as pre-emergence after first irrigation followed by hoeing and application of 2,4-D @ 1.0 kg a.i./ha at 75 days after planting or atrazin @ 2.0 kg a.i. /ha as pre-emergence together with dicamba @ 350 g a.i. /ha at 75 days after planting was the most effective treatment in managing binding weeds and increasing cane yield.



Binding weeds infested sugarcane crop

- **Leaf whorl method of inoculation**

This methodology has been developed for screening sugarcane genotypes for resistance to brown rust (*Puccinia melanocephala*). It was found that foliar spray of Propineb (0.25%) or Chlorothalonil (0.25%) on appearance of rust pustule and further application two times at fortnightly intervals effectively controlled the disease. Leaf whorl inoculation method -First appearance of brown rust in the field, rust affected leaves were selected. Suspension of uredospores (10^4 - 10^5 spores/ml)

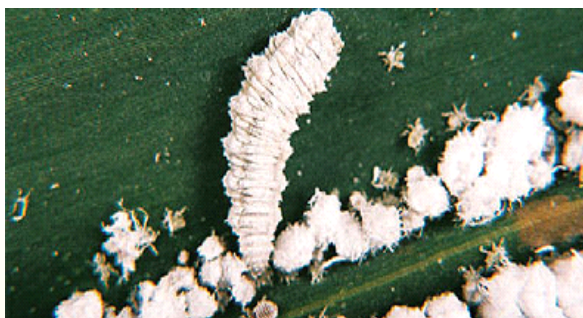


Brown rust infected sugarcane leaf



was prepared in sterilized distilled water and 1 ml freshly prepared suspension was poured in each leaf whorl. A total of 10 clumps were inoculated @ 3 shoots per clump. The inoculated plants were marked by cutting 1/3rd of the tips of the uppermost leaves to identify them for recording observations. After 4 weeks, following observations were recorded. 1. Average no. of rust pustules per square inch. 2. No. of leaves bearing rust pustules.

- During the period, one hundred seventy four sugarcane entries were evaluated under zonal trials for red rot, smut, YLD and wilt diseases.
- Mass multiplication of *Dipha aphidivora* has been carried out on sugarcane woolly aphid susceptible variety (Co 86032, CoC 671) grown under green shade net. One hundred - two hundred larvae of *Dipha* were released by tagging leaves and after 45 - 60 days larvae of *Dipha* were harvested for redistribution for economically and eco-friendly management.



Mass multiplication of *Dipha aphidivora*

- Removal of lower leaves followed by foliar application of imidacloprid 0.005% + 2% urea is recommended for effective whitefly management.
- Pheromone trap technology has been advocated for monitoring of early shoot borer, top borer, stalk borer and internode borers in sugarcane crop.
- Soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting and 60 days after planting or chlorantraniliprole 18.5 SC @ 375 ml/ha applied as spray after 30 and 60 days



Pheromone trap technology in sugarcane

of planting was found most effective for the control of sugarcane early shoot borer. It increased cane yield, total cane height, sucrose (% in juice) and CCS (%) in north western zone significantly.

- Mass production technologies have been developed for bio-agents (*Metarhizium anisopliae*, *Micromus igorotus*, *Dipha aphidivora* and *Encarsia flavosutellum*). The mass multiplication of *Beauveria bassiana* was done on different solid media. It was found that the solid media par boiled rice produced the highest spore count of 13×10^8 per ml with less biomass (0.13g/ 100 g) followed by maize (12.1×10^8 /ml), rice (12×10^8 /ml) is best suitable media. The predator green-lace wing, *Chrysoperla zastrowi sillemi* was mass multiplied in the laboratory on laboratory host (*Corcyra cephalonica*).

b) Visible and implementable achievements-

Crop Improvement

One hundred seventy four kg sugarcane fluff was produced by breeders of AICRP(S) centre made station crosses, zonal crosses, polycrosses and general collections.

Year	Number of crosses				Quantity of fluff (kg)
	Bi-parental	Polycrosses	General collection (Total No.)	Selfs	
2012-13	632+47*	18	744	10	32.70
2013-14	597+50*	20	204	14	43.88
2014-15	511+56*	21	319	15	38.21
2015-16	611+27*	21	219	17	24.63
2016-17	200+17*	60	76	193	35.31

*Zonal

crosses



Sugarcane Fluff

- One hundred twenty five zonal varietal trials were conducted at various AICRP(S) centre's in the country.



Year	Trial	No. of Trial	Trial conducted			Entries evaluated			Promising entries		
			Early	Mid-late	Total	Early	Mid-late	Total	Early	Mid-late	Total
2012-13	IVT	7	11	13	24	45	60	105	22	25	47
	AVT	19									
2013-14	IVT	7	9	13	22	31	57	88	22	25	47
	AVT	15									
2014-15	IVT	7	11	11	22	48	52	100	17	9	26
	AVT	15									
2015-16	IVT	8	14	11	25	66	68	134	15	13	28
	AVT	17									
2016-17	IVT	8	16	14	30	67	91	158	16	22	38
	AVT	22									

- Twenty sugarcane varieties were identified under AICRP on Sugarcane for release during 12th Five Year Plan

Year wise	Maturity group	Sugarcane varieties identified under AICRP on Sugarcane for various sugarcane growing zones
2012-13	Early group	Peninsular Zone (Co 06022, CoN 05071), North West Zone (Co 05009), North Central Zone (CoSe 05451)
	Mid-late group	Peninsular Zone (Co 06027), East Coast Zone (Co 06030), North West Zone (CoPant 05224), North East Zone (CoBln 04174)
2013-14	Early group	East Coast Zone (CoA 08323, CoC 08336), North West Zone (CoLk 07201)
	Mid-late group	North West Zone (Co 06034), North Central Zone (CoP 06436)
2014-15	Early group	Peninsular Zone (PI 07131)
2015-16	Early group	North West Zone (CoPb 08212)
	Mid-late group	North Central Zone (CoP 09437)
2016-17	Early group	Peninsular Zone (Co 09004), North Central Zone (UP 09453)
	Mid-late group	North West Zone (CoLk 09204, Co 09022)

Crop management methods and technologies -

- A new project entitled "**Evaluation and identification of climate resilient ISH genetic stocks**" was initiated to identify elite ISH clones tolerant to drought and water logging in eight selected locations. A total of 139 clones of inter-specific and inter-generic origin were pooled and planted in multiplication cum observation plot at Sugarcane Breeding Institute, Coimbatore. Twenty seven clones were selected and evaluated at 8 AIRCP(S) centres for initial multiplication and further evaluation would be in the targeted abiotic condition.
- Four hundred seventy four isolates of red rot pathogen were screened for the occurrence new pathotype on defined host differentials.

Year wise	No. of red rot pathogen isolates isolated and evaluated	Defined host differentials used for the screening of new pathotype of red rot pathogen
2012-13	64	Co 419, Co 975, Co 997, Co 1148, Co 7717, Co 62399, CoC 671, CoJ 64, CoS 767, CoS 8436, BO 91, Baragua, Khakai, SES 594, CoV 92102, Co 7805, Co 86002, CoSe 95422 and Co 86032
2013-14	69	
2014-15	74	
2015-16	172	
2016-17	95	



Sugarcane red rot disease infected cane

- One hundred thirty varieties of sugarcane were screened against pokkah boeng disease under natural conditions. Varieties namely CoH 92, CoH 160, CoH 164, CoH 167, CoH 150, CoH 99 were found resistant to pokkah boeng disease. Varieties CoH 56, CoH 151, CoH 119, Co 0118, Co 1148, CoH 56, CoH 128, Co 7717, Co 0237, CoJ 64, Co 05011, CoJ 85, Co 05011, S -11 252 and S-11 202 were found moderately susceptible. It was also recorded that high humidity, high rainfall and lower temperature favours the disease development. Soaking sets overnight in carbendazim (0.10%) followed by foliar spray of carbendazim (0.05%) three times at fortnightly intervals soon after the appearance of disease effectively manages the disease.



Pokkah Boeng infected sugarcane

- Survey of sugarcane diseases naturally occurring in the area on important varieties programme was conducted during XII-plan and indicated prevalence of red rot in all the sugarcane growing states except Maharashtra, Karnataka and Madhya Pradesh and high incidence of red rot was recorded in Haryana, Andhra Pradesh and Tamil Nadu. Smut incidence



was less in general except in Andhra Pradesh and Tamil Nadu where it ranged from 10-60. Wilt incidence was higher in Bihar, Assam, Madhya Pradesh and Andhra Pradesh. Grassy shoot disease was severe in western Uttar Pradesh and Andhra Pradesh. Rust up to 50% in Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka. Sugarcane yellow leaf disease higher incidence was in Maharashtra and Madhya Pradesh. Pokkah boeng incidence was low except in Haryana and Uttarakhand. Besides this, brown spot disease is gaining importance in Maharashtra.

- One hundred thirty nine elite and ISH genotypes genotype have been evaluated and considered in breeding programme as possible donor for resistance.
- Survey for major insect-pests has been done in the country and indicated the high incidence of early shoot borer in Uttar Pradesh, Haryana, Karnataka and Andhra Pradesh. Stalk borer and top borer were in high incidence in Uttar Pradesh. Black bug, root borer, stalk borer and pyrilla were in high incidence in Haryana. Mealy bug, scale insect and internode borer incidence was very high in Maharashtra. Pyrilla was severe in Madhya Pradesh and central Uttar Pradesh. Red mite was in Andhra Pradesh. Whitefly was in Gujarat.



Sugarcane root borer



Sugarcane internode borer



Sugarcane top borer

- Naturally occurring bio-agents have been reported in the country viz., *Trichogramma* spp., *Lixophaga diatraeae*, *Agathis stigmaterus*, *Cotesia flavipes*, *Orgilus elasmopalpi*, *Apanteles diatraeae*, *Apanteles impunctatus*, *Euplectrus plathypenae*, *Syntomosphyrum clisiocampe*, *Solenopsis invicta*,

Pheidole dentate and *P. floridana* of top borer, stalk borer, pyrilla, whitefly, woolly aphid, scale insect, mealy bug and early shoot borer in the sugarcane agro-ecosystem.

c) **Bullet Points/Numerical terms/Economic returns -**

Sugarcane is long duration crop and requires more nutrients and water for better growth and development. In India, there are two distinct agro-climatic regions of sugarcane cultivation viz., tropical and sub-tropical regions. Five sugarcane growing agro-climatic zones (North Western Zone, North Central Zone, North Eastern Zone, Peninsular Zone and Coastal Zone) have been identified under AICRP(S). Crop yield is major factor for economic returns instead of government provided minimum support price. The economic returns of the individual states have been worked out. It recorded that production cost varies from state to state. So, actual benefits and cost of production differs significantly intra-state and inter-states of the country which includes from fixed preparation to transferable factors viz., crop season, region, availability of labourers, distance from sugar mills/collection and cost etc.

Impact analysis of one of the AICRP(S) sugarcane variety Co 86032 has been done by Sugarcane Breeding Institute, Coimbatore, prevalent in tropical region of the country. The variety has been widely adopted in states like Tamil Nadu, Karnataka, Maharastra, Gujarat, unified Andhra Pradesh and Kerala. The variety covered 11.96 m ha area and has generated Rs. 20354 crore as additional monetary benefits since its inception by increased cane yield coupled with improving sugar recovery. The impact of variety on sugar recovery was studied with the base year of 1999-2000. In the analysis, it has been shown that after introduction of the variety Co 86032, the average sugar recovery has increased to 9.45% from previous years (8.69%).

Table 2: Impact of sugarcane variety Co 86032 in tropical region of the country

Year	Area in m ha	Increased yield (m tonnes)	Total value (Rs. in crore)	Sugar recovery (Rs in crore)	Final value (Rs. in crore)
2011-12	1.10	12.43	2209.75	79.76	2289.51
2012-13	1.26	14.31	2874.17	99.24	2973.41
2013-14	0.78	6.70	2067.61	-	2067.61
2014-15	1.11	10.10	3005.09	-	3005.09
2015-16	1.01	9.20	2674.40	NA	2674.40

Source: Ram Bakshi , Hemaprabha G and Murali P. 2017. Importance of new varieties suitable for tropical India. Indian Farming 67(02): 16-18.)



Similarly, a sugarcane variety Co0238 is widely grown in the sub-tropical region of the country. The major growing states include like Uttar Pradesh, Uttarakhand, Harayana, Punjab and Rajasthan. In Uttar Pradesh state, this variety played major role in crop productivity and sugar recovery. The other prominent varieties of the states are CoLk 94184 and Co 0118. Because of these varieties, the additional sugar produced due to increased yield of Rs 2229.22 crore, and also additional sugar produced due to increased sugar recovery of Rs. 815.06 crore. The total value of additional sugarcane and sugar produced of Rs. 3044.98 (2229.92+815.06) crores. Besides this, per hectare additional income generated to the farmers is of Rs. 34196/ha and sugar-mills too of Rs. 12499/ha. Detailed information on sugarcane variety Co0238 in improving Uttar Pradesh cane yield and sugar recovery is being described below-

Table 3: Impact of Co 0238 on cane yield (t/ha) and sugar recovery (%) in Uttar Pradesh during 2012-13 to 2015-16

Items	2012-13	2013-14	2014-15	2015-16
Cane yield - UP	61.6	62.7	65.1	66.5
Sugar recovery %-UP	9.18	9.26	9.55	10.61
Avg. cane yield of district with Co 0238	61.3	62.49	64.6	65.22
Avg. cane yield of district without Co 0238	61.0	61.46	62.45	62.79
Difference in cane yield	0.30	1.03	2.15	2.43
Increase in cane yield over 2012-13		0.73	1.85	2.13
Calculated cane yield excluding region effect (t/ha)		63.43	66.95	68.63
Increased yield of Co 0238 (t/ha)		18.63	17.6	8.69
Calculated cane yield of Co 0238 (t/ha)		81.33	82.7	75.15
Avg. sugar recovery of district with Co 0238	9.11	9.30	9.64	10.67
Avg. sugar recovery of district without Co 0238	8.67	8.71	8.83	9.40
Difference in sugar recovery % over 2012-13	0.44	0.59	0.81	1.27
Increase in sugar recovery % over 2012-13		0.15	0.37	0.83
Calculated sugar recovery excluding region effect		9.45	10.01	11.5
Area of Co 0238 in UP (ha)		72623	176763	402719
Area of Co 0238 in UP (%)		3.1	8.3	19.6
Additional cane production due to increased yield of Co 0238 (lakh tonnes)		13.53	31.11	35.0
Additional sugar production due to increased yield of Co 0238 (lakh tonnes)		1.25	2.97	3.71
Additional sugar production due to increased sugar recovery % of Co 0238 (tonnes)		6830.19	42576.90	222280.75
Cane crushed (lakh q)	8150.62	7011.74	7427.30	6426.61
Sugar produced (lakh q)	748.51	649.54	708.98	681.99

Source: Cane commissioner office Uttar Pradesh

Under AICRP(S), a large number of sugarcane varieties have been developed and are being adopted by the sugarcane growers of the country. The sugarcane varieties were of high yielding and high sugar content. The sugarcane varieties adopted by sugarcane growers of Uttar Pradesh state only in 12th five year plan, are being given below -

Table 3: Dissemination of AICRP (S) varieties at farmer's field (ha) during 12th Plan in Uttar Pradesh

Early group	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Co. 0118	0	0	3774	8542	18134	41244
Co. 0232	0	0	66	134	72	282
Co 0237	0	0	195	0	189	28
Co. 0238	0	72628	176763	402719	728604	1208081
Co. 0239	0	5988	14466	24929	35616	44346
CoSe 01421	0	0	0	0	0	30
Co 05009	0	0	0	0	0	33
CoPK 05191	0	0	0	0	0	2549
Co 89029	0	0	18	160	1	0
Co Lk94184	0		14014	43855	88174	144198
CoS 95255	6917	6220	4646	4020	2433	1206
Co Se 95422	0	29920	16548	8114	5420	4528
Co. S. 96268	6398	5894	5861	4536	3350	2581
Co. 98014	0	0	17775	38267	60178	64585
Total area under AICRP(S) varieties (ha)	13315	120650	254126	535276	942171	1513691
Grand total area (ha)	224511	343943	455241	707447	1085132	1619872
% Share of AICRP in total	5.93	35.1	55.8	75.7	86.8	93.4

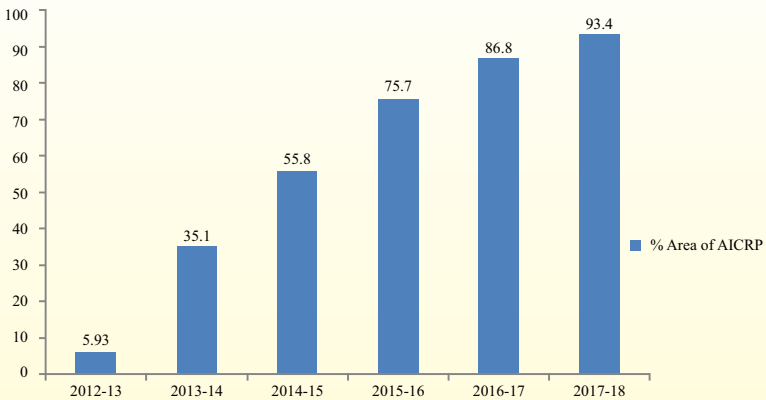


Fig . Adoption trends of AICRP(S) Early varieties in UP at farmer field

Under AICRP on Sugarcane, agro-technologies were developed and Front Line Demonstrations were conducted on farmers' fields under the supervision of scientists working at various AICRP (S) centres. In this analysis, report of



AICRP on Sugarcane centres was considered as evaluating regions of the state. The technologies were analyzed and compared with state average yield and with other states. The states where FLDs trials were demonstrated - Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar, Andhra Pradesh, Uttarakhand, Gujrat, Assam, Haryana, Kerala, Madhya Pradesh, Odisha, Punjab and Rajasthan. The agro-techniques were evaluated *viz.*, - Planting of Tissue Culture Seedlings, Production Potential of Improved Varieties, Use of Cane Cutter Planter in sugarcane cultivation, Ring Pit Method of sugarcane planting, Paired Row Planting with intercrop in sugarcane, Wide Row Spacing, Integrated Weed Management, Drip Irrigation, Water Management, Integrated Nutrients Management, Application of Bio-fertilizers, Intercropping in Sugarcane, Adaptation of full package of practices, Integrated Insect - Pest Management, Management of ratoon cane, Trash Management, Management of late planting, Management of Sugarcane Seed Crop. The cane yield data was recorded and analyzed. It was observed that agro-technologies had greater potential to

Table 4: Different agro-technological impact on sugarcane cultivation during under AICRP(S) programme

S. No.	Technologies applied in Sugarcane	Technological Impact on Sugarcane Cultivation		
		Farmers Practices Yield (t/ha)	Field Demonstrated Trial Average Yield (t/ha)	% Increased Yield (t/ha)
1.	Adoption of Full Package of Practices	71.70	91.61	31.03
2.	Management of Sugarcane Seed Crop	94.31	108.08	14.61
3.	Planting of Tissue Culture Seedlings	94.31	191.26	102.80
4.	Production Potential of Improved Varieties	64.66	81.20	28.24
5.	Use of Cane Cutter Planter in Sugarcane Cultivation	79.60	84.18	5.57
6.	Ring Pit Method of Sugarcane	79.60	98.35	26.13
7.	Pair-row Planting with Intercrop in Sugarcane	94.31	111.84	18.59
8.	Wide Row Spacing	94.31	103.77	10.04
9.	Integrated weed management	71.60	84.08	19.60
10.	Integrated Nutrients Management	79.10	92.37	15.99
11.	Application of Bio-fertilizers	94.31	112.37	19.16
12.	Drip Irrigation in Sugarcane	79.10	98.82	24.97
13.	Water Management in Sugarcane	94.31	106.38	12.80
14.	Intercropping in Sugarcane	71.60	90.01	27.48
15.	Integrated Insect - pests Management	64.66	84.61	33.41
16.	Management of Ratoon Cane	64.66	80.85	23.78
17.	Trash management	79.60	91.20	16.27
18.	Management of Late Planting in sugarcane	64.90	75.73	16.96

increase cane productivity over the farmers' practices. Increased productivity under FLDs trials was recorded which was variable with technologies adopted. It means, if sugarcane growers adopt these technologies they may get additional/enhanced benefits. Detailed impact of individual agro-techniques in terms of increased cane yield per hectare is given.

In order to this, the cumulative impact of all the agro-technologies demonstrated in the state was also estimated compared with states average cane yield. It was observed that maximum technological impact on net gain cane yield (t/ha) was reported in the Maharashtra state 24.60 followed by Odisha state 24.23 while the minimum Uttarakhand 6.49 and Punjab 7.51. Detailed impact of agro-technologies of the state is given below -

Table 5: State wise agro-technological impact on sugarcane cultivation under AICRP(S) programme

S. No.	State	State Farmers Practices Average Yield (t/ha)	Field Demonstrated Trials Average Yield (t/ha)	Net Gain Yield (t/ha)	% Increased Yield (t/ha)
Tropical region					
1.	Maharashtra	76.90	101.50	24.60	32.00
2.	Karnataka	85.65	96.51	10.86	12.69
3.	Tamil Nadu	102.64	112.93	10.30	10.04
4.	Andhra Pradesh	77.85	95.92	18.07	23.22
5.	Bihar	46.00	66.08	20.08	43.66
6.	Gujarat	72.02	88.49	16.42	22.81
7.	Kerala	91.50	108.87	17.37	18.98
8.	Madhya Pradesh	41.83	59.08	17.25	41.25
Sub-tropical region					
9.	Uttar Pradesh	58.47	73.21	14.71	25.17
10.	Uttarakhand	58.69	65.18	6.49	11.07
11.	Assam	38.06	55.56	17.50	45.99
12.	Haryana	67.70	81.97	14.27	21.09
13.	Odisha	61.13	85.36	24.23	39.64
14.	Punjab	63.68	71.19	7.51	11.79
15.	Rajasthan	67.40	77.67	10.27	15.24

Under AICRP on Sugarcane, various efforts were made to improve socio-economic status of sugarcane growers and sugar-miller in the country. Both production and productivity of the crop is increased. The average cane yield of the country is 70.0 t/ha which was lower in earlier decades. If we look on the current position (30.11.2017) of sugar-millers in the country, higher number of sugar-mills started early sugarcane crushing compared to previous years.

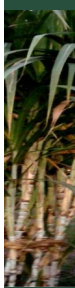


Table 6: Current position (30.11.2017) of sugar-mills functioning in the country

Particulars	Uttar Pradesh	Maharashtra	Karnataka	Gujarat	Telangana	Punjab
No. of operating sugar-mills	110	162	59	17	7	10
Cane crushed (Lakh MT)	138.06	134.77	48.31	20.46	1.71	-
Sugar Produced (Lakh MT)	13.59	12.27	4.16	1.72	0.12	-
Sugar Recovery (%)	9.85	9.10	8.61	8.43	7.03	-

In intercropping system, remunerative intercropping system has been worked out viz., Sugarcane + Potato cropping provides benefits of Rs. 1,06,736/ha to sugarcane growers, and Sugarcane + Rajmah cropping system provides additional benefits of Rs. 89,884/ha. Similarly, in other cropping system, it has been estimated and intercropping has been found good source of mid-term income generation to sugarcane growers.

Besides this, sugarcane processing network generates valuable by-products and those can be used in many industries for different purposes. They may be additional source for generating income. Bagasse, molasses, filter cakes/press mud are major by-products. A sugar industry on an average produces about 30.0 tonnes of bagasse, 4.5 tonnes of molasses, 3.5 tonnes of filter cake/press mud.

To improve socio-economic status of the sugarcane growers of the country, a technical bulletin having set of package of practices for sugarcane cultivation in India has been developed by AICRP(S). Sugarcane growers are being advocated to reduce cost of cultivation and increase production and productivity and also additional benefits by adopting recommended agro-technologies in sugarcane cultivation in the country.

d) Export avenues

Sugarcane supports one of the largest agro-processing industries of India. Besides, about half a million skilled and semi-skilled workers, mostly from rural areas are also engaged in the sugar industry.

Sugarcane is presently grown at around 5.0 million ha in both tropical and subtropical regions. Sugarcane production during 2016-17 is 336.9 million tonnes at 69.7 t/ha cane productivity, sugar production 25.12 million tonnes and mean sugar recovery was 10.62%. By 2030 AD, India would require nearly 33 million tonnes of white sugar for domestic consumption alone. The production of alcohol for blending with fossil fuel and use of bagasse in cogeneration of electricity has great potential in future and thus requirement of cane will increase further. With an average sugar recovery of 10.75 per cent, about 520 million tonnes of sugarcane will have to be produced and this will entail an increase in sugarcane productivity to the tune of 100 to 110 t/ha with the

emphasis of reduced cost of cultivation and doubling farmers income.

Sugarcane productivity has increased from 48.0 t/ha (1970-71) to about 70 t/ha (2015-16) whereas, total cane production has gone up from 126 million tonnes to 336 million tonnes (2015-16). The production of white sugar stood at the level of 25.10 million tones (2015-16). During the span of five years 2012-13 to 2016-17, country produced more sugar than the internal consumption and got an opportunity to export sugar.

Recently, wide spread and adaptation of high sugar early maturing varieties particularly Co 0238, CoLk 94184 and Co 0118 has changed sugarcane production status of sub-tropical region of the country mainly Uttar Pradesh state. The sugar recovery has achieved 10.62% during 2016-17 at state level which was below 10 during previous years. It would further open the export avenues in future.

e) Benefits accrued to the farmers (stakeholders)

For sugarcane cultivation, country is identified as five different sugarcane cultivating zones. Under AICRP on Sugarcane, various programmes have been started to equip sugarcane growers with high yielding high sugar varieties, protection and production technologies in the country. Sugarcane growers are being demonstrated with advanced production and protection technologies to get higher cane yields. Besides this, under Tribal Sub-Plan scheme sponsored by Govt. of India has also been working for upliftment of tribal farmers in tribal port areas of the country. Under National Food Security Mission (Commercial Crop) sponsored by Govt. of India, the work has been started to sensitize and equip with advanced production and protection technologies.

Sugarcane varieties have been widely adopted and occupied larger share in sugarcane area of the country viz., (Co 86032 (70%) in Peninsular zone, Co 0238 (35%) in North Western Zone and Central Zone, and CoLk 94184 (28%), BO 91 (20%), Co 6907 (20%) and Co Bln 9104 (18%) in Eastern Zone of country. Because of adaptation and large scale cultivation of high yielding early sugarcane varieties, economic output of sugarcane growers has been changed. Recently, wide spread and adaptation of high sugar early maturing varieties particularly Co 0238, CoLk 94184 and Co 0118 has changed the scenario of sugarcane and sugar production status of the Uttar Pradesh in the country. The sugar recovery at national level has increased to the level of 10.62% in 2015-16 due to development and dissemination of improved high yielding sugar early varieties through ICAR institutes/SAUs under AICRP(S).



A technical bulletin on "Sugarcane in India: Package of practices for sugarcane cultivation of the different sugarcane cultivating zones" of country has been published by AICRP(S) to provide technical inputs to increase production and productivity of the cane and improve socio-economic status of the sugarcane growers. Sugarcane growers are advocated to cultivate mid-term income generation crop and sustain soil fertility and sustain crop productivity. Sugarcane varieties developed and adopted at large scale by sugarcane growers in the country. Besides this, eco-friendly (bio-control) management of insect-pests and diseases and seed production programme of improved varieties were also taken up for quick spread among the sugarcane growers.

f) Validated technologies transferred to other Departments (Centre/State) or other agencies

Under AICRP(S), sugarcane varieties are being developed, keeping in view the high tonnage and high sugar content and commercial can sugar produced per unit area. Thus early maturing varieties having high sugar content and higher tonnage are being promoted in the country. Advanced Varietal Trials and Zonal Trials have been conducted for testing of sugarcane clones to be adopted on large area/region in India. Besides this, crop production and protection technologies have also been developed to maximize sugarcane productivity under minimum cost and maximum benefit principle. Under TSP and NFSM, Training of farmers and Front Line Demonstrations have been conducted for the farmers on improved sugarcane production and protection technologies.

Table 7: Validated technologies transferred to other Departments (Centre/State) or other agencies

S. No.	Agro-technologies in sugarcane	Technologies transferred to
1	Planting of Tissue Culture Seedlings, Production Potential of Improved Varieties, Use of Cane Cutter Planter in Sugarcane Cultivation, Pair-row Planting with Intercrop in Sugarcane, Integrated water, weeds, nutrients, insect-pests management, Application of Bio-fertilizer, Intercropping in Sugarcane, Adoption of Full Package of Practices, Management of Ratoon Cane, Trash management, Management of Sugarcane Seed Crop	Tropical and sub-tropical states of the country
2	Ring Pit Method of Sugarcane	North West and North Central zone
3	Wide Row Spacing, Drip Irrigation in Sugarcane	Tropical states of the country
4	Management of Late planting	In sub-tropical states of the country

Agro-technologies widely adopted by sugarcane growers, are being described below-

Trench Method of Planting: Trench method of planting is being widely adopted in tropical and sub-tropical regions of the country. Trenches are dug at a

distance of 75-90 cm, with the help of ridger tractor mounted or by manual labourer. The trenches should be about 30 cm deep. The mixture of fertilizers (NPK) should be uniformly spread in the trenches and mixed thoroughly in the soil. Then setts are planted end to end method within the trenches made. Drenching of the setts is done with chlorpyrifos @ 0.05% to protect from the soil borne and insect - pests. Trenches are filled up with loose soil after planting. The sugarcane Cutter and Planter developed by Indian Institute of Sugarcane Research (IISR), Lucknow (U.P.) can also be used for combining the operations of opening the furrows, placement of fertilizers and then planting setts in the rows. Paired row trech planting is being done at 30:120 cm in subtropical India. However, in Maharashtra and other tropical regions spacing may be increased up to 150 cm. Trench method of planting avoids lodging of cane particularly in ratoon crop. Paired row planting is also best practice for surface drip irrigation system and involving maximum resource use efficiency and cane productivity (25-30%). This method is spreading fast in sugarcane growing areas of subtropics as growers can realize high input use efficiency and it provides ample scope for accommodating inter-crops between sugarcane rows (Srivastava and Verma 2017). Under this method of planting, farmers can obtain an average cane yield of **110 t/ha** with a **cost benefit ratio of 2.15**.



Trench method planted cane setts (manually) Tractor operated trench opener and planting

A success story on trench method of planting has been telecast by news channel ABHI TAK on dated 10.06.2016. The detail information is available through given url <https://youtu.be/5q8sKJOqZ1g>. The name of farmer is Sri Brahmopal belong to district Jaunpur. He has awarded Rs 7000 for highest productivity of sugarcane as 220 t/ha through trench method of planting. He also awarded of cash prize Rs 50000 by *Rajya Ganana Samity of Uttarpradeh* for achieving the highest yield in the state by adopting this method.

Furrow Irrigated Raised Bed (FIRB) technique: In this method, 3 rows of wheat in the month of November are sown on raised beds and sugarcane is



planted at 80-85 cm apart furrows in February in the furrow irrigated raised beds (FIRB) system. Sugarcane gives about 30% higher cane yield as compared to wheat-sugarcane sequential system, without reduction in wheat yield. In this system, irrigation is applied only in furrows, requiring less volume of water which work out to be a 20% water saving.



FIRB technique

Skip-furrow/alternate furrow irrigation: In this method, instead of irrigating all the rows and inter-row spaces, one row is skipped (left out) and irrigation water is applied in alternate furrows. This method saves around 30-40% water without impairing cane productivity.



Skip furrow irrigation method adopted at IISR, Lucknow

Inter-cropping with sugarcane: The short duration and high value crop is planted along with sugarcane. It gives mid-season income for sugarcane farmers and improves socio-economic status of sugarcane growers.



Sugarcane + potato



Sugarcane + cauliflower

Trash management in ratoon crop: In this system, sugarcane farmers are advised to apply trash of the crop to conserve soil moisture, soil organic status and reduces weeds population. This method is also eco-friendly sound and increase cane productivity.



Trash mulching technique in sugarcane

Weed Management Sugarcane is one of the crops which get severely affected due to the weeds. The extent of the crop loss due to the weed varies from the 10% to the total crop failure. The slow germination and initial slow growth of the crop provides ample opportunity to weeds to germinate and establish long before the plant crops offer any competition. In sub-tropical India, it was observed that critical period of crop weed competition coincides with the emergence of annual as well as dicot weeds. Hence, cultural and mechanical methods successfully check the loss in cane yield. Manual or mechanical hoeing at 30, 60 and 90 day's stage of the crop has been found to effectively minimize the yield loss. However, hand weeding has not been found economic against broad leaved weeds and *Cyperus rotundus*. As far as cultural methods are concerned, trash mulching and inter cropping has been found quite effective for suppressing weeds in sugarcane.

AICRP(S) Publications

Salient publications of technologies developed and validated under AICRP(S) having NAAS rating 6.0 or above

1. Anil Khippal, Samar Singh, Mehar Chand, Singh J., Verma, R. and Kumar, R. 2016. Mechanized and profitable intercropping of legumes in autumn planted sugarcane. *Legume Research* 39 (3): 411-418.
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