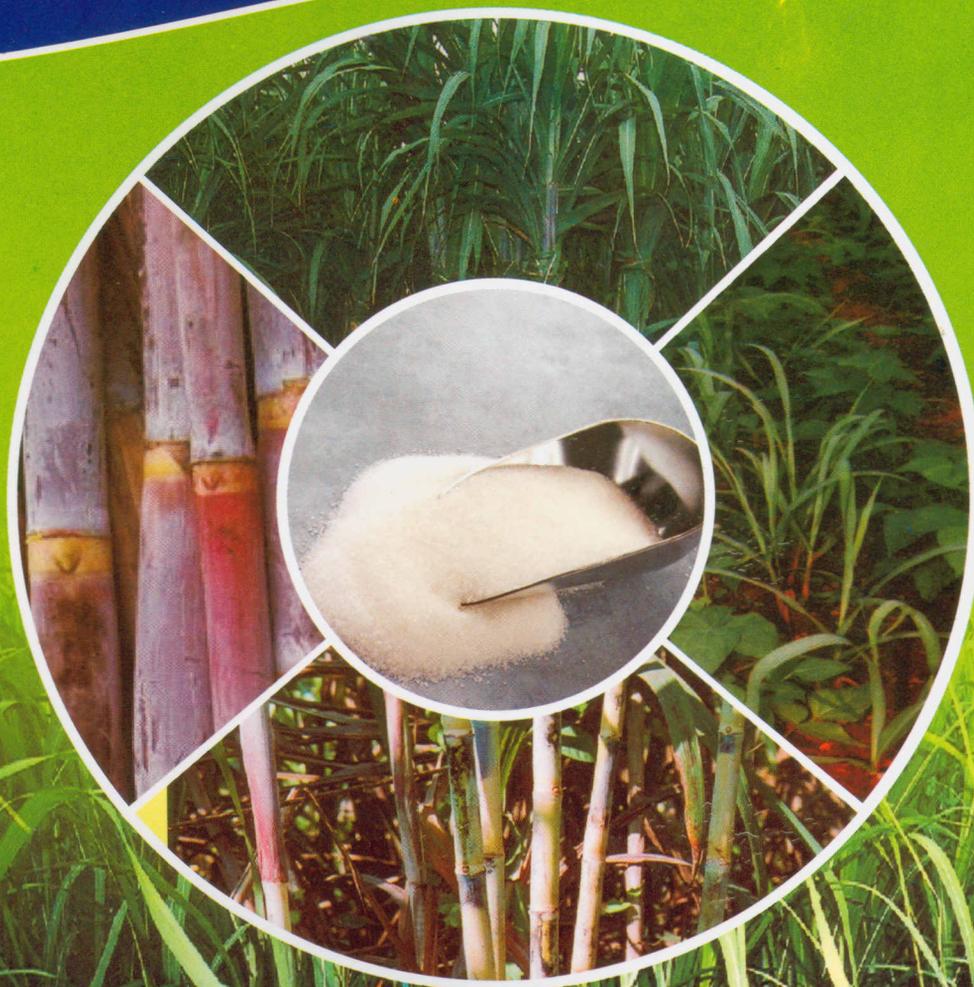


# TECHNOLOGY PACKAGE FOR HIGHER SUGARCANE PRODUCTION IN GOA



**ICAR RESEARCH COMPLEX FOR GOA**

(Indian Council of Agricultural Research)

OLD GOA- 403 402, GOA, INDIA

**TECHNOLOGY PACKAGE  
FOR  
HIGHER SUGARCANE PRODUCTION  
IN GOA**

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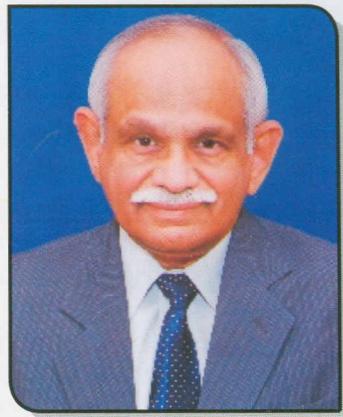
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## FOREWORD

Sugarcane is the commercial crop of India as well as the State of Goa and adjoining regions. I am happy to note that ICAR Research Complex for Goa is bringing out the Research Bulletin entitled "TECHNOLOGY PACKAGE FOR HIGHER SUGARCANE PRODUCTION IN GOA" to serve as a reference package manual for higher productivity of sugarcane in Goa.

Sugarcane is the only commercial field crop cultivated in the region. Of late, cultivation of this crop is facing specific constraints affecting the production in the region. I am happy to note that the Institute has introduced and evaluated a series of sugarcane genotypes over a period of time. The efforts made to identify profitable genotypes and thereby improve the profitability of sugarcane growers are commendable. Similarly, identification of ideal planting dates for higher productivity and recovery will augment the profitability of sugarcane in Goa. In addition, identification of white woolly aphid tolerant varieties will also serve as a cost effective means inturn sustaining the crop cultivation in the region. The efforts made in assessing the intercropping system through identification of short duration leguminous crops need a special mention in taking the results to the door step of the farmers.

This compilation "TECHNOLOGY PACKAGE FOR HIGHER SUGARCANE PRODUCTION IN GOA" will serve as a high production package and provide relevant information to the researchers, extension workers as well as the farming community.

I am sure that this Bulletin will serve as a reference material to all those who are involved in sugarcane and will go a long way in improving the sugarcane production and livelihood security of small and marginal farmers of the region.

My best wishes on the occasion.

**Anil Kumar Singh**

Deputy Director General (NRM)

November, 2011

# PREFACE

Sugarcane is an important crop dominating in the interior talukas both in North and South Goa. The crop is traditionally grown less intensively leading to lower productivity. Lack of sufficient labour force especially for harvesting, insufficient irrigation facilities and the remunerative prices for the produce is affecting the cane cultivation in the state. However, a sole sugar factory established in the state with a crushing capacity of 1.5 to 2.0 lakh tonnes suffers every year for want of sufficient cane, inturn bringing the cane from the neighbouring states at a higher price.

Improving the local productivity with an advanced production technology seems to be a possible alternative for the decreasing cane area over the years. Keeping this in view, ICAR Research Complex for Goa, right from its inception has undertaken sugarcane research especially through evaluation of a series of introduced varieties so as to identify a suitable genotype for different situations of cultivation. Further the research work was continued on different aspects of planting dates, fertilizer management, intercropping, pest and disease management, etc. The research efforts at various levels have given a renewed direction to this crop to improve the production and productivity.

This Research Bulletin is a compilation of sugarcane research carried out by various scientists at this Institute right from inception. The present bulletin involving the latest information on the different aspects of production technology is aimed at bringing an awareness among the sugarcane growers, extension workers and the policy makers associated with the crop for a positive change in the scenario.

While bringing out this bench mark publication, I sincerely acknowledge the invaluable contributions rendered by various visionaries, research workers and scientists and Indian Council of Agricultural Research, New Delhi for encouraging the research on sugarcane crop.

Our sincere thanks are due to all the previous Directors of ICAR Research Complex for Goa for their inspiration, constant encouragement, leadership in introduction and evaluation of various sugarcane genotypes suited to the region, effective transfer of technology by taking up large scale field demonstrations, etc.

Thanks are due to various Scientists of the Institute viz. Dr. K.D Patil, Dr. B. C. Virakthamath, Dr. H. M. Wasnik, Dr. J. R. Faleiro, for their research contribution.

The co-ordination and help rendered by Sugarcane Breeding Institute, Coimbatore, Vasanthdada Sugar Institute, Pune, Agricultural Research Station, Sankeshwar at different stages is gratefully acknowledged.

The conduct of various on-farm trials and frontline demonstrations in sugarcane was possible with the co-operation of Directors, Dy. Directors and Zonal Agricultural Officers of Directorate of Agriculture, Government of Goa over the years. Further the field trials were possible only with the co-operation of the Sanjeevani Sugar Factory. The co-operation and enthusiasm evinced by the farmers of Goa deserves high appreciations.

AUTHORS

# → CONTENTS ←

Sl. NO.	PARTICULARS	PAGE NO.
	Foreword	
	Preface	
I.	Introduction	1
II.	Reasons for low yield/ recovery of Sugarcane in Goa	2
III.	Scientific Cane Production	
	a) Climatic Requirement & ideal planting time	5
	b) Soil requirement	6
	c) Land preparation	6
	d) Selection of suitable variety	7
	e) Selection of setts and treatment	8
	f) Planting	11
	g) Fertilizer Application	12
	h) Irrigation	12
	i) Interculture	15
	j) Weeding	16
	k) Intercropping	17
	l) Pest and Diseases of Sugarcane	18
	m) Harvesting	22
IV.	Ratoon Management	23
V.	References	25
VI.	Annexure	26

# I. Introduction

Sugarcane (*Saccharum officinarum* L.) is an important cash crop cultivated in India in an area of 5.04 m.ha with a production of 340.56 m.t. Uttar Pradesh has the largest area with almost 50 per cent of the cane area in the country, followed by Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat, Bihar, Haryana and Punjab. Sugarcane production is also highest in Uttar Pradesh followed by Maharashtra. Productivity wise, Tamilnadu stands first with over 108 tonnes per hectare followed by Karnataka and Maharashtra. Bihar has the lowest productivity among the major sugarcane growing states. The productivity of Goa is 53-55 t/ha. Long hours of sunshine and cool nights with clear skies are highly favourable for sugar accumulation. This is why average recoveries of Maharashtra and Gujarat are highest in the country.

In Goa, sugarcane is presently grown over an area of approximately 912 ha. The annual production of cane in Goa is about 49,108

tonnes with an average productivity of 53-55 m.t/ha with a recovery of 8.5 per cent (2010-2011), which is very low. Goa has a sugar factory with a crushing capacity of 1.75 to 2 lakh tonnes of cane annually. Thus the present availability of cane meets less than half of the requirement of the factory. This deficit is met by bringing cane from neighbouring states, which is not only uneconomical but detrimental to the interest of local growers. Thus, there is tremendous scope to produce this cane locally by adopting improved technology package strategy. Further, there is a scope for bringing additional area under this cash crop especially in command areas of Salaulim and Anjunem irrigation projects.

Stepping up per unit productivity of both plant as well as ratoon cane to a minimum level of 75-100 mt/ha is possible by following sound management practices and making available all the critical inputs like quality planting material, irrigation water, machinery in time and strengthening extension services.

## II. Reasons for low yield / recovery of sugarcane in Goa

The sugarcane grower faces several constraints which come in the way of boosting sugarcane production and in attaining desired level of sugar in the cane at the field level. These constraints are social, administrative, climatic, managerial or agronomic and technical. In this bulletin, an attempt has been made to briefly discuss the climatic, agronomic and technical constraints.

### Climatic reasons

The sugar production depends mainly on cane yield and percent sugar recovery, hence this objective requires combined attention on cane yield and its sugar contents. Sucrose yields in sugarcane could be improved by increasing the efficiency of biomass production and /or by increasing the fraction of total biomass partitioned to stalk sucrose, or both. This could be achieved by optimally matching the physiology of genotypes to the driving environmental conditions. A careful study of climatic parameters like mean temperatures, relative humidity and rainfall pattern over the last two decades in relation to the growth period of sugarcane, indicate that the cane in Goa is subjected to heavy evapo-transpiration losses. Moisture stress during the early part of the cane growth mostly during March to June is an important and critical problem. Similarly, if one takes into consideration the influence of these parameters during the maturity period of cane from mid November to March end, it

is seen that the mean minimum temperature ranges between 18.1°C to 20.8°C but hardly reaches a congenial low temperature of 15°C, which is ideal for sugar accumulation. In addition to this, Goa does not enjoy a greater difference between maximum and minimum temperatures due to its proximity to the sea. All these factors come in the way of getting desired productivity and recovery.

The crop requires fairly high temperature, low relative humidity, sunny weather with no rainfall during germination and tillering stage, moderate temperature and high relative humidity and well distributed rainfall for fast growth and cool weather, moderate dry and sunny period for ripening. Early and continuous rains from May to July also influence the development of sugarcane growth, tillering, millable canes and thickness of canes. Further, this also has bearing on intercultural operations and fertilizer application in time (Narendra Singh *et al.*, 2008). Heavy rainfall and water-logging during July- August period delays the growth and development of sugarcane crop and thereby, the sugar accumulation. Further, heavy rainfall and water logging during sugar accumulation period in cane reduces the rate of dry matter production per plant. Re-growth in crop instead of sugar accumulation during the period may also be the possible reason for lower sugar recovery (Tiwari, 2005).

Sucrose accumulation begins in leaves and subsequently translocated into stalks. The ripening of cane occurs because stalk elongation is more sensitive to low temperature, restricted soil moisture and low nutrition. Consequently, the photosynthates which normally support the growth of plant and stalk elongation get redirected into sugar storage.

Relative temperature disparity is important factor which helps in cane maturity. Dry conditions or low relative humidity 21-30 days prior to harvest has direct positive impact on sucrose accumulation in cane. The cool and dry climate during ripening period is conducive to higher accumulation of sucrose. For the process of physiological maturity to occur, where a seasonal reduction of air temperature does not occur, the crop must be subjected to a moderate drought, inducing sugar accumulation in plant tissues.

Sugarcane productivity can be improved by adopting an improved package of practices like planting and harvesting schedule for cane cultivation with sound management techniques. Earlier and/or delayed harvesting might influence the cane productivity and sugar recovery. Thus, there is a need for proper planting and harvesting schedule so as to overcome the losses in cane yield and sugar recovery.

### **Agronomic / Managerial reasons**

These are the primary causes which result in low productivity of cane and poor quality cane for crushing.

- I. **Quality of seed setts:** With and exception of a few progressive growers, majority have no option but to use whatever planting material that is

readily available for planting. The seed setts are often selected from immature or diseased crop, inadequately manured crop or from any source. Not much attention is bestowed upon the very important aspect of sett treatment, which results in poor crop.

- II. **Water scarcity:** - Sugarcane in Goa is irrigated mostly from well, lift irrigation schemes or canal. The growth of cane is maximum during February to May. If during this critical period the crop is subjected to drought, heavy losses in terms of yield and recovery occur in the field. Therefore, it is desirous to provide adequate irrigation during these critical months.

- III. **Inadequate fertilization:** - Sugarcane is a heavy feeder and responds to adequate doses of fertilizers. Ignorance of farmers regarding fertility status of soil, soil health and lack of knowledge regarding fertilizers, make the farmer to resort to inadequate fertilizer application. The right time of its application and correct method of application are to be thoroughly understood in relation to the soil test reports in order to meet the nutritional requirements of this crop.

- IV. **Late planting:** January-February is the most ideal time for planting sugarcane under Goa conditions. This is not only due to climatic considerations but also to facilitate adequate fertilization before the onset of monsoon. But due to various reasons, sugarcane in Goa is planted as late as May. Such crop neither can be adequately manured nor receive the congenial climate for initial growth. This results in poor crop.



*CO-8014: One of the predominant sugarcane varieties of Goa*

- V. **Lesser application of organic manures:**  
- Soil is the storehouse of nutrients. Its physical and chemical characteristics has to be understood. Continuous use of chemical fertilizers alone slowly deteriorates the soils. The soils of Goa are lateritic in nature with poor water holding capacity. Hardly 20-25 per cent farmers use organic manures. The water holding capacity of soil have to be restored by use of organic manures. Soils poor in organic content cannot withstand water stress and results in poor growth of cane and the yield. Advanced composting techniques will augment supply of organic manures.
- VI. **Neglected ratoons:** - About 60-65 percent area of sugarcane in Goa will be under ratoon crop at any given time. Though it is a fact that ratoon has many advantages and yields comparable with the plant crop under good management, neglected ratoons have resulted in poor yields and low quality cane, which has a direct bearing in the overall production and recovery. Good ratoon management practices will resolve this issue.
- VII. **Intercultural operation:** - This is a very important agronomic operation to be done in between the interspaces of cane which includes hoeing, weeding, earthing-up and finally mulching. Due to unavailability of bullock drawn intercultural implements locally, lack of man power and herbicide usage, etc., no farmer generally does adequate interculture. Due to this, the roots do not draw sufficient nutrients and weeds cause 60-70 percent losses both in quality as well as quantity of cane produced. Low cost tools and implements may facilitate timely interculturing.
- VII. **Plant protection:** Not much attention is paid to the various insect pests and diseases that infest sugarcane crop in Goa. Spraying of crop is seldom undertaken due to practical difficulties. This has also attributed to the losses in yield and cane quality.

### III. Scientific cane production

As sugarcane is a commercial crop and the lonely sugar factory in Goa needs to be replenished with the raw material on a continuous basis, identification of location specific planting season based on the requirement of cane needs attention. To enhance the crushing period, there is a necessity of identification and cultivation of short, medium and long duration varieties. A scientific approach on season of planting so as to enhance the period of cane availability is essential.

#### a) Climatic requirements and ideal planting time

The climate of Goa is characterized by the warm and humid conditions during most part of the year. Since Goa does not enjoy a cool and dry climate due to its proximity to the sea, the crop usually matures between December to March, depending on the time of planting. Sugarcane in Goa can be planted between December to March but the most ideal period is between January - February. In no case the planting should be delayed beyond March as this will result in inadequate fertilization and subsequently lower yields.

Field experiments conducted at ICAR Research Complex, Old Goa have resulted in following research findings.

1. February planting of sugarcane recorded highest cane sugar yield (8.88t/ha) and differed significantly from March

/April planting. Similarly delay in planting from February to April was found to significantly reduce the millable cane number from 94,173/ha to 52,347/ha clearly suggesting the advantage of early planting with more tillers.

2. The cane height was also found to reduce from 3.06 m to 2.92 m with delayed planting /harvesting. Although no definite trend was observed as regards cane girth (2.46 to 2.40 cm), the delay in planting was found to significantly enhance the inter-nodal length in all the varieties (11.9 to 12.1cm). Weight of the cane was found to enhance with early planting (1.70 kg/cane). In general, early planting in February was found to favour more number of internodes in cane (27.3/ cane) as compared to late planting or harvesting for ratoon (26.3/cane).
3. The cane yield recorded was significantly lower with delay in planting / harvesting time (from 113.3 t/ha with February planting to 88.5 t/ha with April planting) clearly suggesting the advantage of early planting to harness higher yield potential of the crop.
4. The sugar yield has a positive correlation with the stalk yield and the stalk yield has a positive correlation with number

of stalks, one stalk weight, retention of one stalk weight and stalk length. Therefore as the number of stalks increases and one stalk weight is retained, the stalks yield increases.

5. The brix and Pol content of cane juice was found to improve with delay in cane planting / harvesting from February to April. Highest brix content of 22.3 per cent was observed under April planting / harvesting which also recorded higher Pol content (17.7 %). The purity of cane juice was found to improve with delay in planting / harvesting especially with April planting and further, the recovery per cent was found to improve with delaying the planting / harvesting for ratoon upto March and remained constant thereafter.
6. The better recovery in March and April planted crop may be due to better solar radiation use efficiency during summer months. The highest recovery of 9.70 per cent was observed when the crop was planted or harvested for ratoon during April. It was followed by April planting / harvesting.

Thus, it was concluded that to coincide ripening period with December-January which is more ideal for sugar accumulation in Goa, February planting is ideal keeping in view overall the yield and the recovery.

### **b) Soil requirements**

Sugarcane once planted remains in the field for 2-3 years (including subsequent ratoons). This results in heavy extraction of plant nutrients. Therefore selection of an ideal soil is very crucial for getting consistent

yields. Very often gradual yield reduction is attributed to the poor condition and wrong selection of land (soil). The soils selected for sugarcane should be with good drainage, organic matter content and water holding capacity atleast to a depth of 0.5 m. The pH of soil should be between 6.5 to 8. If the soils are saline or water logged, they have to be amended by applying gypsum, sulphur and organic matter. The soils should not be too shallow with hard pans as the roots will not penetrate deep, resulting in lodging and earthing up will become difficult. It is always desirable to get soils tested for NPK status especially in new areas. Depending on the soil test reports, fertilizer dosage should be worked out and soil physical condition should be improved by use of organic manures, biofertilizers, addition of soil amendments, green manuring and following crop rotations, inter cropping etc.

### **c) Land preparation**

Proper land preparation is very essential for good establishment and vigorous growth of the crop. Plough the field to a depth of 1.5 to 2 foot deep with the help of a tractor and expose it to hot sun for about a fortnight. Thereafter, crush the soil clumps so as to make it soft and friable. Then apply 25 cart loads of well decomposed cow dung manure or compost / ha and cross plough the field in opposite direction to the first ploughing to a depth of 30-50 cm. This will incorporate the manure into the soil. Then level the field to facilitate irrigation. After this, open the furrows with the help of a tractor drawn ridger at a distance of 90 cm. It has been observed that if the direction of the furrows is kept facing East-West, the crop grows luxuriantly and results in better sugar accumulation. Then the field is

laid out in convenient plots depending on the slope of the land by bunding and providing irrigation channels. The length of rows may vary depending upon slope.

Before planting the setts, another 25 cart loads of compost/cow dung manure along with the basal dose of fertilizers (250 kg N 125 kg P<sub>2</sub>O<sub>5</sub> and 150 kg K<sub>2</sub>O) is applied in the furrows at a depth of 10-12cm and the fertilizer is mixed by light digging before planting. It should be remembered that addition of sufficient quantities of organic manures will not only improve the physical condition of soil but also increase the water retention capacity and such soils can withstand intermittent drought conditions or slight water stress. Soils rich in organic matter content give higher yields and quality cane.

#### d) Selection of suitable variety

This is one of the major factors which have direct bearing on the yield of sugarcane. While selecting any variety for planting, due attention ought to be paid to know details such as yield potential of the variety, tolerance to diseases like grassy shoot and 'whip smut', its tolerance to withstand water stress, etc. To enhance more sugar production in Goa, maximum area should be covered with high yielding and high sugar content varieties with multiple pest tolerance.

A number of varieties have been evaluated for their suitability at ICAR Research Complex for Goa. Results of earlier trials indicated a high yielding midlate variety viz. Co-7527 which has yielded 150 Mt/ha as plant cane and 100 Mt/ha as ratoon. Popularization of this variety

**Table 1. Suitable sugarcane varieties and their characteristics**

Variety	Duration (months)	Yield Potential (t/ha)	Recovery (%)	Special Features
Co- 740	11-12	70-80	8.00-9.00	Good ratooner, susceptible to pest and diseases
Co- 85002	10-11	120-130	8.00-8.5	High yielding, thick erect canes with partially hallow pith.
Co- 86032	11-12	90-100	9.0-9.5	High yielding, better recovery with consistency in ratoon performance
Co- 8014	11-12	90-100	8.5-9.0	Good ratooner and consistence in performance
CoC- 671	10-11	90-100	9.5-10.0	High tonnage with high recovery, good for plant cane only
SNK-707	10-11	90-100	9.0-10.0	Drought tolerant and early
Co-7527	10--11	100-120	8.5-9.0	High yielding as plant cane
SNK- 632	10--11	120-140	8.0-8.5	Drought tolerant and early, stout canes with early side tillers
SNK-49	10-11	100-120	9.0-10.0	White wooly aphid tolerant

and its rapid multiplication and use would go a long way to increase the present production. Co- 85002 is another such variety suitable to Goa conditions with yield of 120-130 t/ha but the sugar recovery of the variety is only 8.3 per cent. Further studies made to recommend suitable replacement for Co-740 indicated that an early duration variety CoC-671 is better both for higher yield and better recovery especially



type of setts for planting and subjecting them to various treatments before planting is the key to healthy crop. Always remember to change the seed after three years. Select healthy and fresh setts from specially maintained seed nurseries. Ensure following while selecting setts:



*Different views of Co-86032, a high yielding variety suitable for Goa*

as a plant cane. Another variety Co-86032 is a midlate variety which is popular in Maharashtra (with coverage of nearly 42 % of the area) was found to be more consistent both for plant cane and ratoons with an average yield of 92.8 t/ha and sugar recovery of 9.95%. Efforts should be made to popularize this variety in Goa and bring maximum area under cultivation.

### **e) Selection of setts and treatment**

This is one aspect which is grossly neglected by the cane growers. Selection of the right

- The setts should be selected from 10-11 month old, disease free crop.
- Select thick, fresh and tender setts.
- The eye buds should be prominent but not over mature.
- If setts are brought from distance place, it is advisable to bring it with leaves intact to avoid drying of cane.



*A stout erect cane variety with resistance to lodging*



*High yielding white woolly aphid tolerant sugarcane variety.*

## A. Setts treatment

1. Cut the cane with sharp knife. Occasionally disinfect the knife with 2% phenol solution.
2. Dip the setts in 1.2% solution of Carbendizim (50g Bavistin in 100 litres water) for 20-30 minutes before planting. Add 1 kg lime to this solution to enhance germination.
3. If the setts are brought from long distance or if they have become stale or have dried up, dip them for 24 hours in a solution containing 500g lime in 200 litres of water. This will help to revive the buds. The treatment with Bavistin can follow later.
4. If the setts are infested with scale insects, mealy bugs or white flies, then add 265 ml of 30% Dimethoate in 100 liters of water and dip the setts for 3-5 minutes before planting.
5. In order to ensure uniform germination and healthy growth of sprouts, it is advisable to treat the setts finally with bacterial culture like *Trichoderma* / *Azospirillum* / *Azotobacter* or 'Bactin' developed by Vasantdada Sugar Institute, Pune. To ensure this, dry the treated setts for 4-6 hours in shade. Make slurry by mixing 10 kg Bactin with 3-4 baskets of cow dung or fine soil in 100 litres of water. Dip the setts in this slurry and then plant.
6. Wherever a facility for hot water treatment is available, the setts should be treated for 2 hours at 50°C in hot water to check the chronic diseases like grassy shoot and smut. In lieu of this,

follow all the sett treatments detailed above.

## B. Sett selection : The following types of setts can be used for planting:

**Three budded setts:** - This is the most popular and conventional type of setts used by growers. About 30,000 three budded setts are required to plant one ha area by placing these setts end to end in furrows (90 cm wide). While planting, care should be taken to ensure that one central eye bud is facing upwards whereas the other two eye buds are placed sideways.

**Two budded setts:** - These types of setts are suited for "paired row" planting. The setts having two eye buds and setts are planted at a distance of 22-30 cm in furrows.

**One budded setts:** - The knife used for making one eye budded setts should be sharp. To make such setts, sharp vertical cut is given leaving 2-3 cm distance on each side of the eye bud so that the length of the sett below eye bud remain 8-9 cm. These setts are to be planted in irrigated furrows 2-3 cm deep at a distance of 22 cm in sandy soils and 30 cm in clayey soils. Avoid dry planting. If the setts are planted at 30 cm distance, 11-12 thousand one budded setts are required to plant one hectare. If the setts are planted at 45 cm, 8,000 one budded setts are required for one hectare.

Care to be taken while using one eye bud setts

- 1) Always follow wet planting especially after January planting.
- 2) Take adequate care to treat the setts against scale insects, mealy bugs, stem borer, termites, etc.

- 3) Follow treatment with bacterial culture to enable the roots to be active and go deep to face drought.
- 4) Ensure adequate irrigation especially during first month at an interval of 8-10 days.
- 5) Gaps noticed in the field should invariably be filled by providing additional seedlings raised separately.

#### Advantage of one eye bud setts

1. About 40-60% reduction in seed requirement and cost.
2. Reduction in transportation cost.
3. Planting is fast.
4. Increased yield.
5. Facilitates fertilizer application and plant protection.

#### Tissue culture plantlets for seed multiplication

To multiply a high yielding selected variety for large scale use as setts, it is advisable to use tissue culture as the seed multiplication ratio is 1:25 because of high tillering. Further, it is possible to get a disease free material with uniform high vigour.

#### f) Planting

Both wet method and dry method of planting can be adopted for growing cane. Wet planting is mostly done in low to medium fertile soils. In this method, the furrows are thoroughly irrigated and treated setts are placed 3-5 cm deep ensuring that all the eye buds face upwards. The simple technique is to place the thumb on the middle bud and press the sett in the wet furrow ensuring that the other two buds remain sideways facing upwards. In the highly fertile soils, dry method of planting can be adopted. The setts are planted in dry furrows at specified distances (end to end in case of 3 budded, 22 to 30 cm in case of 2 budded and 30-45 cm in case of one budded



*VSI 434- A promising high yielding tissue cultured variety*

setts as described before) and covered with soil up to half the depth of furrow and field is then irrigated. Subsequent earthing-up operations during top dressing of fertilizers in the ridges becoming furrows which serve as irrigation channels.

### **g) Fertilizer application**

Sugarcane is a heavy feeder, since the crop remains in the field for about a year. It requires sufficient nutrition at various stages of its growth. The cane quality and yield is decided on the time, method of application and quantity of fertilizer applied. Fertilizers are expensive inputs and judicious use of this input becomes imperative. Sugarcane requires 250 kg N, 125 kg  $P_2O_5$  and 150 kg  $K_2O$ /ha under local conditions. However, the exact quantities of fertilizers to be applied to a particular field are decided on the basis of soil test report. Table 2 gives the quantity of different fertilizers locally available and the time of their application/ha. The farmers can choose from either straight fertilizers (NPK) or complex fertilizers i.e. Suphala

and Uramphos as per their local availability. The fertilizers are placed below the setts and while top dressing they should be placed 8-10 cm away from rows and 6-8 cm deep in the soil and earthed up. The field should be irrigated on the next day. Application of Zinc to sugarcane has found to influence sugarcane yields. Experiments conducted at ICAR Research Complex have shown that application of 10 kg  $ZnSO_4$  / ha along with 300:150:150 kg NPK/ha recorded more cane height, weight, girth and yield. It resulted in about 9-12 per cent increase in yield over the control. It is advisable to use Phosphate Solubilizing Bacteria (PSB) Culture along with organic manure/ compost @ 10 kg/ha for optimizing phosphorus uptake.

### **h) Irrigation**

This is one of the most important aspects of sugarcane cultivation for realizing higher productivity. The utility of water will be enhanced if the soil is rich in organic content. Water is a valuable commodity and its use should be made in a most appropriate manner.



*Tissue culture plantlet ready for planting*

**Table 2. Quantity of individual fertilizers (kg/ha) and the time of their application to meet recommended dosage (250 kg N:125 kg P<sub>2</sub>O<sub>5</sub>:150 kg K<sub>2</sub>O /ha)**

Sl. No.	Time of application	Straight Fertilizers (NPK)			Complex Fertilizers					
		Urea	Muss-orie-phos	Muriate of potash	15:15:15			18:46:0		
					Suph-ala	Urea	Muri-ate of Potash	Sama-rth	Urea	Muri-ate of potash
1	Basal dose (at planting)	55	625	125	427	----	----	272	----	112
2	Second dose (45 days after planting)	165	----	----	----	175	----	----	146	----
3	Third dose (90days after planting)	165	----	----	205	50	----	----	146	----
4	Last dose (135days after planting before monsoon)	165	-----	125	205	50	42	-----	146	113
Total (per ha)		550	625	250	837	275	42	272	438	225
Total dose/acre		220	250	100	335	110	17	109	175	90

Moisture conservation methods like addition of adequate quantities of organic manure to soil and trash mulching of top soil @ 15 tonne/ha helps in conserving soil moisture.

In general, sugarcane requires 120 to 140 acre inches of water including the rain water. In sandy loam soils, irrigate the channels and then take up planting. In clay soils, plant the setts first and then irrigate. During germination period (30-40 days), irrigate at 10-12 days interval at 5 cm depth. During

tillering stage, the frequency of irrigation may be 8-10 days. In Goa, for a February planted crop, irrigation is to be given at an interval of 8-10 days till May, depending on soil type. In all, 12 to 14 irrigations are required till monsoon sets in. From October to December, 5-6 irrigations at an interval of 12-15 days may be given. In all about 18-20 irrigations are sufficient to raise a healthy crop. However, the following techniques would help in economizing frequent use of water:

1. Addition of organic manure @ 50 cartloads/ha.
  2. Spreading sugarcane trash as soil mulch @ 15 t/ha.
  3. Giving irrigations through alternate furrows.
  4. Adopting paired row method for planting cane late.
  5. Installing watersaving modern irrigation systems such as sprinkler, drip or biwall.
- Drip irrigation recorded significantly higher water use efficiency (1.66 t/ha.cm) as compared to furrow irrigation (1.15 t/ha.cm).
  - In both the methods, the WUE decreased as the frequency of irrigation increased. Initial investment was higher in drip system owing to higher fixed cost incurred in installation of drip system.
  - The gross returns were also higher (Rs.78,450/ha) in drip system in comparison to furrow system (Rs. 72,680/ha).

### **Drip irrigation in sugarcane:**

Drip irrigation is found to be the most efficient method to irrigate sugarcane. Experiments revealed that sugarcane requires a mean total of 73 cm of irrigation water. However, to supply this in furrow irrigation an additional 30 cm is required which is 41 per cent of the net irrigation requirement. Studies conducted at ICAR Research Complex for Goa, Old Goa on comparison of drip system with furrow irrigation for three years with one plant cane and two ratoons indicated that

- Although there was no significant difference between drip and furrow irrigation methods for cane yield and C.C.S, irrigation at IW/CPE ratio of 0.75 recorded significantly higher cane yield and C.C.S over other levels.
- The savings in irrigation water was nearly 41 per cent in drip system with a potential to irrigate an additional area of 0.53 ha of sugarcane.



*Aligning laterals and drippers in sugarcane is crucial for enhanced efficiency of drip system*

**Table 3. Economics of irrigation treatments in sugarcane**

Particulars	Drip method IW/CPE ratio				Furrow method IW/CPE ratio			
	0.50	0.75	1.00	Mean	0.50	0.75	1.00	Mean
Fixed cost (Rs/ha)	11 940	11 940	11 940	11 940	2 630	2 630	2 630	2 630
Variable cost (Rs/ha)	7 491	8 091	8 844	8 141	7 676	8 366	9 211	8 418
Total cost (Rs/ha)	19 431	20 031	20 781	20 081	10 306	10 996	11 841	11 048
Cane yield (t/ha)	105.98	126.64	129.46	120.69	103.74	113.80	117.92	111.82
Gross income (Rs/ha)	68 887	82 316	84 149	78 449	67 431	73 970	76 648	72 683
Net income (Rs/ha)	49 456	62 285	63 368	58 368	57 125	62 974	64 807	61 635
Savings in water (%)	52.7	29.1	5.4	29.07	-	-	-	-
Additional area irrigated (ha)	1.11	0.53	0.06	0.53	-	-	-	-
Additional net income from additional area (Rs/ha)	54 896	25 527	3 802	28 078	-	-	-	-
Total net income (Rs/ha)	104352	87 822	67 170	86 448	57 125	62 974	64 807	61 635
Total extra income (Rs)	42 717	26 187	5 525	24 813	-	-	-	-
Income /mm of water used	89.9	36.75	5.83	44.16	-	-	-	-

- With the additional net returns from additional area irrigated through drip system, the total net returns were estimated at Rs. 61,630/ha.

#### **i) Interculture**

Sugarcane setts begin to germinate after 30-40 days of planting. Wherever the buds have not germinated, or show grassy shoot

disease symptoms, germinated setts should be gap filled/planted. This can be ensured by providing additional area along the bunds for meeting such eventualities. Poly bag technique of raising seedlings from one eye bud sett will also help.

After a week of germination, hoeing is done in order to remove first flush of weeds. The soil is loosened enhancing good aeration. As the crop grows 6 weeks old, first split dose of fertilizer is given 8-10 cm away from rows and 5-10 cm deep and this is followed by light earthing up. Subsequent top dressing with fertilizers is given at 90 days and 135 days and finally heavy earthing up is given before onset of monsoon so as to give a better anchorage to the cane clump to avoid lodging.

Intercultural operations within the rows are not done adequately in Goa for want of appropriate bullock drawn implements. Implements like Ankush plough, Jamboo ridger etc., are low cost high utility implements which ensures adequate hoeing, breaking of ridges, digging the inter row spaces and earthing up. These implements should be popularised.

During October-November with the cessation of rainfall, the lower dried leaves of sugarcane should be stripped off and spread over inter row spaces and irrigation channels as a soil mulch to conserve soil moisture especially in early stages of crop and ratoons. The observations made ICAR Research Complex for Goa, Old Goa on the impact of trash mulch are very encouraging not only to conserve moisture but also to suppress weed growth inturn enhancing the cane growth substantially.

## **j) Weeding**

Due to the slow initial growth of crop, the irrigation channels as well as ridges and inter row spaces get infested with variety of narrow and broad leaved weeds which pose a serious problem to cane growers, causing losses up to 60-70 per cent in neglected fields. The initial period of 2-3 months of the crop (depending on the variety) is very crucial for control of weeds. Use of sugarcane trash mulching is very effective in controlling weeds. The weeds are either manually removed during hoeing or are killed by use of herbicides. For narrow leaved weeds and grasses, spray 2 kg Atrazine dissolved in 100 litres of water, 4-5 days after planting when there is enough moisture in the soil. In case of heavy infestation, give second spray after 4-5 weeks. For controlling broad leaved weeds chemically, use 1.75 kg 2, 4-D after the emergence directing the spray on weeds.

Use of chemical weedicides should be done in the morning or evening. The operator should walk in reverse direction to avoid trampling of the sprayed area. While spraying all the bunds, channels, ridges etc. should be adequately covered with herbicidal spray.

## **k) Intercropping**

Since a space of 90 cm is available in between two rows of sugarcane and the initial growth of sugarcane is slow, two rows of inter crops at a spacing of 30 cm each from either side or one row at 45 cm (depending on crop selected) can be sown one week after planting sugarcane. Intercropping also helps in reducing the growth of weeds and their competition during early growth period of cane. The inter row spaces can be put into use for sowing short duration



*Intercropping high yielding french bean in 2: 1 ratio is more remunerative*

crops like soybean, groundnut, french bean, cowpea, black gram, green gram onion, raddish, bhendi, etc. Research conducted in this direction has indicated that by growing these crops as intercrop in sugarcane, the net income from the combination is more than that of sugarcane crop alone. Research results has further shown that french bean intercropping yields 8.6 quintals of fresh beans/ha in two and half months period. Use of intercrops like pulses, groundnut, soybean etc., also help to improve soil nutrient status due to their root nodules which harbour beneficial soil bacterium *Rhizobium* that helps in fixing atmospheric nitrogen from air into the soil. Intercropping further helps in better utilization of land, water, nutrients and other resources.

### **Integration of sugarcane with other enterprises**

Compared to monocropping of sugarcane, it is always advisable to integrate with beneficial allied agricultural activities like dairying which not only adds additional returns to the grower but also makes it available the valuable manure for application to the cane so as to sustain the soil fertility and the

returns in the long run.

Sugarcane tops which are low in sugars can be fed to dairy animals as fodder. The cowdung of the dairy animals can be recycled through a bio-gas plant for fuel requirement of the household and the slurry for application to field. Cow dung manure available in the system can be used for cane production. Further, the large quantities of sugarcane trash available in the system can be composted through vermiculture using cowdung.

### **1) Pests and diseases of sugarcane**

Sugarcane in Goa is infested by following pests and diseases. Their nature of damage and control measures are suggested below:

#### **1. Sugarcane Woolly Aphid:**

Sugarcane woolly aphid is a foliage sucking pest. Woolly aphid earlier was known to be minor pest in India but has now assumed the status of economic pest after its severe outbreak in Maharashtra during July 2002. It feeds on sugarcane by inserting their stylets through the stomata of the plant leaves. Both nymphs and adults suck the cell sap from



*A view of woolly aphid incidence in sugarcane*



**Shoot borer-a pest of sugarcane causing total drying of shoot**

lower surface of leaves. They suck the sap from phloem. They excrete large amount of honey dew which falls on the leaves giving them a sticky coating on which black sooty mould (*Capnodium* sp.) develops making the leaves look all black. Due to the thick coating of sooty mould process of photosynthesis is significantly hampered in severely infested plants, thereby causing considerable reduction in cane yield (25%) and sucrose content (26.71%), whereas, during the early growth period plants may die.

### **Control**

1. Use of woolly aphid tolerant varieties suitable for Goa region such as SNK-49 and SNK-61.
2. Soil application of Phorate 10G @ 10 kg or Carbofuron 3G @ 30 kg /ha in infested crop not more than six months old. The granule should be applied with due precautions, along the row side at the base of the plant followed by light irrigation, if required.
3. Foliar application of Dimethoate 30 EC @ 0.05%, Metasystox 25 EC @

0.04%, Acephate 75 SP @ 0.1% and Endosulphan 35 EC @0.05%.

### **2. Early shoot borer**

This insect pest can cause up to 30 per cent losses in sugarcane crop. Under Goa conditions, this pest is noticed from March to May. Hot climatic conditions and low humidity are the predisposing factors for spread of this pest. The female lays eggs in rows in straight lines on the under surface of leaves. The larvae after hatching bore a hole into the growing cane near to the soil surface and feeds on tender portion. This results in death of the central shoot by gradual drying.

### **Control**

1. Destroy all infested shoots.
2. Spray the crop with 35 per cent Endosulfan by mixing 14 ml in 10 litres of water 3-4 weeks after germination or spray 50 per cent BHC @ 3 kg in 500 litre water twice at an interval of 10 days, or

3. Apply in furrows, 6% Gamma BHC (Lindane) @ 16 kg/ha and irrigate. This will also control termites.
4. Avoid late planting of cane.
5. Do adequate hoeing.
6. Release of biological control agents such as *Trichogramma* eggs @ 5 lakh/ha or spray with 300 larvae infested with granulosis virus in 250 litres water.

### 3. Stem borer

The stalk borer in advanced stage infests the sugarcane crop as stem borer. This pest is found during tillering stage and beyond and it makes holes in the cane and feeds on inner contents. These holes are concealed under the dry leaves. The incidence of this pest is favoured by hot weather from February to May.

**Control:** Adequate control of early shoot borer will ensure crop free of this pest.

### 4. Scale insect

This pest infests the cane when the tillers start maturing. The nymphs and adults stick on the outer surface of cane and suck the sap, thus devitalizing the plant. The crop remains stunted and dries up. The spread of this pest is through infested setts, air and ants. This pest is more pronounced in ratoon crop. It causes 30-35 per cent weight loss and 2 to 3 cent reduction in sugar recovery in heavily infested crop. Use of infested setts for planting, neglected ratoon, poor soil, water scarcity and drought in summer are some of the predisposing factors.

### Control

1. Do not use infested setts for planting.
2. Infested cane should be harvested early and the trash burnt. No ratoon is advisable from such crop.
3. Plough the field immediately, collect stubbles and burn them.
4. Provide adequate irrigation.
5. Treat the setts with 30% Dimethoate (Rogor) @ 265 ml or 85% Phosphomidon @ 80 ml or 50% Malathion @ 300 ml in 100 litres of water by dipping the setts for 3-4 minutes before planting.
6. Use granular Phorate @ 10 kg/ha when tillering is over.

### 5. Termites

This insect pest damages the crop at two stages. Once when the setts are planted, when the worker class of termites feed on the tender eye bud resulting in poor germination. They also feed on cut ends of setts and cause germination losses. Later on when the cane is fully grown, they feed around basal portion as well as cane portion near ground. Their feeding results in drying of cane.

### Control

1. Locate the termetoria to locate the queen and destroy it.
2. Apply 20% Gama BHC 5 litres in 1,000 litres water in furrows.

In addition to above, the sugarcane is also infested by sap sucking insect pests such as white flies and mealy bugs. These can be controlled by spraying any systemic insecticide.



*Grassy shoot- a common problem in ratoons*

## **6. Rats**

A rat causes damage not only to sugarcane but many other crops. Burrowing of rats into water channel causes loss of water. The rats due to their gnawing habit causes 10% more damage to cane than by eating it. The site of damage is near the joints where the cane is hard. Their damage causes cane to dry and lose weight. Lodging of cane is many times attributed to burrowing of rats near the base.

**Control:** Identify the live burrows on bunds

and in the fields. Baiting is necessary if Zinc Phosphide is used.

More recently, ready to use rodenticide, Bromdiolone 0.005% (Moosh Moosh) or rattol is found to be an effective rat killer. Place 1-2 cakes in each live burrow along bunds, 2-4 weeks after planting. Cakes are also distributed in field after earthing up at 10-15 m interval. About 30-50 cakes are required for one acre. The rodent control work should be done on a collective basis rather than individually.

## 7. Wild boars

This is also a menace to sugarcane growers. This can be kept away by having battery operated fencing.

## Diseases

Two major diseases infest sugarcane crop in Goa.

### 1. Grassy shoot

This is a mycoplasma disease which is on a rise in Goa. A large number of lean and lanky pale sprouts appear in the clumps like "Bunchy grass". The normal stalk (cane) is not formed and the incidence of this disease is more in ratoon crop. This disease is transmitted through setts.

#### Control

1. Select healthy setts for planting. Setts from diseased field should be avoided.
2. Uproot and destroy infested clumps by burning as soon as disease is noticed.
3. Treat the setts in hot water at 50° C for 2 hours.
4. Dip the setts in a solution containing 50 g Bavistin in 100 litres of water 20-30 minutes before planting.

### 2. Whip smut :

This is a fungal disease infesting sugarcane crop. The growing point projects a long black whip like structure covered with black spores. Affected plants have slender cane and quality is destroyed. The whip is covered with silvery membrane which if ruptured, gives out black powdery mass of spores which is spread through wind, water or soil.

## Control

1. Locate infested clumps and destroy them.
2. Select healthy setts for planting.
3. Follow sett treatment as suggested for grassy shoot disease.

### m) Harvesting

Sugarcane is ready for harvest in about 11-12 months after planting depending on the variety and the season. The mature cane is yellowish with prominent eye buds, giving a metallic sound if tapped with fingers. Similarly, it breaks at nodes if bent. But, the better indicator for determining the maturity is the brix reading taken with hand refractometer. If the reading shows 19 and above, the cane is mature and ready for harvest. The stand of subsequent ratoon crop depends on the correct manner of harvesting. The cane should be cut as close to the ground level as possible with the help of a sharp knife. Care should be taken to give a horizontal smooth cut without damaging the eye bud below the soil. If the cane is harvested above the ground, the yield is reduced, sugar is lost in the lower portion (as the lower portion contains more sugars) and there is lodging as well as poor tillering in the ratoon, since the buds sprout from above the ground and have no support. On the other hand, if the cane is cut below the ground, the lower eye bud is damaged and this badly affects germination. Use of improved 'Vikas' knife developed by Vasantdada Sugar Institute cuts the cane at right place with ease and gives a smooth cut thus avoiding the trouble of stubble shaving operation for ratoon crop.

## IV. Ratoon management

In Goa, 65-70 per cent of area under sugarcane is retained as ratoon crop. Ratooning offers many advantages in the economy of cultivation since it saves the cost on procurement and preparation of setts, land preparation, planting, etc. The productivity and quality of ratoon crop in Goa are very poor since most of the ratoons are neglected or subjected to mismanagement. The productivity of ratoon can be upgraded to the level of plant crop or even better, provided sound ratoon management practices are followed by cane growers.

The following steps are suggested for ratoon management:

- a) **Harvesting:** Follow proper harvesting as suggested above.
- b) **Collection of trash:** All the trash and dry leaves may be collected and used for mulching.

c) **Shoulder breaking:** This is an operation wherein the ridges formed are dismantled with the help of improved implement like 'Ankush plough' or Kirloskar No. 100 plough. The soil around the clump is then dug to make it loose. The furrows and interrow spaces are also dug with shovel tooth cultivator to make the soil loose. This operations result in destroying all the top dead and useless roots which decay in soil. It also facilitates development of new roots. The effective roots penetrate deep to draw more water and nutrients.

d) **Gap filling:** It is a very important operation in order to ensure adequate plant population. All the gaps noticed in the field should be promptly filled

**Table 4. Quantity of individual fertilizers (kg/ha) and the time of their application to meet recommended dosage (300 kg N:125 kg P<sub>2</sub>O<sub>5</sub>:150 kg K<sub>2</sub>O /ha) in a ratoon crop of sugarcane**

Sr. No.	Time of application	Urea (kg)	MussoriePhos (kg)	MOP (kg)
1)	Before first irrigation (within 10-12 days of harvesting)	326	625	250
2)	45 days after first irrigation	163	----	----
3)	Before earthing up (after 120-130 days)	163	----	----
		650	625	250

by planting young seedlings raised separately by following polybag technique or other suitable method. Similarly all the diseased clumps should be uprooted and destroyed and fresh planting should be done.

- e) **Fertilizers:** Therequirementofnitrogen is to be kept 20 per cent more than the plant crop i.e. 300kg N/ha (650 kg Urea). The fertilizer is usually given in three doses as shown below:

The fertilizers must be applied 10-12 cm away from the clumps and 12- 15 cm deep. Use of PSB (Phosphate Solubilizing Bacteria) will optimize phosphorus uptake.

- f) **Mulching:** The initial growth of cane being slow, the inter row spaces are exposed to heavy evapo-transpiration during summer months, resulting in drought situation. Therefore, trash (dry leaves) should be used as a mulch @ 15 tonnes/ha to avoid water losses. Mulching also helps to smother the weeds which eat away nutrients.

- g) **Weeding:** Suitable weed control measures suggested for plant cane may be followed.

- h) **Tying of sugarcane:** This operation is very essential to avoid losses from cane at maturity especially when the variety planted is susceptible to lodging or the tillering has started at level higher than the soil surface resulting in poor anchorage. The individual canes may be supported by tying with neighbouring canes as well with adjacent clumps.

- i) **Intercropping:** Various short duration crops can be grown during initial four months to get additional returns as discussed earlier.

- j) **Plant protection:** Ratoon crop is mostly subjected to early attack of shoot borer and diseases like grassy shoot and smut. Suitable protective measures should be adopted as described above to keep the field free from diseases and pests.

## V. References

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# ANNEXURE

## COST OF CULTIVATION OF NEWLY PLANTED SUGARCANE PER HECTARE IN GOA (Estimated)

Sl.No.	Particulars	Amount in Rs.
1	Land preparation/Tillage@Rs3000/acre	7,500.00
2	Cost of Seed material/Planting	
	a)30000(3 eyes bud) no. @ Rs.430/-per thousand setts	12,900.00
	b) Labour for planting, cutting and seed treatment. 25 labour days X Rs.157/-	3,925.00
	c)Seed treatment(Bavistin+Malathion)	525.00
3	Manures and fertilizers	
	a) Organic manure / compost	5,000.00
	b) Inorganic Fertilizers	
	Rock Phosphate	1,940.00
	Urea +	2,760.00
	10:26:26 +	4,030.00
	MOP	1,230.00
4	Weeding	
	a) Chemical weed control inclusive of cost of weedicides and spraying charges.	3,720.00
5	Earthing up-60 labour days x Rs.157	9,420.00
6	Irrigation-36 labour days x Rs.157	5,650.00
7	Electricity Charges	2,000.00
8	Watch and ward/Crop protection	2,000.00
9	Miscellaneous Expenses	2,000.00
10	Harvesting cane- 60 mt @ Rs. 350/mt	21,000.00
	Total	85600.00

