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Abstract

This paper is an attempt to estimate the magnitudes of yield gaps, causative factors and constrains for attending greater farm potential in adsali, suru, preseasonal and ratoon sugarcane production in Maharashtra. Primary data were collected from 250 sugarcane cultivators using random sampling technique. Data collected during 2011-2012 were analyzed using the IRRI methodology on yield gaps, multiple linear regression and tabular analysis. Results reveal that the magnitude of yield gap-I was higher, which implies that, the technology developed at research station cannot be duplicated on demonstration plots to exploit the full potential of sugarcane. This gap was attributable to environmental differences and non transferable component of technology. The orthodox practices being followed on farmerâ€™s field lead to yield gap-II .The farmers usually do not adopt a technology as a package but take up individual practices suitably trimmed to fit into their budget and skills (management and operational) which lead to the variation in the adoption of cultural practices and consequently to the yield gaps. The yield gaps cannot be completely eliminated, but can be minimized by efficient and effective resources management.

Keywords: Sugarcane, yield gaps analysis, Adoption technology, Constraints

JEL Code: O13,O32, Q16

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1. Introduction

Sugarcane occupies a very prominent position on the agricultural map of India. Historically origin of Sugarcane Spp. *Saccharum barberi* is India and of *Saccharum officinarum* is New Guinea. Sugarcane is known to be thriving well in Brazil, India, Australia, Cuba, USA, Philippines, USSR and Indonesia. 115 countries of the world cultivate sugarcane and produce about 133 million tonnes of sugar which is three fourth of the total sugar production (169 million tonnes) of the world. Remaining sugar comes from sugar beet (Anonymous 2011). Sugarcane is the sole raw material for the largest agro-processing industry in the rural sector, providing employment to millions of people in the rural sector.

1.1. Sugarcane scenario in India

India ranks second in the world, after Brazil, in terms of area and sugarcane production. In India, sugar industry is the second largest industry next to the textile industry is playing a vital role in the socio-economic transformation of the country. In Australia, about 5 million sugarcane cultivators produces ton of sugar. While in India about 50 million sugar cane farmers and their dependants have been involved in sugar cane cultivation. About 0.5 million skilled and unskilled workers are employed by the sugar industry and additional employment is also generated by the allied industries.

Sugarcane is in great demand for various other uses like fodder, paper production and most importantly bio-fuels. In a typical sugar mill, 100 tonnes of sugarcane on an average produces 10 tonnes of sugar, 4 tonnes of molasses from

which ethanol is produced, 3 tonnes of press mud which is converted into bio-fertilizer, 30 tonnes of bagasse used for cogeneration of power to yield 1,500 KW electricity and for manufacturing paper. Besides, about 30 tonnes of cane tops and leaves are generally left in the field, which through recycling further add to the economic value of the crop (Anonymous, 2009).

In India, there are two distinct zones for sugarcane cultivation, tropical-south and subtropical north. Subtropical north while comprising 60 per cent of total cane area contributes only 48 per cent to total cane and 37 per cent to total white sugar production in the country. The lower cane productivity and sugar recovery in subtropical north zone is the main cause of variation between the zones. The average cane productivity in subtropical north zone was 54.7 tonnes/ha and 56.4 tonnes/ha in comparison to 81.9 tonnes/ha and 80.8 tonnes/ha in tropical south zone (2009-10 and 2010-11) (Anonymous 2011).

In India, sugarcane has second place in acreage and production of sugarcane in the world's sugar economy. Area, production and productivity of sugarcane in India from 1960-61 and 2011-12 are shown in table 1.1.

Table 1.1: Area, Production and Productivity of sugarcane in India

Year	Area (000 ha)	Production (000tonnes)	Productivity (tonnes/ha)
1960-61	2415 (100)	110544 (100)	45.50 (100)
1970-71	2615 (8.28)	126368 (14.31)	48.30 (6.15)
1980-81	2667 (10.43)	154248 (39.54)	57.80 (27.03)
1990-91	3686 (52.63)	241045 (118.05)	65.4 (43.74)
2000-01	4316 (78.72)	295956 (167.73)	68.6 (50.77)
2010-11	4885 (102.28)	342382 (209.72)	71.00 (56.04)
2011-12	5081 (110.39)	347870 (214.69)	68.46 (50.47)

[Source: Ministry of Agriculture, Government of India]
[Note: Figures in the parenthesis indicates percentage increase over the base year 1960-61]

It evident from the table that, area allocation for sugarcane crop and its total production have been increased by 110.39% and 214.69 % respectively during the period from 1960-61 to 2011-12. The period from 1960-61 to 2011-12 was characterized by marginal fluctuations in the area and production of sugarcane. The production of sugarcane increased continuously from 1960-61 to 2011-12.This continuous increase in production was primarily attributed to the area expansion and not to the productivity improvement. The decreasing trend in the productivity of sugarcane was noticed during recent years. The productivity of sugarcane was decreased to 68.46 tonnes/ha during 2011-12.

The important reasons for declining productivity of sugarcane are as follows:

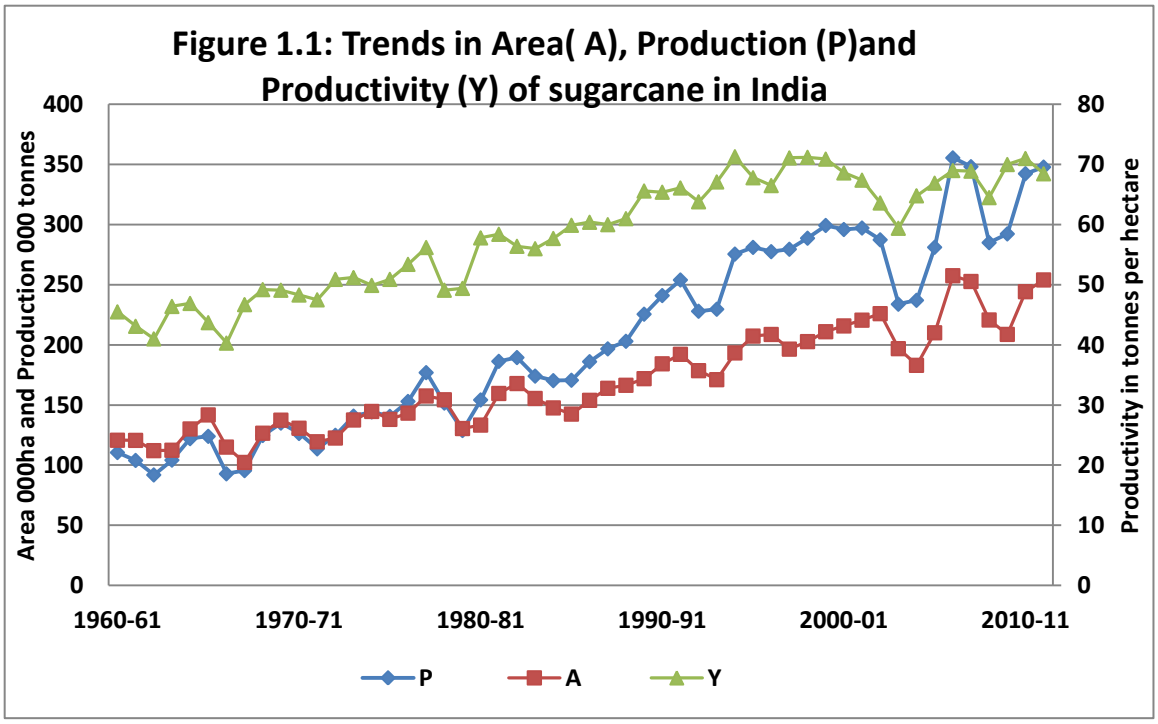
1. Inadequate availability of quality seed material.
2. No proper adoption of high yielding and high sugared varieties.
3. Inadequate irrigation facilities and poor water management
4. Poor drainage and ill – health of the soil.
5. Lack of adequate and timely application of manures and fertilizers.
6. Inadequate farm mechanization in major farm operations
7. Inadequate efforts to control insects, diseases and weeds
8. Negligence to ratoon crop
9. Lack of participation of sugar factories in development activities.
10. Lack of efficient technology transfer mechanism
11. Inadequate farm credit

In future, the above reasons of low sugarcane and sugar productivity will continue in addition to following major problems and limitations:

1. Limitations to increase the area under sugarcane
2. Increasing cost of cultivation
3. Water availability for irrigation
4. Soil fertility deterioration
5. Disturbance of cyclic nature on sugar production
6. Shortage of manpower
7. Shortage of electric power

8. Fragmentation of land
9. Diversion of sugarcane area to other competitive crops

One of notable characteristics of the sugarcane agriculture in India is its inherent instability (Murali *etal* 2012). As may be observed from figure 1.1, area, production and yield exhibits wide fluctuations over the years.



Statewise area, production, productivity of sugarcane and sugar recovery for the year 2011-2012 was given in table 1.2.

Table1.2 Statewise area, production, productivity of sugarcane and sugar recovery (2011-2012)

Particulars		Area ('000' ha)	Sugarcane production ('000' tones)	Productivity (Tones/ha)	Av. Sugar recovery (%)
States	Maharashtra	1022	81991	80.10	11.32
	Uttar Pradesh	2162	122652	59.58	9.16
	Karnataka	430	37991	90.25	11.14
	Tamil Nadu	346.4	36548	102.83	9.35
India		5081	347870	70.31	10.25

[Source: Ministry of Agriculture, Government of India]

In India Uttar Pradesh is the major sugarcane growing state, contributing about 48% of the area and 40% of the production. Other important cane growing states are Karnataka, Maharashtra, Andhra Pradesh, and Tamil Nadu. In terms of productivity Tamil Nadu ranks first with average productivity of about 102.83 tonnes /ha followed by are Karnataka (90.25 tonnes/ha) and Maharashtra (80.10 tonnes/ha) and Uttar Pradesh (59.58 tonnes/ha) against a national average of 70.31 tonnes/ha. In India, Utter Pradesh ranks 1st in area and production of sugarcane and Maharashtra rank 1st in sugar production and sugar recovery (Table1.2).

Sugarcane has provided a unique advantage for better land use through intercropping and increases the input use efficiency by diversifying risk in long duration crop (Anonymous, 2011).

1.2. Sugarcane scenario in Maharashtra

Maharashtra is the highest sugar producing state of India. Maharashtra sugarcane yield in 2011-12 was 80.10 tonnes /ha, much higher compared to the yield of 59.58 tonnes/ha for the second highest sugar producing state Uttar Pradesh and national average of 70.31 tonnes/ha. The average sugar recovery rate of the four sugarcane cultivation types in Maharashtra was 11.32% in 2011-12; the recovery rate of Adsali sugarcane was even higher at 12.3% (Table 1.3). The average recovery percentage of Maharashtra was way above the recovery percentage of Uttar Pradesh at 9.16% and all India percentage of 10.25%. In terms of the land productivity adjusted for recovery rate is even higher for Maharashtra at 98.8 tonnes/ha (161.14 tonnes/ha for Adsali) compared to 61.04 tonnes/ha for Uttar Pradesh (Sandrp 2013).

Of the four sugarcane cultivation types prevalent in Maharashtra, ratoon is most popular with 40% cane area under it, possibly since it has shortest duration of 11 months, fitting almost perfectly with the annual October to March cane crushing season. Same can be said about Suru type, which is having duration of 12 months and coverage of 20%. Adsali type has the highest yield and recovery rate, but has only 10% of the sugarcane area is under cultivation, possibly due to

the longest duration of 17 months. Pre-seasonal type, as the name suggests, is planted about 2.5 months before the season, and stands between Ratoon and Adsali in terms of duration, yield and recovery rate(Sandrp 2013).

Table 1.3 Basic parameters of sugarcane crop in Maharashtra in 2011-12

Particulars	Types				Total/ weighted avg.
	Adsali	Preseasonal	Suru	Ratoon	
% share	10.00	30.00	20.00	40.00	100.00
Production (lakh ton)	122.64	275.94	143.08	276.94	818.60
Yield(ton/ha)	120.00	90.00	70.00	65.00	80.10
% recovery rate	12.30	12.00	11.45	10.50	11.32
Yield adjusted for recovery rate (tonnes/ha)	161.14	117.90	87.50	74.51	98.79
Crop duration in months	17.00	14.50	12.00	11.00	12.85

(Source: Price Policy for Sugarcane: the 2013-14 Sugar season, Commission for Agricultural Costs and Prices, Ministry of Agriculture, Government of India.)

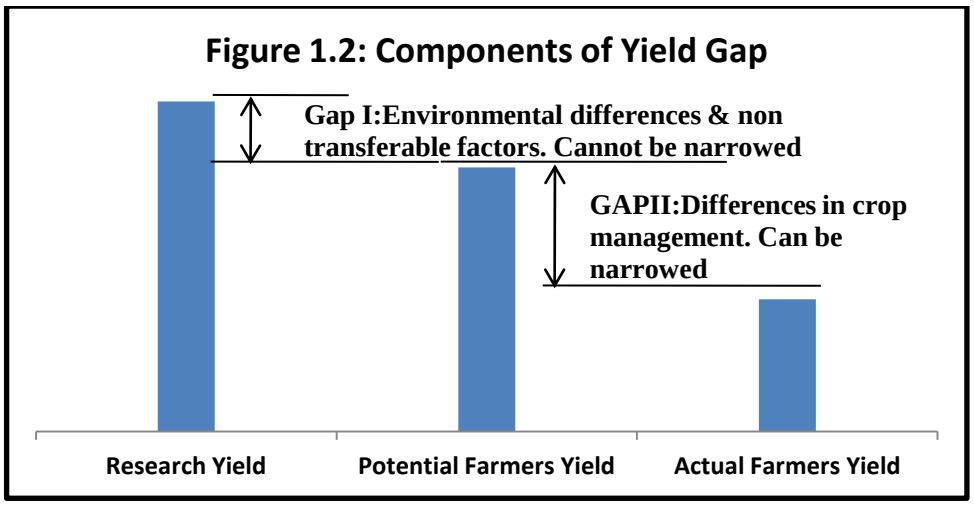
In Maharashtra, area under sugarcane is just 3% of the total cropped area of the state, but it utilises more than 60% of total water available for irrigation in the state, "leading to massive inequity in the use of water within the state" (CACP 2012-2013). The excess use of water through flood irrigation combined with higher doses of fertilizers is observed to be resulting in enhanced rate of degradation of land resources in certain parts of the state. This reflected in declining of sugarcane productivity in recent decade in Maharashtra (Samui *eta*l 2005).

The productivity of the crop primarily depends on the extent of levels of resources use and total management of crop and adoption of recommended technology. The inputs such as labour, planting material, manure, fertilizers, irrigation, plant proportion, weedicide and intercultring operations are the major factors responsible for the yield of the crop. Most of the sugarcane growers are not using the recommended levels of the inputs. Therefore there exists a gap between the recommended and actual use levels of inputs. This leads to a gap between production and productivity of sugarcane.

Technology breakthrough in the field of agriculture has resulted in increased crop productivity. Even through large scale verification trials and demonstration are conducted to test feasibility and suitability of the new technologies before releasing the for adoption on farmers field, but the crop yields realized on farmers field are considerably lower than those recorded on the demonstration plots and research station farms. Several studies show the existence of considerable untapped yield potential in various crops (Ray and Chahal 1986, Madhavswamy and Sheshareddy, 1987 and Choudhary, *etal* 1993), and attribute this gap to difference in the cultural practices and differences in input use levels between the farmer's fields and the demonstration plots. Proper application of inputs at the recommended levels and better management practices are thought of as the solution for improvement in crop productivity on farmers fields (Basavaraja 1988).

1.3.Estimation of yield gaps

The concept of yield gaps in crops originated from different constraint studies carried out by International Rice Research Institute (IRRI) during the seventies. The yield gap comprises at least two components. The first component-yield gap I is the difference between experiment/research station yield (potential yield) and the potential farm yield (fig.1.2). The first of these cannot be narrowed, is not exploitable, and mainly owes to factors that are generally not transferable, such as the environmental conditions and some of the built-in technologies that are available at research stations or experimental farms. It is hypothesized that yield differences exist between the levels obtained at experimental or research station and the potential of the same varieties on farmers fields.



The second component- yield gap II is the difference between the potential farm yield and the actual average farm yield. Alam(2006) and Herdt (1996) provided a similar description of the yield gaps and components. The second component arises when farmer deviates from the recommendation to achieve the agronomic yield potential (Duwayri,*etal* 2000). This yield gap II is exploitable and is the focus of the study.

A large yield gap II implies that farmers did not fully adopt the existing technologies because they were not packaged appropriately or because economic conditions made them unattractive (Pingali and Heisey 1999). A small yield gap, on the other hand, indicates that the available technologies are almost fully used (Nin- pratt ,*etal*).

The yield gap reflects mainly differences in management practices (for example, the amount of fertilizer used, land preparation, time of the year of different practices) under similar agro ecological conditions. For example, the national average yield is not an appropriate indicator of farm-level performance because it is an average across different agro climatic zones, different soil types, different crop ecologies, crop types, and technologies. For this reason, it is important to obtain average yields from homogenous agro ecological conditions, similar to those used to measure potential yields, and also under similar production systems (technologies).

India has exhibited average crop yield of 1040 kg/ha for soybean, has still a yield gap index of 78.79 percent indicating that only 21.21 percent of existing

production potential of soybean is being realized in the country (Bhatia, *etal* 2006, Gaddi 2006).Similar yield gap can be observed for the sugarcane in India and specifically in Maharashtra. Hence, crux of the problem of growth in agriculture as well as sugarcane cultivators is how to increase the output per unit of input and thereby reduce this gap and identify the constraints responsible for adoption of recommended technology for sugarcane cultivation. Therefore, an attempt is made to analyze the trends in Area, Production and Productivity, input use and output levels, magnitude of the gaps, factors contributing to yield gaps and constraints responsible for gaps in sugarcane production in Maharashtra. In this regards the following specific objectives were formulated.

The objectives of the study are as follows:

1. To study the trends in Area, Production and Productivity of sugarcane.
2. To examine the input use and output levels of sugarcane in Maharashtra.
3. To estimate the gap in the use levels of inputs and output of sugarcane in Maharashtra.
4. To identify the factors contributing to yield gap of sugarcane.
5. To identify the constraints in use of the recommended levels of inputs for sugarcane.

The paper is organized in five sections. After this first section on the introduction section II, provides the information on study area, sampling design, analysis methods, data and its sources. In the section III, results and discussion is presented and then concluding observations and suggestions are made in the section IV. The result and discussion section is further divided into following subheads:

a. land use and Cropping pattern of sample cultivators
b. Trends in area, production and productivity
c. Input use and output levels of sugarcane
d. Gaps in the use levels of input and output of sugarcane
e. The factor affecting yield gap

f. Constraints in use of the recommended levels of inputs for sugarcane production.

2. Methodology and Data

2.1. Selection of Area

"Quantification of yield gaps in different planting types of sugarcane in Maharashtra" has been purposively conducted in Maharashtra. The present study was conducted in three main districts in western Maharashtra having major area under sugarcane cultivation; Satara, Pune and Kolhapur. The other reason to select above districts was due to their high sugar recovery level. Satara and Kolhapur districts come under high recovery zone whereas Pune came under medium recovery zone in Maharashtra.

The Karveer, Karad and Baramati tahsils from Kolhapur, Satara and Pune districts, respectively, having maximum area under sugarcane were selected purposively for the present study.

2.2. Selection of cultivators or samples

The samples or sugarcane growers were selected on random basis from above three tehsils. The list of sugarcane growers was obtained from the revenue records maintained at selected tehsils and then categorized into three groups according to operational holding of sample farmers in small (Below 2.00 ha), Medium(2.01 to 4 ha) and large(above 4.01 ha) size groups.

The Operational holding wise distribution of different planting type of sugarcane cultivators is shown in the table 2.1.

Table 2.1.Tahsilwise and Operational holding wise distribution of different planting type of sugarcane cultivators

Planting type	Size groups	Districts			Total
		Pune	Satara	Kolhapur	
		Tahsils			
		Baramati	Karad	Karveer	
Adsali	Small	6	4	3	13
	Medium	8	6	-	14
	Large	19	10	4	33
Total adsali		**33**	**20**	**7**	**60**
Preseasonal	Small	3	3	4	10

	Medium	4	5	2	11
	Large	8	7	9	24
Total preseasonal		**15**	**15**	**15**	**45**
Suru	Small	2	2	2	6
	Medium	2	3	3	8
	Large	5	4	3	12
Total suru		**9**	**9**	**8**	**26**
Ratoon	Small	13	12	12	37
	Medium	8	10	5	23
	Large	28	12	19	59
Total ratoon		**49**	**34**	**36**	**119**
Tahsilwise Total		**106**	**78**	**66**	**250**

In all 250 samples sugarcane cultivators were selected from three tehsils. As shown in table, the ratoon sugarcane cultivators were largest (47.60%) followed by adsali(24%), preseasonal(18%) and suru (10.40%) respectively. The 42.40% sugarcane cultivators are from Baramati tehsil of Pune district whereas sugarcane cultivators from Karveer tehsil of Kolhapur are 26.40%. Sample cultivators from Karad tehsill of Satara district were 31.20%.

2.2.1. Method of data collection

The primary data was collected from sample sugarcane growers by the survey method. The sample sugarcane growers were contacted individually for collection of required information. The schedule was prepared by keeping in view the objectives of the study. The schedule was pre-tested by contacting of few cultivators in the area under study and accordingly modifications were made. The details of the schedule is given in Appendix-I.

The field level data or information on the use of various inputs viz., seed, manures, and fertilizers, number of irrigations, labour use pattern and yields obtained from sugarcane cultivation, etc., and general information of sample cultivators, such as family composition, land utilization, cropping pattern and assets position of the farmers etc., were collected from the sample sugarcane growers. The information on research station yields and yields of field level demonstration plot were obtained from the Central Sugarcane Research Station, Padegaon, Satara (M.S.). The data was collected for the crop harvested in the year 2011-12.

The time series data on area, production and productivity of sugarcane in India and Maharashtra were collected from various Govt. publications viz; Epitome of Agriculture, Economic Survey Reports and District Statistical Abstracts for period of 1960 to 2012.

2.3. Analytical frame work

For the quantitative assessment of the objectives set out in the study, the following analytical tools were employed.

a) Growth rate analysis

b) Tabular analysis

c) Regression analysis

2.3.1. Trends in area, production and productivity of sugarcane

In order to examine the trends in area, production and productivity of sugarcane, the compound growth rates were estimated for the State, by using exponential production function of the following type;

$$Y = ab^t$$

Where,

Y = Area/ production/productivity of crop
A = Constant
b = Régression coefficient
t = Time

$$\text{CGR}(\%) = (\text{Antilog}(b - 1)) \times 100$$

The Compound growth rates were estimated for the time periods i. e. Pre-green revolution period (1960-1969), Post-green revolution (1970-1989) Post-liberalization period (1990-2012) and Overall period (1960-2012).

2.3.2. Estimation of variability

The variability in area, production and productivity of sugarcane in Maharashtra was studied by calculating the coefficient of variation (CV) for the different time periods, i.e. Pre green revolution period of 10 years (1960-69), Post green revolution period of 20 years (1970-89), Post-liberalization Period of 22 years (1990-2012) and overall period of 52 years (1960-2012) by using the following formula,

$$\text{CV} = \frac{\text{SD}}{\text{Mean}} \times 100$$

Where,

CV = Coefficient of Variation

SD = Standard deviation

$$\text{Mean} = \sum X/N$$

X = area/production/productivity of crops

N = number of years

2.3.3. Computation of yield gaps

The yield gaps were quantified using tabular analysis. Some of the concepts which have been used in the study are defined below:

a. Yield gap refers to the difference between the potential yield and actual farm yield.
b. Potential yield refers to that which is obtained in the experiment station. The yield is considered to be the absolute maximum production of the crop possible in the given environment, which is attained by the best available methods and with the maximum inputs in trials on the experiment station in a given season.
c. Potential farm yield is the yield obtained on the demonstration plots on the farmers' fields in the study area. The conditions on demonstration plots closely approximate the conditions on the cultivators' fields with respect to infrastructural facilities and environmental conditions.
d. Actual yield refers to the yield realized by the farmers on their farms under their management practices.
e. Yield Gap-I corresponds to the difference between experiment station and potential farm yield. Yield Gap-I is hypothesized to be caused by either the environmental differences between experiment station and farmers' fields or by non-transferable technology.
f. Yield Gap-II corresponds to the difference between potential farm yield and the actual farm yield. It is hypothesized to be caused by biological and socio-economic constraints; biological constraints stem from the non-application of essential production inputs and the socio-economic constraints from the social or economic conditions that prevent farmers from using the recommended technology.

g. Total yield gap corresponds to the difference between potential yield and actual yield.

2.3.4. Indices of yield gap

a) Index of yield gap refers to the percentage of yield potential unrealized i.e.

$$1.\text{Index of yield gap(IYG} = \frac{(Y_p - Y_a)}{Y_a} \times 100$$

b) Index of realized potential yield is defined as the percentage of the yield potential achieved.

$$2.\text{Index of relized potential yield(IRPY)} = \frac{Y_a}{Y_p} \times 100$$

c) Index of realized potential farm yield is defined as the ratio of actual yield to potential farm yield, expressed in percentage. Thus,

$$3.\text{Index of relized potential farm yield(IRPFY)} = \frac{Y_a}{Y_d} \times 100$$

It may not possible for all farmers to raise the crop productivity on their farms to the level of research station. However, it would be realistic to aim at demonstration plot yield (potential farm yield) level. Therefore emphasis was given on yield gap-II and here in after simply referred as yield gap. For the computation of yield gap, simple tabular analysis was used.

2.3.5. Production function analysis

The multiple linear regression equation has been used in agriculture for studying the relationship between yield gap and input variables. The form of function used for estimating the numerical values of parameters of various independent variables influencing the yield gap is,

$$Y_g = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + ut$$

Where,

Yg = Yield gap (tonnes /ha), (Potential farm yield- Actual yield)

a = Intercept

b_i's = Regression coefficients of respective resource variables

X_1 = Human labour (mandays/ha)

X_2 = Bullock power (pairdays/ha)

X_3 = Machine power (hrs/ha)

X_4 = Nitrogen (kg/ha)

X_5 = Phosphorus (kg/ha)

X_6 = Potash (kg/ha)

X_7 = Manures (qtls/ha)

X_8 = Planting material (qts/ha)

X_9 = weedicide charges (Rs. /ha)

ut = Error term

The production function for sugarcane (Adsali, suru, Preseasonal and ratoon) cultivation was estimated separately. In all, nine input variables viz., human labour, bullock power, machine power, nitrogen, phosphorus, potash, manures, expenditure on planting material and weedicide charges were considered for production function analysis. The significance of each of the co-efficient of the variables from the estimated functions were tested with the help of 't' statistics.

2.3.5.1. Significance of input variables

A great deal of caution needs to be exercised in selection, classification and aggregation of input variables used in production process for studying the yield gap. A brief description of inputs used as explanatory variables in the present study is given below.

a) **Human labour (X_1):** Human labour used for preparation of land to harvesting of crop has been used in terms of man days. One man day consists of eight hours of work per adult male. It includes hired and family labour. Female labour was converted into adult male by multiplying hours of female labour by 0.75.

b) **Bullock power (X_2):** Bullock power used for different farm operations was considered as a separate input and it was measured in pair days. One pair day refers to eight hours of work done by one pair of bullock.

c) **Nitrogen (X_4):** The quantity of nitrogen (N) used in kg for the crop was considered as an independent variable.

d) **Phosphorus (X_5):** The phosphorus (P) used in kg for crop has been taken as a separate independent variable for the analysis.

e) **Potash (X_6):** Potash (K) plays an important role in maintaining the quality of produce. This plant nutrient was considered as a separate explanatory variable and was worked out in terms of kg.

f) **Manures (X_7):** This factor mainly responsible for increase in production. Sugarcane growers of this region use manures on a limited scale. Under this situation it was felt necessary to estimate the productivity of this factor. It has been measured in terms of quintals.

g) **Planting material (X_8):** The quantity of sugarcane setts used in quintals for the crop was considered as an independent variable.

h) **Weedicide (X_9)** charges has been measured in rupees.

i) **Yield gap (Yg):** The yield gap i.e. difference between the potential farm yield and actual yield on farmers field measured in tonnes was used as a dependent variable.

3. Result and discussion

The result and discussion of the research is shown below.

3.1. Land Use and cropping pattern

The Land utilization pattern has great importance, since land is the limiting factor in agricultural production. The average land utilization pattern according to different size groups of sample holdings is given in Table3.1.

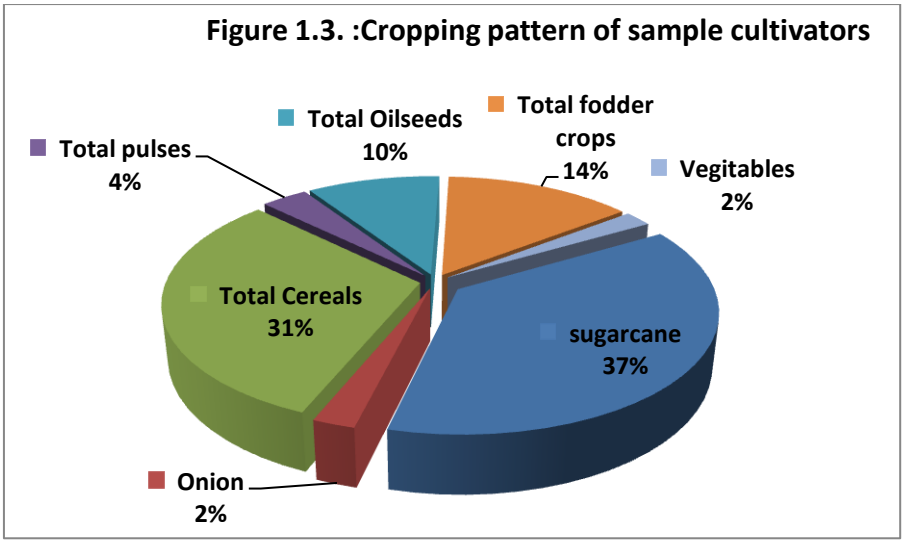
At overall level, average size of land holding was 3.41 hectares of which 88.30% was under cultivation. The average size of holding for small, medium and large sized farms was 1.13, 2.66 and 6.72 hectares respectively. As the size of the land holdings increases the proportion of irrigated land showed decreasing trend. At overall level, the gross cropped area was 4.35 hectares whereas, cropping intensity was 144.50 percent. The average gross cropped area for small, medium and large sized farms was 1.70, 3.72 and 7.83 hectares respectively.

Table 3.1: Average land use and cropping pattern of sample cultivators

(Hectares/ sample)

Particulars	Size groups							
	Small		Medium		Large		Overall	
	Area	%	Area	%	Area	%	Area	%
A. Land Use Patten								
Total land holding	1.13	100.00	2.66	100.00	6.72	100.00	3.41	100.00
Net cultivated area	1.05	92.92	2.47	92.86	5.44	88.89	3.01	88.30
Irrigated area	0.99	87.61	2.18	81.95	4.69	76.63	2.76	80.90
Unirrigated area	0.06	5.31	0.29	10.90	0.75	12.25	0.25	7.30
B. Cropping pattern								
Total sugarcane	0.61	35.88	1.35	36.29	3.17	40.49	1.62	37.24
Adsali	0.15	8.82	0.45	12.10	1.10	14.05	0.49	11.26
Preseasonal	0.11	6.47	0.20	5.38	0.47	6.00	0.25	5.75
Suru	0.15	8.82	0.18	4.48	0.35	4.47	0.21	4.83
Ratoon	0.20	11.76	0.55	14.78	1.25	15.96	0.67	15.40
Onion	0.08	4.71	0.08	2.15	0.19	2.43	0.10	2.30
Total Cereals	0.65	38.24	1.15	30.91	1.90	24.27	1.35	31.03
Total pulses	0.05	2.94	0.09	2.42	0.55	7.02	0.15	3.45
Total Oilseeds	0.08	4.71	0.38	10.22	0.67	8.56	0.43	9.89
Total fodder crops	0.15	8.82	0.55	14.78	1.25	15.96	0.61	14.02
Vegetables	0.08	4.71	0.09	2.42	0.10	1.28	0.09	2.07
GCA(Gross Cropped Area)	1.70	100.00	3.72	100.00	7.83	100.00	4.35	100.00
Cropping Intensity in %	161.90		150.61		143.93		144.50	

Cropping pattern is dependent on several factors such as soil type, climate, resources available with the farmers, requirements of the farm families, decision making ability of the cultivator under the situation of changing prices, price structure and relative prices of output of different crops. Further more, the requirements of maintenance of the soil fertility and risks and uncertainties associated with crops due to drought or excess moisture conditions are taken into consideration while deciding the cropping pattern. The details of groupwise area allocation for different crops on the sample farms are presented in Table 3.1 and graphically shown in figure 1.3.



At overall level average total cropped area was 4.35 hectares. It was observed that the sugarcane occupied a dominant position in cropping pattern contributing 37.24% to total cropped area. The total area under sugarcane went on increasing with an increase in size of sample farms. Out of four plantation type, ratoon sugarcane covered maximum area (15.40%) followed by Adsali (11.26%), preseasonal (5.75%) and suru sugarcane (4.83%).Ratoon sugarcane occupies more than 50 percent of the total sugarcane area in the country. However, its contribution in the total cane production is meagre 25% to 30 %(Rehman and Ullah, 2008).Ratoon sugarcane crop costs less than plant sugarcane. The Ratoon sugarcane is the most economical among all types of sugarcane. The savings on operational cost along with seed material is almost 25% to 30% compared to other types of sugarcane. Also there is no need for preparatory tillage to grow this crop.

Ratoon sugarcane matures earlier than other types of sugarcane and thus early supply of cane is assured. As a result, harvesting is faster and next crop can be sow on time. Therefore ratoon sugarcane area is more than other type of sugarcane. Next to cash crop cereals occupied second position with share of 31.03% in the gross cropped area followed by fodder crops (14.02 %), Oil seeds (9.89%), pulses (3.45%) and vegetables (2.07%).

The cropping pattern of sample cultivators indicates that, farmers have allocated relatively more area to sugarcane crop as compared to other crops. It was mainly due to the factors such as establishments of sugar factories in the area, sugarcane as high value cash crop and availability of canal and lift irrigation facilities.

3.2.Trends in area, production and productivity of sugarcane in Maharashtra

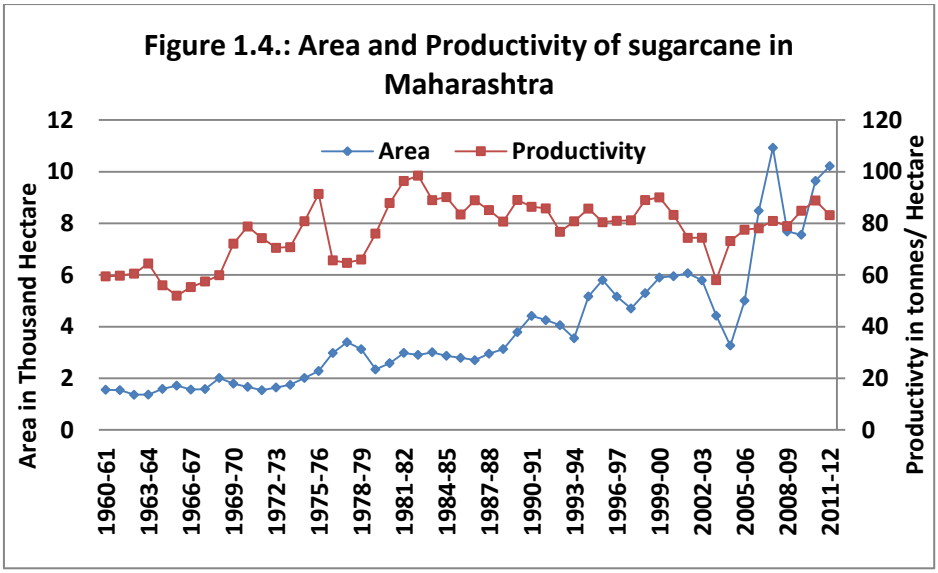
The rates of compound growth in area, production and productivity of sugarcane in Maharashtra at different time periods viz., Pre green revolution period (1960-1969), i.e. Period I, Post-green revolution (1970-1989) i.e. Period II, Post-liberalization period (1990-2012) i.e. Period III and Overall Period (1960-2012) have been presented in table 3.2.

Table 3.2:Trends in area, Production and productivity of sugarcane in Maharashtra

Sr. No.	Periods	Area	Production	Productivity
1	Period I(1960-1969)	2.6926**	3.2965**	0.588
2	Period((II) (1970-1989)	3.6012***	4.7978***	1.1549**
3	Period (III) (1990-2012)	3.76816***	3.5466***	-0.2136
4	Period Overall(1960-2012)	3.69204***	4.2989***	0.5853

(Note: "**" and "***" indicates the significance levels as 5 and 1 percent respectively)

The area (2.69 percent per annum) and production (3.29 percent per annum) of sugarcane increased significantly during pre green revolution period. The area (3.60 percent per annum), production (4.79 percent per annum) and productivity (1.15 percent per annum) of sugarcane increased significantly during period II, indicating positive effect of green revolution. During period III, significant growth was observed in area (3.76 percent per annum) and production (3.54 percent per annum) of sugarcane in Maharashtra.



The area and production has increased significantly during overall period (figure 1.4). The Maharashtra state has registered a considerable change in sugarcane production during different phases of green revolution. During period II, the significant rise in area and productivity of sugarcane was attributed to construction of dams and establishment of sugar factories in Maharashtra. The production of sugarcane shows a significant growth during entire period (1960-61 to 2011-12); this was mainly achieved due to increase in area.

3.3. Variability in area, production and productivity of sugarcane

For judging the variability in area, production and productivity of sugarcane in Maharashtra state and during different time periods i.e. Pre- green revolution period (1960-69), Post-green revolution period (1970-89) and Post-liberalizations Period (1990-2012), and overall period (1960-2012), coefficient of variation (CV) was worked out, which is most commonly used measure of variability. The variability in area production and productivity of sugarcane in Maharashtra at different time periods are depicted in Table 3.3

The result reveals that during post green revolution period (period II) high variability was noticed in yield (12.63 percent). Post liberalisation period (period III) the variability in yield of sugarcane was 8.67 percent. This reduction in variability was due to effect of woolly aphid's pest in year 2000-2005.

Table 3.3: Variability in area, Production and productivity of Sugarcane in Maharashtra

(Percent)

Sr. No.	Periods	Area	Production	Productivity
		CV	CV	CV
1	Period I(1960-1969)	12.08	16.29	9.26
2	Period((II) (1970-1989)	24.03	29.00	12.63
3	Period (III) (1990-2012)	35.40	38.19	8.67
4	Period Overall(1960-2012)	61.68	66.91	15.20

Note: Area in 00 ha, production in 00 tonnes and productivity in kg/ha
CV=coefficient of variability

The largest variation in area and production was observed in period III (35.40 percent and 38.19 percent). During overall period of 52 years, the magnitude of variability for area, production and productivity was 61.68 percent, 66.91 percent and 15.20 percent respectively .It is necessary to stabilise its acreage through appropriate price and non price policy factors to stabilise the production of sugarcane.

3.4. Resource use structure and Sugarcane productivity

The profitability of the farm business can be decided from relationship between costs incurred and returns obtained. The cost structure depends upon the type of resource employed, the resource mix and the extent of application.

Sugarcane crop is grown under two types; planted (Adsali, Preseasonal and Suru) and ratoon. The growth period and use of inputs are different for different planting types. The primary focus of this section is therefore to examine the resources use structure for different following planting types of sugarcane.

a) Adsali sugarcane

Adsali type of sugarcane is planted from 15 July to 15 August and the crop matures in 16 to 18 months. Because of extended growing season, there is increase in yield and sugar recovery. The biggest advantage of Adsali is that it passes through only one summer season and Adsali planting provides a longer period for vegetative growth and ultimately the cane gives higher yield. In this study, the Adsali sugarcane sample farms were 24 percent of the total sample.

The details of per hectare resource use structure of Adsali sugarcane on sample farms are presented in table 3.4.

Table 3.4: Per hectare resource use level and productivity of Adsali sugarcane

Sr. No	Particulars	Size groups			
		Small	Medium	Large	Overall
1	Human Labour(Man days)	386.42	373.49	359.86	368.24
2	Bullock Power(Pair days)	4.88	3.61	3.85	3.97
3	Machine Power (Hours)	36.37	37.64	38.06	37.43
4	Planting material (Quintals)	54.24	57.26	48.44	51.85
5	Manure (Quintals)	57.14	40.8	9.80	26.57
6	Fertilizers (kilograms)				
	a. Nitrogen (N)	448.95	438.02	427.41	434.10
	b. Phosphorus (P)	226.00	218.04	213.33	216.84
	c. Potash (K)	233.96	222.18	209.63	217.34
7	Productivity (Tonnes)	125.76	120.93	112.41	117.08

It is noted from table that, at the overall level, the average use of total human labour for Adsali sugarcane was 368.24 man days. The average use of human labour was maximum in small size group (386.42 man days) followed by medium (373.49 man days) and large (359.86 man days) sized farms. The overall average use of bullock power and machine power was 3.97 pair days and 37.43 hours respectively. The average use of bullock power showed decreasing trend while the average machine power use showed increasing trend with the increase in size of holding. The use of planting material was 51.85 quintals per hectare at overall level. The highest use of planting material was observed in the case of medium sized farms (57.26 quintals / ha) followed by small (54.24 quintals/ha) and large (48.44 quintals/ha) sized farms. The use of manure at overall level was 26.57 quintals per hectare. Among the size classes, it showed decreasing trend with increasing in size holding.

At the overall level, average use of nitrogen (N) was 434.10 kg. The maximum use of nitrogen was noticed in the case of small sized farms (448.95 kg per hectare) followed by medium (438.02 kg per hectare) and large (427.41 kg per hectare) sized farms. The use of phosphorus (P) at the overall level was 216.84 kg per hectare. Among the size groups, the maximum use of

phosphorus was in small sized farms (226 kg per hectare), followed by medium sized farms (218.04 kg per hectare) and large (213.33 kg per hectare) sized farms. The average use of potash at the overall level was 217.34 kg per hectare. The average use of potash for small, medium and large sized farms was 233.96 kg per hectare, 222.18 kg per hectare and 209.63 kg per hectare respectively. The average productivity of Adsali sugarcane was 117.08 tonnes per hectare at the overall level. Among the size groups, average productivity of 125.76 tonnes per hectare for small sized farms was highest followed by medium and large sized farms at 120.93 tonnes and 112.41 tonnes respectively.

b) Preseasonal sugarcane

The preseasonal sugarcane planting season is October-November and crop is matures in 13 to 15 months and supplies sugarcane in early crushing period. The share of Preseasonal sugarcane was 18 percent of the total sample sugarcane farms. The resource use structure of preseasonal sugarcane for sample farms per hectare for various size groups is depicted in table 3.5.

Table 3.5 : Per hectare resource use level and productivity of Preseasonal sugarcane

Sr. No	Particulars	Size groups			
		Small	Medium	Large	Overall
1	Human Labour(Mandays)	347.02	328.61	305.31	317.14
2	Bullock Power(Pair days)	10.42	4.95	3.13	5.03
3	Machine Power (Hours)	27.99	30.56	35.61	33.26
4	Planting material (Quintals)	54.70	48.04	53.16	52.28
5	Manure (Quintals)	50.74	40.34	12.08	42.22
6	Fertilizers (kilograms)				
	a. Nitrogen(N)	365.77	364.55	350.45	336.38
	b. Phosphorus(P)	157.72	147.92	140.59	144.97
	c. Potash(K)	230.54	219.32	206.69	213.32
7	Productivity (Tonnes)	108.69	104.80	97.67	101.02

The table reveals that average use of total human labour in the case preseasonal sugarcane for overall level was 317.14 man days. Maximum use of human labour was noticed in the case of small sized farms (347.02 man days) followed by medium (328.61 man days) and large (305.31 man days) sized farms. The average use of bullock power at overall level was a 5.03 pair days.

The average use of bullock power use showed decreasing trend for increasing farm holdings. The average use of planting material at overall level was 52.28 quintals per hectare. The highest use of planting material was observed in small sized farms (54.70 quintals per hectare), followed by large sized farms (53.16 quintals per hectare) and medium sized farms 48.04 quintals per hectare.

The average use of manure was highest in small sized farms at 50.74 quintals per hectare followed by medium sized farms at 40.34 quintals per hectare and large sized farms at 12.08 quintals per hectare. The average use of N, P and K for overall level was 336.38 kg per hectare, 144.97 kg per hectare and 213.32 kg per hectare respectively. Among the size groups, the average productivity of preseasonal sugarcane was 101.02 tonnes per hectare at overall level. The productivity of small sized farms was the highest 108.69 tonnes per hectare followed by medium (104.8 tonnes per hectare) and large sized farms (97.67 tonnes per hectare).

c) Suru sugarcane

The Suru sugarcane planting season is January-February and crop is matures in 12 months. The share of suru sugarcane was 10 percent of the total sample sugarcane farms. The resource use structure and productivity of Suru sugarcane on sample farm is shown in table 3.6.

Table 3.6: Per hectare resource use level and productivity of Suru sugarcane

Sr. No	Particulars	Size groups			
		Small	Medium	Large	Overall
1	Human Labour(Mandays)	281.69	268.52	260.93	267.75
2	Bullock Power(Pair days)	5.88	3.70	3.11	3.84
3	Machine Power (Hours)	26.76	28.13	32.46	29.72
4	Planting material (Quintals)	53.52	48.46	46.86	48.66
5	Manure (Quintals)	23.98	20.06	14.79	20.80
6	Fertilizers (kilograms)				
	a. Nitrogen(N)	329.58	288.27	274.42	289.60
	b. Phosphorus(P)	201.06	187.03	195.47	202.54
	c.Potash(K)	209.15	216.05	190.86	204.78
7	Productivity (Tonnes)	96.48	93.83	89.77	87.56

As evident from the table, the average use of total human labour in Suru sugarcane at overall level was 267.75 man days. The average use of total human labour for small, medium and large farm size were 281.69 man days, 268.52 man days and 260.93 man days respectively. The average use of bullock power for overall level was 3.84 pair days. The highest use of bullock power was observed in small sized farms (5.88 pair days) followed by medium (3.70 pair days) and large (3.11 pair days) sized farms. The average use of machine power was 29.72 hours. Among the different size groups, machine power use increase with increase in size of holdings.

The use of planting material at overall level was 48.66 quintals per hectare. The maximum use of planting material was noticed in small size farms (53.52 quintals per hectare) followed by medium (48.46 quintals per hectare) and large sized farms (46.86 quintals per hectare). The use of manure at overall level was 20.80 quintals per hectare and increase with the size of holdings.

The average use of Nitrogen (N), Phosphorus (P) and potash (K) was 289.60 kg per hectare, 202.54 kg per hectare and 204.78 kg per hectare respectively. The maximum use of Nitrogen was observed in small sized farms (329.58 kg per hectare) followed by medium sized farms (288.21 kg per hectare) and large sized farms (274.42 kg per hectare).

The use of phosphorus increases with increase in size of holdings. The maximum use of potash was observed in medium sized farms (216.05 kg per hectare) followed by small sized farms (209.15 kg per hectare) and large sized farms (190.86 kg per hectare)

The average productivity of Suru sugarcane was 87.56 tonnes per hectare at overall level. Among the different size groups of farm holdings the highest productivity was observed in small sized farms (96.48 tonnes per hectare) followed by medium (93.83 tonnes) and large sized farms (89.77 tonnes per hectare)

d) Ratoon sugarcane

The ratoon sugarcane occupies the sizable proportion of total area under cane cultivation at 47.60 percent of sugarcane area in selected districts. The major advantage of ratoon sugarcane lies in its early maturity, lower cost of cultivation and high sugar recovery during early period of crushing. The maturity of ratoon sugarcane is 12 months. The resource use structure and productivity of ratoon sugarcane is shown in table 3.7.

As shown in table, the average use of human labour was 229.40 man days at overall level. The average use of bullock power was 7.87 pair days. The human labour and bullock power use decreases with increase in size of farm holdings. The average use of machine power was 8.44 hours. The machine power use increases with increase in size of farm holdings. The average use of manure was observed in small sized farms (3.17 quintals per hectare) followed by large sized farms (0.81 quintals per hectare) whereas medium size farms have not use manure.

Table 3.7: Per hectare resource use level and productivity of ratoon sugarcane

Sr.No.	Particulars	Size groups			
		Small	Medium	Large	Overall
1	Human Labour(Mandays)	241.87	231.49	219.78	229.40
2	Bullock Power(Pair days)	9.55	8.48	704.0	7.87
3	Machine Power (Hours)	6.36	7.26	9.05	8.44
4	Manure (Quintals)	3.17	-	0.81	1.83
5	Fertilizers (kilograms)				
	a. Nitrogen(N)	268.52	275.17	263.79	267.27
	b. Phosphorus(P)	190.86	176.12	166.62	174.17
	c.Potash(K)	184.24	178.03	165.20	172.30
6	Productivity (Tonnes)	76.84	72.81	68.14	71.13

At the overall level, average use of Nitrogen (N), Phosphorus (P) and Potash (K) was 267.27 kg per hectare, 174.17 kg per hectare and 172.30 kg per hectare respectively. The use of N, P and K has decreases with increase in size of farm holdings.

The average productivity of ratoon sugarcane at overall level was 71.13 tonnes. The yield obtained on small sized farms was highest (76.84 tonnes per hectare) followed by medium (72.81 tonnes per hectare) and large (68.14 tonnes per hectare) sized farm holdings.

There exited a great variability in the resource use structure for sugarcane. Among the different planting types, the use level of resources such as human labour, machine power, planting material, nitrogen, phosphorus, potash and manure were higher in adsali sugarcane followed by preseasonal, suru and ratoon sugarcane. It is important note that, use of manure is not recommended for ratoon sugarcane but farmers use the manure. The productivity of sugarcane was highest for adsali planting followed by preseasonal, suru and ratoon sugarcane almost in all the size groups.

In general, among the different size groups of holdings for all the planting types, maximum productivity was observed in small sized farms followed by medium and large sized farms respectively. The optimum use of resources and efficient resource management by the small size farms can be attributed in realising the higher productivity. Further our finding confirmed with the earlier studies with results of Gaddi *etal* 2002, Chand *etal* 2011 indicate that all resources use decline with an increase in farm size. Lower the size of farm holding optimum was the use of inputs. Obviously, greater use of these factors would result in higher productivity and those farm categories with the higher value of these inputs or factors are also expected to realise higher productivity (Dong *etal* 1993, Frisvold 1994, Raghbendra *etal* 2000). In medium and large sized farms, the available resources may be diverted to other crops. In addition to this, the inefficient resource management due to large size farms might be the reason for low productivity.

3.5. Gaps in recommended and actual use levels of inputs

Inputs play a significant role for boosting the production of sugarcane. The production and productivity of sugarcane depends on the judicious and balanced use of inputs. The productivity of sugarcane crop is primarily influenced by the factors such as planting material, manures, fertilizers, irrigation, labour etc. Besides, there is very often a close complementary relationship among the different inputs for increasing production. Therefore, balanced and timely use of all these resources up to recommended levels is very important. The standard levels and time of application of inputs (*viz.*, planting material, manures, fertilizers etc.) recommended for Western Maharashtra by Mahatma Phule Krishi Vidyapeeth, Rahuri are taken into consideration for the present study and are incorporated in respective tables. It is true that, the requirements of inputs are different for adsali, preseasonal, suru and ratoon types of sugarcane. The average gap between recommended and actual use levels of major inputs like planting material, manures and fertilizers ingredients such as nitrogen, phosphorous and potash for sugarcane in different planting type is depicted in Table 3.8 to 3.11.

a) Adsali Sugarcane

The farm sizewise average gaps in the recommended and actual use levels of inputs on adsali sugarcane farms are presented in Table 3.8.

The average use of inputs such as planting material, phosphorus and potash at the overall level for adsali sugarcane was excess than the recommendations. The proportionate gap between the recommended and actual use levels of manure was the maximum at 91.14 percent followed by nitrogen at 13.18 percent at overall level. Considering the size groups, planting material, phosphorus and potash used were excess than the recommended levels. The maximum percent gap in recommended and actual use levels of all input was observed in large size groups.

Table 3.8.: Per hectare gaps in the recommended and actual use levels of inputs of Adsali sugarcane

Sr.No.	Particulars	Resource use	Size groups			Overall
			Small	Medium	Large	
A	**Gaps in the recommended and actual use levels of inputs**					
1	Planting material(qt)	Recommended	50	50	50	50
		Actual use	54.24	57.26	48.44	51.85
		Gap	-4.24	-7.26	1.56	-1.85
		Percent Gap	-8.48	-14.52	3.12	-3.7
2	Manure(qt)	Recommended	300	300	300	300
		Actual use	57.14	40.8	9.8	26.57
		Gap	242.86	259.2	290.2	273.43
		Percent Gap	80.95	86.4	96.73	91.14
3	Nitrogen(kg)	Recommended	500	500	500	500
		Actual use	448.95	438.02	427.41	434.1
		Gap	51.05	61.98	72.59	65.9
		Percent Gap	10.21	12.396	14.518	13.18
4	Phosphorus(kg)	Recommended	200	200	200	200
		Actual use	226	218.04	213.33	216.84
		Gap	-26	-18.04	-13.33	-16.84
		Percent Gap	-13	-9.02	-6.665	-8.42
5	Potash(kg)	Recommended	200	200	200	200
		Actual use	233.96	222.18	209.63	217.34
		Gap	-33.96	-22.18	-9.63	-17.34
		Percent Gap	-16.98	-11.09	-4.815	-8.67

Note: Negative sign indicates excess use of inputs

b) Preseasonal Sugarcane

The gaps in the recommended and actual use levels of inputs on preseasonal sugarcane farms are depicted in Table 3.9. At the overall level, the average use of manure, nitrogen and phosphorus for preseasonal sugarcane were below recommended. The proportionate gap between the recommended and actual use levels of manure was the maximum (83.11 percent) followed by nitrogen (15.91 percent) and phosphorus (14.72 percent).

Regarding the size groups, excess planting material was used by the small and large sized farms but the gap was noticed in medium size farms (3.84 percent). The percent gap in manure was the highest in larger size farms followed by medium and small size farms. Among the plant nutrients, percent

gap in nitrogen and phosphorus was more in large sized farms followed by medium and small sized farms.

Table 3.9: : Per hectare gaps in the recommended and actual use levels of inputs of preseasonal sugarcane

Sr. No	Particulars	Resource use	Size groups			Overall
			Small	Medium	Large	
1	Planting material(qt)	Recommended	50.00	50.00	50.00	50.00
		Actual use	54.70	48.08	53.16	52.28
		Gap	-4.70	1.92	-3.16	-2.28
		Percent Gap	-9.40	3.84	-6.32	-4.56
2	Manure(qt)	Recommended	250.00	250.00	250.00	250.00
		Actual use	50.74	40.34	12.08	42.22
		Gap	50.00	209.66	237.92	207.78
		Percent Gap	20.00	83.86	95.17	83.11
3	Nitrogen(kg)	Recommended	400.00	400.00	400.00	400.00
		Actual use	365.77	364.55	350.45	336.38
		Gap	34.23	35.45	49.55	63.62
		Percent Gap	8.56	8.86	12.39	15.91
4	Phosphorus(kg)	Recommended	170.00	170.00	170.00	170.00
		Actual use	157.72	147.92	140.59	144.97
		Gap	12.28	22.08	29.41	25.03
		Percent Gap	7.22	12.99	17.30	14.72
5	Potash(kg)	Recommended	170.00	170.00	170.00	170.00
		Actual use	230.54	219.32	206.69	213.32
		Gap	-60.54	-49.32	-36.69	-43.32
		Percent Gap	-35.61	-29.01	-21.58	-25.48

Note: Negative sign indicates excess use of inputs

c) Suru Sugarcane

The per hectare gaps in the recommended and actual use levels of inputs on suru sugarcane farms are depicted in Table 3.10.

The average use of planting material, manure and nitrogen at overall level for suru sugarcane was below recommended level whereas the use level of phosphorus and potash was more than recommended level. The proportionate gap between recommended and actual use levels of manure was the maximum at 89.60 percent. At the overall level, the gap of 2.68 percent between the actual and recommended use of planting material was small.

Table 3.10: : Per hectare gaps in the recommended and actual use levels of inputs of Suru sugarcane

Sr. No	Particulars	Resource use	Size groups			Overall
			Small	Medium	Large	
1	Planting material(qt)	Recommended	50.00	50.00	50.00	50.00
		Actual use	53.52	48.46	46.86	48.66
		Gap	-3.52	1.54	3.14	1.34
		Percent Gap	-7.04	3.08	6.28	2.68
2	Manure(qt)	Recommended	200.00	200.00	200.00	200.00
		Actual use	23.98	20.06	14.79	20.80
		Gap	176.02	179.94	185.21	179.20
		Percent Gap	88.01	89.97	92.61	89.60
3	Nitrogen(kg)	Recommended	300.00	300.00	300.00	300.00
		Actual use	329.58	288.27	274.42	289.60
		Gap	-29.58	11.73	25.58	10.40
		Percent Gap	-9.86	3.91	8.53	3.47
4	Phosphorus(kg)	Recommended	140.00	140.00	140.00	140.00
		Actual use	201.06	187.03	195.47	202.54
		Gap	-61.06	-47.03	-55.47	-62.54
		Percent Gap	-43.61	-33.59	-39.62	-44.67
5	Potash(kg)	Recommended	140.00	140.00	140.00	140.00
		Actual use	209.15	216.05	190.86	204.78
		Gap	-69.15	-76.05	-50.86	-64.78
		Percent Gap	-49.39	-54.32	-36.33	-46.27

Note: Negative sign indicates excess use of inputs

Regarding the size groups, excess planting material and nitrogen was used in small farms but maximum gap was noticed in large sized farms. The percent gap in manure was the highest in large size group followed by medium and small size groups. The excess use of phosphorus and potash was observed in all size farms.

d. Ratoon Sugarcane

The size groupwise gaps in recommended and actual use levels of inputs on ratoon sugarcane farms are given in Table 3.11.

It is evident from the table that actual use level of nitrogen were below recommended level whereas the use level of phosphorus and potash was more than recommended level. It is not recommended to use manure for ratoon sugarcane but still farmers holding small and large size farms use the manure in anticipation of higher productivity. Size groupwise analysis indicated that,

percent gap in nitrogen was more in large sized farms followed by small and medium sized farms. The use of planting material showed the excess use in all planting type of sugarcane. In the study area, sugarcane cultivators use traditional method for cultivating sugarcane.

Table 3.11: : Per hectare gaps in the recommended and actual use levels of inputs of ratoon sugarcane

Sr.No	Particulars	Resource use	Size groups			Overall
			Small	Medium	Large	
1	Manure(qt)	Recommended	0.00	0.00	0.00	0.00
		Actual use	3.17	-	0.81	1.83
		Gap	-3.17	-	-0.81	-1.83
		Percent Gap	-3.17	-	-0.81	-1.83
2	Nitrogen(kg)	Recommended	300.00	300.00	300.00	300.00
		Actual use	268.52	275.17	263.79	267.27
		Gap	31.48	24.83	36.21	32.73
		Percent Gap	10.49	8.28	12.07	10.91
3	Phosphorus(kg)	Recommended	140.00	140.00	140.00	140.00
		Actual use	190.86	176.12	166.62	174.17
		Gap	-50.86	-36.12	-26.62	-34.17
		Percent Gap	-36.33	-25.80	-19.01	-24.41
4	Potash(kg)	Recommended	140.00	140.00	140.00	140.00
		Actual use	184.24	178.03	165.20	172.30
		Gap	-44.24	-38.03	-25.20	-32.30
		Percent Gap	-31.60	-27.16	-18.00	-23.07

Note: Negative sign indicates excess use of inputs

It is interesting to note that, use of manure was far below recommended level in adsali, preseasonal and suru sugarcane due to high cost and non availability of F.Y.M. Among the various inputs of sugarcane production, excess use of fertilizers like nitrogen, phosphorus and potash by farmers in anticipation of maximising the sugarcane yield. The excess use not only increase the cost but also converts the soil to more alkaline decreasing the soil fertility thus productivity of the sugarcane.

3.6. Estimated Gaps for different planting types of sugarcane

Yield gap has two components. The first component cannot be narrowed or is not exploitable because it is mainly due to factors that are non-transferable such as environmental conditions. The second component is mainly due to difference in management practices. Yield gap (II) is manageable and can be

bridged by deploying more efficient research and extension services. With the advent of new technology in agriculture, significant improvements in the crop productivity was noticed. However, proper resources mix and appropriate cultivation practices become prerequisite for the adoption and success of new farm technology, which are often beyond the reach of a majority of the farmers. It is observed from table 3.12 to 3.15 that there exist a wide gap in adsali, preseasonal, suru and ratoon sugarcane.

a) Adsali sugarcane

Table 3.12 present the yield performance of adsali sugarcane under different field situations. It is observed from table that there exist a sizable gap in the adsali sugarcane productivity between research station, demonstration plots and the sample farmer's fields.

Table 3.12: Adsali sugarcane yield levels realised and the estimated yield gaps under different field situations

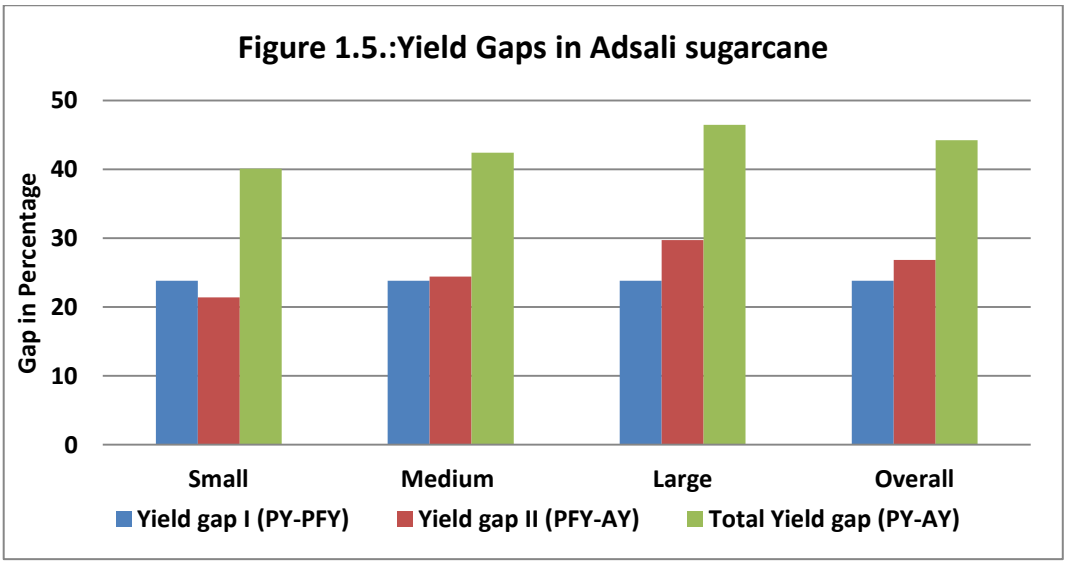
(Tonnes/ha)

Sr. No.	Particulars	Size groups			Overall
		Small	Medium	Large	
1	Potential Yield(PY)	210	210	210	210
2	Potential farm yield(Demonstration)(PFY)	160	160	160	160
3	Actual Yield(AY)	125.76	120.93	112.41	117.08
4	Yield gap I (PY-PFY)				
	(a)Potential yield	210	210	210	210
	(b)Potential farm yield	160	160	160	160
	(c) Percent gap	23.81	23.81	23.81	23.81
5	Yield gap II (PFY-AY)				
	(a)Potential farm yield	160	160	160	160
	(b)Actual yield	125.76	120.93	112.41	117.08
	(c) Percent gap	21.40	24.42	29.74	26.83
6	Total Yield gap I (PY-AY)				
	(a)Potential yield	210	210	210	210
	(b)Actual yield	125.76	120.93	112.41	117.08
	(c) Percent gap	40.11	42.41	46.47	44.25

Adsali sugarcane yield realised on the research station (210 tonnes per hectare) and on demonstration plots (160 tonnes per hectare) were significantly

higher than yield on sample farms (117.08 tonnes per hectare). It is inferred that there is 23.81 percent of yield gap between potential yield realised at research station and the yield that was reported at the demonstration plots (figure 1.5).

This gap is nothing but yield gap I, which explains the extent of the untapped potential yield that is possible to achieve at the sample farms. Yield gap II which is the difference between the potential farm yield (Yd) and the actual yield (Ya) was 26.83 percent. The total yield gap which indicates the difference between potential yield (Yp) and actual yield (Yp) was 44.25 percent. Among the size groups, maximum gaps were observed in large size farms followed by medium and small size farms.



b) Preseasonal Sugarcane

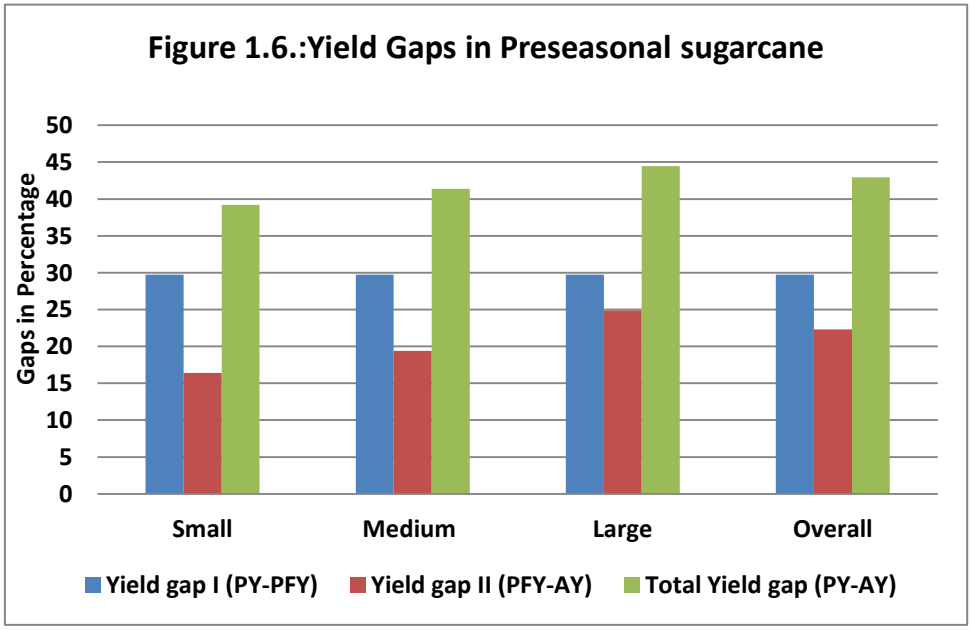
The average estimated yield gaps in preseasonal sugarcane farms are depicted in table 3.13 and figure 1.6.

The potential yield at research station was 185 tonnes per hectare while potential farm yield at demonstration plots were 130 tonnes per hectare. The actual yield of sample farms is 105.55 tonnes per hectare. The yield gap I for preseasonal sugarcane was 29.73 percent and yield gap II was 22.29 percent. The total yield gap III was observed at 42.95 percent at overall level. Among the size farms maximum yield gap I, Yield gap II and yield gap III were noticed in range of 24 to 44 percent on large sized farms respectively.

Table 3.13: Preseasonal sugarcane yield levels realised and the estimated yield gaps under different field situations

(Tonnes/ha)

Sr. No.	Particulars	Size groups			Overall
		Small	Medium	Large	
1	Potential Yield(PY)	185	185	185	185
2	Potential farm yield(PFY)	130	130	130	130
3	Actual Yield(AY)	112.5	108.5	102.8	105.55
4	Yield gap I (PY-PFY)				
	(a)Potential yield	185	185	185	185
	(b)Potential farm yield	130	130	130	130
	(c) Percent gap	29.73	29.73	29.73	29.73
5	Yield gap II (PFY-AY)				
	(a)Potential farm yield	130	130	130	130
	(b)Actual yield	108.69	104.8	97.67	101.02
	(c) Percent gap	16.39	19.38	24.87	22.29
6	Total Yield gap I (PY-AY)				
	(a)Potential yield	185	185	185	185
	(b)Actual yield	108.69	104.8	97.67	101.02
	(c) Percent gap	39.19	41.35	44.43	42.95



c) Suru sugarcane

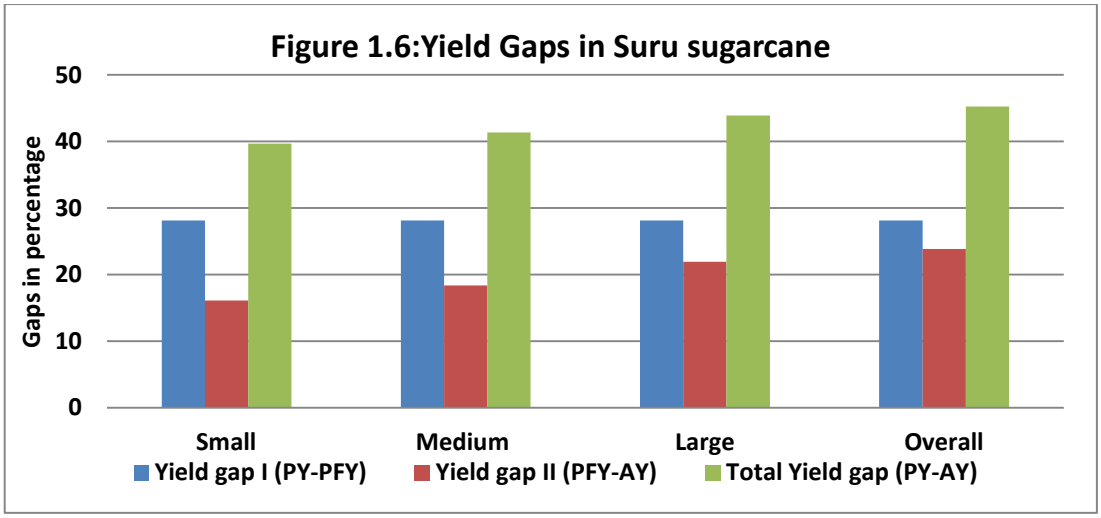
Table 3.14 presents the average yield performance of suru sugarcane under different field situations. It is observed from table that there existed a sizable gap in the suru sugarcane productivity between research station, demonstration

plots and the sample farmer's fields. Suru sugarcane yield realised on the research station (160 tonnes per hectare) and on the demonstration plots (115 tonnes per hectare) were amply higher than on farmers fields (87.56 tonnes per hectare).The total yield gap (yield gap III) was noticed to the extent of 45.28 percent while, yield gap I and Yield gap II were 28.13 percent and 23.86 percent respectively. Among the size groups yield gap II and yield gap III were maximum for large sized farms followed by medium and small size farms.

Table 3.14: Suru sugarcane yield levels realised and the estimated yield gaps under different field situations

(tonnes/ha)

Sr. No.	Particulars	Size groups			Overall
		Small	Medium	Large	
1	Potential Yield(PY)	160	160	160	160
2	Potential farm yield(Demonstration)(PFY)	115	115	115	115
3	Actual Yield(AY)	96.48	93.83	89.77	87.56
4	Yield gap I (PY-PFY)				
	(a)Potential yield	160	160	160	160
	(b)Potential farm yield	115	115	115	115
	(c) Percent gap	28.13	28.13	28.13	28.13
5	Yield gap II (PFY-AY)				
	(a)Potential farm yield	115	115	115	115
	(b)Actual yield	96.48	93.83	89.77	87.56
	(c) Percent gap	16.10	18.41	21.94	23.86
6	Total Yield gap I (PY-AY)				
	(a)Potential yield	160	160	160	160
	(b)Actual yield	96.48	93.83	89.77	87.56
	(c) Percent gap	39.7	41.36	43.89	45.28



d) Ratoon sugarcane

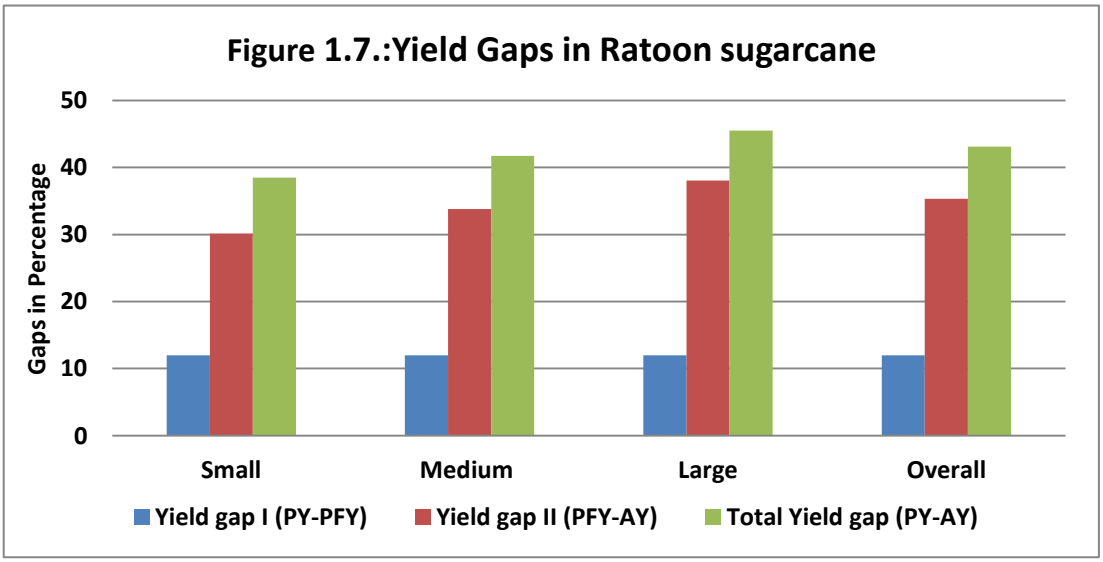
The table 3.15 shows the gap between productivity of research station, demonstration plots and sample farms of ratoon sugarcane. Ratoon sugarcane yield realised on the research station farms, demonstration plots and sample farms were 125 tonnes per hectare, 110 tonnes per hectares and 71.13 tonnes per hectares respectively. It is inferred from table that there is 12 percent yield gap between potential yield and the potential farm yield. (Figure 1.7)Yield gap II was 35.34 percent and total yield gap (yield gap III) was 43.10 percent at overall level. Among the farm size, as the size increases the yield gap II and III were also increased showing increasing trend.

The higher yield levels on research stations and demonstration plots were attributed to the fact that the experiments are conducted on scientific lines and are equipped with the all requisite resources including the technical input on the research station, while the demonstration trails are carried out under the supervision of agriculture extension workers. Higher yield gap I implies that greater amount of potential yield was left untapped on demonstration plots. This was attributable to the significant environmental differences and partly to the non-transferable component of technology like cultural practices. Hence, the technology developed at research station cannot be fully replicated on the demonstration plots. The results of the study are in conformity with (Gaddi *etal* 2002) for cotton production.

Table 3.15: Ratoon sugarcane yield levels realised and the estimated yield gaps under different field situations

(Tonnes/ha)

Sr. No.	Particulars	Size groups			Overall
		Small	Medium	Large	
1	Potential Yield(PY)	125	125	125	125
2	Potential farm yield(Demonstration)(PFY)	110	110	110	110
3	Actual Yield(AY)	76.87	72.81	68.14	71.13
4	Yield gap I (PY-PFY)				
	(a)Potential yield	125	125	125	125
	(b)Potential farm yield	110	110	110	110
	(c) Percent gap	12	12	12	12
5	Yield gap II (PFY-AY)				
	(a)Potential farm yield	110	110	110	110
	(b)Actual yield	76.87	72.81	68.14	71.13
	(c) Percent gap	30.12	33.81	38.05	35.34
6	Total Yield gap I (PY-AY)				
	(a)Potential yield	125	125	125	125
	(b)Actual yield	76.87	72.81	68.14	71.13
	(c) Percent gap	38.5	41.75	45.49	43.1



As mentioned earlier, the yield gap I is non exploitable because mainly due to differences in the environmental factors. Yield gap II can be bridged because it is mainly due to the difference in farmer's management (Bhatia *etal.* 2006 and Aggrawal *etal.*2008).

3.7. Indices of yield gaps for sample sugarcane farms

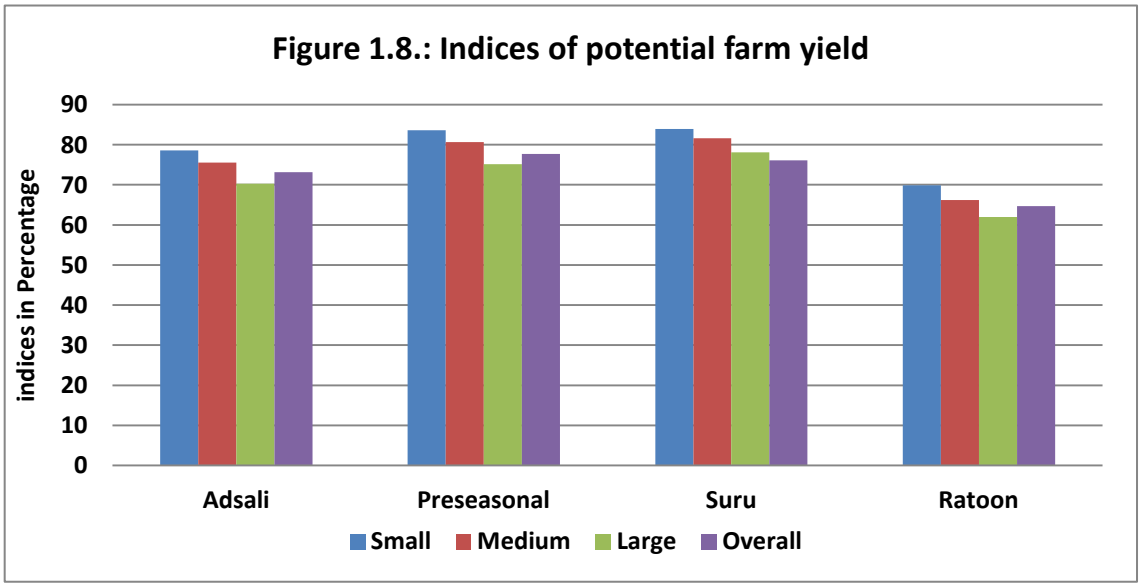
As shown in Table 3.16 and fig.1.8. The estimated index of yield gap at overall level, worked out to be the highest (45.28 percent) for Suru sugarcane followed by Adsali (44.25 percent), ratoon (43.10 percent) and Preseasonal (42.95 percent) sugarcane farms respectively. So, there exists a tremendous scope to improve the sugarcane production in the study area. The Index of potential yield on adsali, preseasonal, suru and ratoon farms at the overall level were 55.80 percent, 57.05 percent, 54.73 percent and 56.90 percent respectively. It may not always possible for the farmers to adopt certain aspects of new technology developed on the research station due to difference in the environmental factors and other constraints operating at the farm level. The table 3.16 shows that sample preseasonal sugarcane cultivators realised highest yield to the extent of 77.71 percent of the farm potential yield. It was followed by Suru (76.14 percent), adsali (73.18 percent) and ratoon sugarcane farms (64.66 percent). Thus if all the recommended package of practices and production technology used on the demonstration plots are adopted on sample farms by the sample sugarcane cultivators then sugarcane yield could increase by 23 percent on suru and preseasonal farms, 27 percent on Adsali sugarcane farms and 35 percent on ratoon sugarcane farms.

This resulted in comparatively higher yield levels and narrower yield gaps on the small farms than on their medium and large counterparts. Hence, due to smaller size of holding, more intensive care and crop management practices taken by the small farmers resulted in higher yield levels. On the other hand, comparatively lower yield levels realised on large farms was attributed to the fact that large farmers who are more dependent on human labour were unable to pay more personal attention during farm operations. Further our findings confirm earlier studies (Gaddi *etal.* 2002) on the yield gaps and constraints of the production of Rabbi Sorghum.

Table: 3.16.: Estimated indices of yield gaps on sample sugarcane farms

(Percent)

Sr. No	Particulars	Size groups			Overall
		Small	Medium	Large	
1	**Indices of yield gap**				
	(i)Adsali	40.11	42.41	46.47	44.25
	(ii)Preseasonal	39.19	41.35	44.43	42.95
	(iii) Suru	39.70	41.36	43.89	45.28
	(iv) Ratoon	38.50	41.75	45.49	43.10
2	**Indices of realized potential yield**				
	(i)Adsali	59.90	57.60	53.50	55.80
	(ii)Preseasonal	60.81	58.65	55.57	57.05
	(iii) Suru	60.30	58.64	56.11	54.73
	(iv) Ratoon	61.50	58.25	54.51	56.90
3	**Indices of potential farm yield**				
	(i)Adsali	78.60	75.58	70.26	73.18
	(ii)Preseasonal	83.61	80.62	75.13	77.71
	(iii) Suru	83.90	81.59	78.06	76.14
	(iv) Ratoon	69.88	66.19	61.95	64.66



3.8. Production function analysis

The productivity of crop primarily depends on the extent of resource use level and total management of the crop. In general, most of the farmers are not using the recommended levels of inputs. This led to wide gap between the

potential farm yield and actual farm yield which is called as yield gap II. In order to minimize the yield gap it is necessary to find out the factors affecting the yield gap.

3.8.1. Production function model

The functional relationship between the yield gap of sugarcane and nine independent variables such as human labour, bullock power, machine power, N, P and K fertilizer ingredients, manures, planting material and weedicide charges were estimated by fitting the multiple types of regression equations separately for each type of sugarcane planting. The estimates of the functional analysis were worked out by using equation as given below.

$$Y_g = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + ut$$

Where,

Yg = Yield gap (tonnes /ha), (Potential farm yield- Actual yield)

a = Intercept

b_i's = Regression coefficients of respective resource variables

X_1 = Human labour (mandays/ha)

X_2 = Bullock power (pairdays/ha)

X_3 = Machine power (hrs/ha)

X_4 = Nitrogen (kg/ha)

X_5 = Phosphorus (kg/ha)

X_6 = Potash (kg/ha)

X_7 = Manures (qtls/ha)

X_8 = Planting material (qt/ha)

X_9 = weediside charges (Rs./ha)

ut = Error term

3.8.2. Factors affecting yield gap of sugarcane

The estimated parameters of production functions of four planting types i.e. adsali, preseasonal, suru and ratoon sugarcane in respect of elasticises of yield gaps, standard errors of regression coefficients, their significance and the coefficients of multiple determination (R^2) are presented in the Table.3.17.

The coefficient of multiple determinations (R^2) indicates the proportion of total variation in the dependent variable jointly explained by the independent variables. At the same time, the regression coefficient of individual resource variable is the production elasticity of respective resource variable in multiple regression equation. It indicates the percentage change in yield gap associated with one unit change in the concerned input at its geometric mean level, when other factors are being held constant. These results are of paramount importance as they provide readily information relating to probable effects of resource use changes on yield gap. While, discussing the results, the planting type wise comparison is attempted in order to get an idea regarding variations in the productivities of different resources in the production of sugarcane.

a) Adsali Sugarcane

The results of the estimated production function analysis indicated that the selected nine independent variables have jointly explained 69 percent variation in the yield gap of adsali sugarcane. The regression coefficient of human labour (X_1), Bullock power (X_2) and manure (X_7) were negative and significant at 5 percent level of significance, while nitrogen(X_4) was negative and significant at 1 percent significance level. The negative and significant coefficient indicated that one unit increase in the human labour; bullock pair days, nitrogen and manure will minimize the yield gap by 0.68 percent, 1.8 percent, 0.08 percent and 2.15 percent respectively. The magnitude of regression coefficient of machine power, phosphorus, potash, planting material and weedicide were positive and turnout to be non-significant even though indicates the excess use of these resources but needs to be reduced.

b) Preseasonal Sugarcane

The value of R^2 is 0.70 for preseasonal sugarcane indicated that 70 percent total variation in the yield gap jointly explained by the selected nine independent variables. The regression coefficient of Nitrogen(X_4), Phosphorus (X_5) and Manure (X_7) were negative and significant at 10 percent level. These negative and significant variables indicate that, there is scope to minimizing

the yield gap. The magnitude of regression coefficient of human labour(X_1), bullock power (X_2),potash(X_6) planting material (X_8) and weedicide (X_9) were significant even though indicated the excess use of these resources needs to be reduced.

c) Suru sugarcane

It is noted from the table that of the nine variables, human labour (X_1),bullock power (X_2), machine power(X_3),Nitrogen(X_4), Phosphorus(X_5), Potash(X_6), Manure(X_7),Planting material(X_8) and weedicide (X_9) included in the production function analysis of suru sugarcane have jointly explained 74 percent variation in the yield gap. The regression coefficient of human labour, machine power, nitrogen and planting material were negative and significant at 5 percent level of significance, while manure was negative and significant at 10 percent level. These negative and significant coefficients indicated that, one unit increase in the use of human labour, machine power, nitrogen, planting material and manure will minimize the yield gap by 0.16, 0.26, 0.03, 0.05 and 2.89 units respectively. The positive coefficients indicated that the excess use of these resources which needs to be reduced.

d) Ratoon sugarcane

The proportion of total variation explained jointly by the selected nine resource variables was 72 percent in the ratoon sugarcane. The regression coefficient of bullock power (X_2) and nitrogen (X_4) were negative and significant at 1 percent level of significance. The negative and significant variables indicated that there is a scope to increase the use of these inputs for minimizing the yield gaps. The use of human labour(X_1),machine power(X_3), phosphorus(X_5), potash(X_6) and weedicide (X_9) though minimize the yield gap but their coefficient were non-significant.

Table.3.17.: Results of estimated regression analysis of sugarcane on sample farms

Sr. No.	Particulars	Planting type			
		Adsali N=60	**Preseasonal** N=45	**Suru** N=26	**Ratoon** N=119
1	Human labour (days) (X_1)	-0.6834** (-0.2681)	0.0717 N.S (0.0608)	-0.1652** (0.0726)	0.0095 N.S (0.0083)
2	Bullock power (days) (X_2)	-1.8623** (-0.9127)	0.4566 N.S (0.3147)	2.8357 N.S (2.0195)	0.8117*** (0.2829)
3	Machine Power (hrs) (X_3)	1.4756 N.S (-0.8878)	-0.3067* (0.169)	-0.2670** (0.1098)	0.7020 N.S (0.5162)
4	N(kg) (X_4)	-0.0831*** (-0.0257)	-0.6785** (0.3347)	-0.0376** (0.0149)	0.0813*** (0.0271)
5	P(kg) (X_5)	0.0828 N.S (-0.0455)	-0.4128** (0.1778)	0.3924 N.S (0.199)	0.0286 N.S (0.0219)
6	K(kg) (X_6)	0.0496 N.S (-0.049)	0.7094 N.S (0.5408)	0.0934 N.S (0.0492)	0.0369 N.S (0.0349)
7	Manure(qt) (X_7)	-0.1514** (-0.0569)	-0.5117** (0.2001)	0.8935** (0.3148)	0.2440 N.S (0.1729)
8	Planting Material (qt) (X_8)	0.0316 N.S (-0.4643)	0.7178 N.S (0.6807)	- 0.0510** (0.0216)	--
9	Weedside (Rs/ha) (X_9)	0.0656NS (-0.039)	0.0847 N.S (0.0534)	0.0811 N.S (0.0452)	0.0855 N.S (0.0505)
10	R^2	0.69	0.7	0.74	0.72
11	Degrees of freedom	42	31	16	110

Note: ***, **, * indicates the levels of significance at 1, 5 and 10 per cent respectively
N.S. = Non significance
(Figures in the parenthesis are the standard errors of respective regression coefficients)

From the above discussion, it is apparent that, the use of inputs such as manure, chemical fertilizers and planting materials are mainly responsible for the yield gap in the different sugarcane plantations.

3.9. Constraints in the adoption of recommended sugarcane production technology.

Appropriate quantity and timely use of inputs as per the recommendations in the cultivation of long duration crops like sugarcane holds large importance in minimising the yield gap. However, the adoption of recommended sugarcane production technology depends on the extent of knowledge of package of practices and constraints in operating at farm level. Therefore, the level of adoption and constraints in the adoption of sugarcane production technology developed by Mahatma Phule Krushi Vidyapeeth, Rahuri, Dist, Ahmednagar(MS) on the sample farms has been studied and results are discussed in the subsequent paragraphs.

3.9.1. Adoption of recommended production technology for planted sugarcane

The new technologies developed by researchers are sometimes not adopted by farmers due to some constraints. Because of non-adoption of recommended technology either fully or partially, the farmers do not get potential yields. It is necessary to study the level of adoption recommended production technology by the farmers, to know their rationale in non-adoption of specific recommendation and thereby, identify the constraints. For this purpose the sample farmers were inquired about the adoption of different components of recommended production technology. The information on this aspect was classified as planted (Adsali, Preseasonal and Suru) and ratoon type of sugarcane in subsequent sections.

The information on the adoption levels of different components of recommended sugarcane production technology by the adsali, Preseasonal and Suru sample sugarcane growers are presented in table 3.18.

a) Preparatory tillage

As sugarcane crop stands in field for more than a year, it is necessary to give deep ploughing by iron mould board plough drawn by bullocks or tractor. If preceding crop is a green manure crop, ploughing is not necessary as for burying green manure crop ploughing is required. The proper time for ploughing is immediately after the preceding crop is harvested or just after a good shower of rain is received. The land is then exposed to atmosphere for a month or two and then harrow is worked three to four times to break clods and to make the land smooth and even. Before last harrowing, recommended dose of organic manure is applied and mixed well with soil. Furrows at required distance depending upon the spacing are then opened across the major slope.

The recommended preparatory tillage practices (2 ploughing and 2 to 3 harrowing) were adopted by only 15 percent, 22.20 percent and 30.77 percent of the adsali, preseasonal and suru sugarcane growers respectively. Majority of the sugarcane growers i.e. 63.33 percent, 55.60 percent and 50 percent were carried out 1 ploughing and 2 to 3 harrowing for adsali, preseasonal and suru type of planting respectively.

b) Planting method

Ridge and furrow method is the most common method of sugarcane planting followed in Maharashtra. The ridges and furrows are opened with the help of ridger by keeping 120 cm distance between furrows in heavy soil and 105 cm distance in light to medium soil. The Main and sub-irrigation channels are opened at appropriate distance. First sets are laid on the top ridges end to end and later planted in furrows by two ways known as wet method and dry method of planting.

In case of layout information it was noticed that 81.67 percent, 80 percent and 80.77 percent of sample adsali, preseasonal and suru sugarcane growers respectively, used conventional method of ridges and furrow. Only 18.33 percent, 20 percent and 19.23 percent of adsali, preseasonal and suru sugarcane growers respectively followed the improved strip method of layout.

c) F.Y.M application

Application of organic manure for maintenance of soil at high fertility level is almost essential. Organic manure improves physical, chemical as well as biological properties of soil. The recommended organic manure per farm yard was 300 quintal/ha, 250 quintals/ha and 200 quintals/ha of the adsali, preseasonal and suru sugarcane respectively. Only 6.67 to 10 percent of adsali, preseasonal and suru sugarcane growers were used more than the 50 percent of recommended dose of FYM. Below 50 percent of FYM dose was used for adsali, preseasonal and suru sugarcane type was 18.33 percent, 11.11 percent and 30.77 percent respectively. It was also noticed that, more than 82.11 percent sample growers of adsali, preseasonal and suru were the non-adopters.

d) Improved varieties

The table 3.19 shows the improved varieties recommended for different planting periods.

Table 3.19: Recommended improved varieties or different planting periods of sugarcane

Sr. No	Planting type	Recommended verities
1	Adsali Sugarcane (15thJuly- 15th Aug)	Co-740, Co-419, Co-88121, CoM-86032, Co- 265.
2	Preseasonal (15 Oct- 15 Nov)	Co-7219, Co-740, Co-86032, CoM-88121, Co- 265.
3	Suru Sugarcane (15th Dec- 15th Feb)	Co- 7125, Co-740, Co-7219, Co-419, Co-88121 , Co-86032, Co- 265

Sugarcane variety CO- 86032 shows better results in all types of soils. Other advantages of CO- 86032 are multi ratooning capacity, cultivated throughout the year, gives higher recovery, self detrashing in nature and amenable for wide row spacing.

Sugarcane variety Com-0265 (Phule - 265) is released for suru, preseasonal and adsali planting especially in the salt affected soils of Maharashtra.

The maximum adoption of CO-86032 variety was to the extent of 66.67 percent, 60 percent and 65.22 percent of Adsali, preseasonal and suru

sugarcane growers. About 17 to 29 percent of sugarcane growers used the Com-265 variety of sugarcane (Table 3.18).

e) Season of planting

Depending upon the variety and sowing time it takes about 12 to 18 months to mature. In general January to March is the period of planting and December to March is the period of harvesting. After harvest, generally a ratoon crop is cultivated from the regrowth. A recommended season for sugarcane cultivation in Maharashtra is given in table 3.20.

Table.3.20. Recommended seasons for Sugarcane cultivation in Maharashtra

Planting type /Ratoon	Planting month	Crop duration in months
Adsali	15July to 15August	18
Pre-seasonal	15 October to 15 November	15-16
Suru	15December to 15February	12
Ratoon	Ratoon of cane harvested during October to February	11

It is evident from the table 3.18 that, the season of planting 80 percent, 77.21 percent and 80.77 percent of the adsali, preseasonal and suru sugarcane growers respectively followed the proper time of planting, while remaining were non adopters.

f) Plantation material

Single, two and three eye bud methods of planting are in practice. To avoid heavy risk of gaps in single eye bud and over population by three eye bud planting methods, two eye bud method is recommended. About 81 to 88 percent of the sugarcane growers used conventional i.e. three eye bud technique of planting. The improved two eye bud method of plantation were adopted by 10 percent,4.44 percent and 7.69 percent of the adsali, preseasonal and suru sugarcane growers respectively, while only one eye bud method of planting was used 6 to 8 percent of the sugarcane growers.

Table 3.18: Adoption of Recommended production technology for planted type of sugarcane

Sr. No.	Components of Technology	Planting type		
		Adsali adoption N=60	Preseasonal adoption N=45	Suru adoption N=26
i	**Preparatory Tillage**			
	a. 2. Ploughing + 2-3 harrowing	09(15.00)	10(22.20)	08(30.77)
	b. 1 Ploughing + harrowing	13(21.67)	10(22.20)	05(19.23)
	c. 1 Ploughing + 2-3 harrowing	38(63.33)	25(55.60)	13(50.00)
ii	**Planting methods**			
	a. Ridges and furrow	49(81.67)	36(80.00)	21(80.77)
	b. Strip method	11(18.33)	09(20.00)	05(19.23)
iii	**F.Y.M.(Farm Yard Manure)**			
	a. No adopting	43(71.67)	37(82.22)	16(61.54)
	b. Below 50 Percent	11(18.33)	05(11.11)	08(30.77)
	c. Above 50 percent	06(10.00)	03(06.67)	02(07.69)
	d. above 75 percent	-	-	-
	e. above 100 percent	-	-	-
iv	**Improved varieties**			
	a.CO 86032	40(66.67)	27(60.00)	19(65.52)
	b.CO265	17(28.33)	13(28.89)	05(17.24)
	c. Other	03(05.00)	05(11.11)	02(06.90)
v	**Season of planting**			
	a. Improper time	12(20.00)	10(22.20)	05(19.23)
	b. Proper time	48(80.00)	35(77.21)	21(80.77)
vi	**Planting material**			
	a. One eye bud (nursery bud)	05(08.33)	03(06.67)	02(07.69)
	b. Two eye bud	06(10.00)	02(04.44)	02(07.69)
	c. Three eye bud	49(81.67)	40(88.89)	22(84.62)
vii	**Seed setts treatment**			
	a. Hot water treatment (500C for 2 hours)	0.00	0.00	0.00.
	b. Azetobactar treatment (10 kg/100 lit. water)	03(05)	2(04.44)	01(3.55)
viii	**Weed management**			
	a.1-2 Weedinges	29(48.33)	19(42.22)	09(34.62)
	b.3-5 weedinges	31(51.67)	26(57.78)	17(65.38)
	a. Chemical weed control	40(66.67)	29(42.22)	18(69.23)
ix	**Fertilizer management**			

	I). N (Nitrogen)			
	1.Below 50 Percent	02(03.33)	02(04.40)	-
	2.Above 50 percent	04(06.67)	05(11.11)	02(06.90)
	3.above 75 percent	39(65.00)	28(62.20)	17(65.40)
	4.above 100 percent	04(06.67)	07(15.56)	5(19.23)
	II). P (Phosphorus)			
	1.Below 50 Percent	-	01(02.22)	01(03.45)
	2.Above 50 percent	13(21.67)	10(22.22)	-
	3.above 75 percent	07(11.67)	12(26.67)	06(20.69)
	4.above 100 percent	40(66.67)	29(64.44)	19(65.52)
	III). K (Potash)			
	1.Below 50 Percent	03(05.00)	03(06.67)	01(03.45)
	2.Above 50 percent	10(16.67)	02(04.44)	-
	3.above 75 percent	03(05.00)	05(11.11)	08(27.59)
	4.above 100 percent	44(73.33)	35(77.78)	17(58.62)
x	**Intercropping**	10(16.57)	11(22.22)	02(7.69)
xi	**Use of Micronutrients**	17(28.33)	09(20.00)	05(19.23)
xii	**Irrigation Management**			
	a.Rainy-14 to 15 days interval	47(78.33)	31(71.11)	17(65.38)
	b. Winter- 15 to 20 days interval	49(81.67)	36(80.00)	19(73.08)
	c. Summer- 8 to 10 days interval	39(65.00)	27(53.33)	15(57.06)
	d. Drip Irrigation	06(10.00)	04(08.89)	02(6.90)
xiii	Diseases and Pests Managements			
	Grassy shoots (Hot water treatment)	0.00	0.00	0.00
	Wooly aphids (Initially phorte, after infestation spraying of Methyl Demeton)	29(48.33)	25(55.60)	13(50.00)
	White grubs (Chlorpyriphos)	03(5.00)	03(6.67)	0.2(6.90)
xiv	Trash mulching operation	03(05.00)	01(02.22)	02(06.90)

Figures in parenthesis are the percentages to the number of respective type of sugar cane cultivated

(N: - Number of sugarcane Cultivators)

g) Seed setts treatment

Following is the recommended sugarcane setts treatment:

a. Seed treatment with hot water at 5^{o}C for two hours or moist air treatment at 54^{o}C for two and half hours.

b. To increase biological nitrogen fixation, setts should be treated with Azatobacter. For one hectare area, dissolve 10 kg Azatobacter in 100 litres of water and dip sets for 10–15 minutes and then do planting after drying them in shade.

None of the sugarcane grower gave hot water treatment to the sugarcane sets. These finding supported that by some other studies also (Mande and Thombre, 2009.). The proportion of farmers using the Azatobactarial treatment for adsali, preseasonal and suru sugarcane were 5 percent, 4.44 percent and 3.55 percent respectively.

h) Weed management

In sugarcane weeds have been estimated to cause 12 to 72 % reduction in cane yield depending upon the severity of infestation. The nature of weed problem in sugarcane cultivation is quite different from other field crops because of the following reasons

- Sugarcane is planted with a relatively wider row spacing
- The sugarcane growth is very slow in the initial stages. It takes about 30 - 45 days to complete germination and another 60-75 days for developing full canopy cover
- The crop is grown under abundant water and nutrient supply conditions
- In ratoon crop very little preparatory tillage is taken up hence weeds that have established in the plant crop tend to flourish well

Total 3to5 weeding recommended for sugarcane. Mechanical weed control methods were used by 51.67 percent, 57.78 percent and 65.38 percent of the adsali, preseasonal and suru sugarcane growers respectively.

Due to non-availability of labourers for hand weeding, chemical weed control is now becoming popular. The recommended dose of weedicide, Application of Atrazine @ 1.0 kg a.i/ha with 1000 litres of water after 2-3 days of Sugarcane planting under moist condition controlled weeds up to 40-45 days. To manage broad leaved weeds, application of 2,4-D Sodium Salt @ 1.0 kg a.i/ha with 600 litres of water was done at 60 days after planting. Finally,

one manual hoeing at 90 days after planting was also followed. The use of weedicides i.e. chemical weed control method were observed to the extent of 66.67 percnet,42.22 percent and 69.23 percent of the adsali, preseasonal and suru sugarcane growers respectively.

i) Fertilizer management

Nutrient management in sugarcane cultivation is very essential for crop growth. The recommended dose (kg/ha) and time of application of fertilizers is as below Table 3.21.

Table.3.21.Recommended dose and time of application of fertilizers

Planting types		Time of application				Total
		At planting	6 – 8 weeks after planting	12 – 16 weeks after planting	At earthing up	
Adsali	N	50.00	200.00	50.00	200.00	500.00
	P_2O_5	100.00	0.00	0.00	100.00	200.00
	K	100.00	0.00	0.00	100.00	200.00
Pre seasonal	N	40.00	160.00	40.00	160.00	400.00
	P_2O_5	85.00	0.00	0.00	85.00	170.00
	K	85.00	0.00	0.00	85.00	170.00
Suru	N	30.00	120.00	30.00	120.00	300.00
	P_2O_5	70.00	0.00	0.00	70.00	140.00
	K	70.00	0.00	0.00	70.00	140.00

The recommended dose of nitrogen (N) for the adsali, preseasonal and suru sugarcane is 500kg, 400 kg and 300 kg per hectare respectively (Table. 3.21). The proportion of farmers using more than the 100 percent of the recommended dose of nitrogen were to the extent of 6.67 percent,15.56 percent and 19.23 percent for adsali, preseasonal and suru sugarcane respectively. Majority of (65 percent, 62 percent and 65.40 percent) adsali, preseasonal and suru sugarcane growers were adopted more than 75 percent of recommended nitrogen dose. The proportion of sugarcane growers using more than 50 percent of nitrogen dose was 7 to 12 percent while less than 4.40 percent farmers were used below 50 percent of recommended dose of nitrogen for all type of planted sugarcane(Table. 3.18).

The recommendation of phosphorus (P) for adsali, preseasonal and suru sugarcane are 200 kg, 170 kg and 140 kg per hectare respectively (Table. 3.21). Regarding the use of phosphorus, 66.67 percent, 66.44 percent and 65.52 the adsali, preseasonal and suru sugarcane growers were respectively used more than recommended dose of phosphorus. The proportion of farmers using more than 75 percent of P dose were11.67 percent 26.67 percent and 20.69 percent for adsali, preseasonal and suru respectively. About 7 to 21 percent of the growers used more than 50 percent of P, while less than 4 percent of growers have been used below 50 percent of the recommended dose of P for preseasonal and suru sugarcane. (Table. 3.18)

The recommendation of potash (K) for adsali, preseasonal and suru sugarcane is 200 kg, 170 kg and 140 kg per hectare respectively (Table. 3.21). The large number of farmers using dose more than recommended level were 73.33 percent, 77.78 percent and 58.62 percent respectively. The proportion of farmers using more than 75 percent of K dose were 5 percent, 11.11 percent and 27.59 percent for adsali, preseasonal and suru sugarcane respectively. About 20 to 22 percent of sugarcane growers were adopted more than 50 percent of K dose while less than 4 percent of growers have been used less than 50 percent of recommended dose of K for all planted sugarcane (Table. 3.18).

j) Intercropping

Intercropping in sugarcane with crops like wheat, potato, cowpea, French bean, chickpea, water melon, brinjal etc. In addition to effective utilization of land, this practice will reduce the weed growth up to 60% and give extra income to farmers.

Recommended intercropping system for sugarcane is as follows:

1. Adsali sugarcane : groundnut, soybean, beans, vegetables and Maize.

2. Preseasonal sugarcane: potato, onion, garlic, vegetables, chickpea, Peas, wheat and maize.

3. Suru sugarcane : summer groundnut, all vegetables and maize.

It is observed from the table (3.18) that, the intercropping system was adoptedby16.57percent, 22.22 percent and 7.69 percent of the Adsali, preseasonal and suru sugarcane growers respectively, whereas remaining cultivators were non adopters.

k) Use of Micronutrients

In soils deficient with micro nutrients like iron, zinc, manganese, copper, molybdenum and boron, in addition to above fertilizers, the recommended dose of micronutrients is 25 kg Ferrous Sulphate, 20 kg Zinc Sulphate, 10 kg Manganese Sulphate, 10 kg Copper Sulphate, 2.5 kg Sodium Molybdate and 5 kg Borax per hectare should be applied. Micro nutrient fertilizers should be mixed with well decomposed dung manure or compost and applied as basal dose. The proportion of farmers using the micronutrients for adsali, preseasonal and suru sugarcane were 28.23 percent, 20 percent and 19.23 percent respectively.

l) Irrigation management

The common method of irrigation followed for sugarcane is the surface irrigation either by flood or through furrows. In conventional flooding method water is always applied more than the biological demand of the crop which may affect the crop growth. However, the irrigation efficiency of surface irrigation is only 30-50% and there is considerable wastage of water. Micro irrigation and water use efficient cultivation techniques become relevant in this context, for conserving water and optimizing its use.

The schedules of water management in monsoon were followed by 78.33 percent, 71.11 percent and 65.38 percent of sugarcane growers for adsali, preseasonal and suru sugarcane respectively. About 81.67 percent, 80.00 percent and 73.08 percent of sugarcane growers have been followed proper irrigation schedule during winter season, while 65.00 percent, 53.33 percent and 57.06 percent growers have been followed proper irrigation schedule during summer for all type of planted sugarcane. Only 7 to 10 percent of

sugarcane growers have been used the drip irrigating system for adsali, preseasonal and suru sugarcane.

m) Diseases and Pests Managements

The majority of farmers using the integrated pest management technology for controlling the woolly aphides for adsali, preseasonal and suru sugarcane were 48.30 percent, 55.60 percent and 50 percent respectively. None of the sugarcane grower gave hot water treatment to the sugarcane sets for controlling grassy shoots.

k) Trash mulching operation

Trash mulching is important in sugarcane cultivation as it helps in checking the weeds and providing needed moisture. Mulching will develop earthworms which in turn will improve the soil aeration and infiltration of water.

Sugarcane trash can be applied @ 1.5 tonnes/acre within 3 days of planting. Similarly, after detrashing the removed leaves can be applied in the interspaces as mulch. Sugarcane trash sprayed with 80 kg urea, 100 kg single Super Phosphate and 10 kg decomposing culture/ha for better decomposition. Sugarcane trash can also be incorporated while making organic manure along with press mud and use of earthworms for preparing vermicompost. The proportion of farmer's using trash mulching for adsali, preseasonal and suru sugarcane were 5.00 percent, 2.22 percent and 6.90 percent respectively.

3.9.2. Adoption pattern of recommended production technology for ratoon sugarcane.

3.9.2.1. Recommended Management practices of Ratoon sugarcane

Ratooning is a method where the lower parts of the plants along with the roots are left uncut at the time of harvesting. It is the most commonly followed and important practice in sugarcane cultivation. In ratoon crops, there is a saving in cost of cultivation in terms of land preparation, seed canes, etc. If ratoons are well maintained, they give high yields. But, for a better ratoon crop, a better plant crop is necessary. Within a week after harvesting the plant crop,

ratoon management Practices like stubble shaving, off bearing, gap filling etc., should be initiated.

a. Instead of burning of trash after the harvest of previous cane crop, it should be spread evenly in between the rows or in alternate row of the ratoon crop.
b. Decomposing culture at the rate of 10 kg/ha along with 80 kg Urea/ha and 100 kg Single super phosphate should be used on trash for fast decomposition of trash.
c. Stubbles above the ground level need to be shaved within 10-15 days after harvest of plant crop. Infected stubbles should be removed and burned.
d. Gaps in ratoon need to be filled with the saplings raised in poly bags by single eye bud method.
e. The hard and compact mass of soil near the root zone should be loosened by breaking the soil by plough near the root.
f. Fertilizer doses must be given at 10-15 cm depth as per the schedule is given in table 3.22.

Table.3.22.Fertilizer application schedule for ratoon sugarcane

Sr. no	Time of application	Kg/ha		
		N	P_2O_5	K_2O
1	Within 15 days after harvest of previous crop and before first irrigation	35.00	70.00	70.00
2	6 weeks after first dose	115.00	0.00	0.00
3	12 weeks after first dose	35.00	0.00	0.00
4	At earthing up	115.00	70.00	70.00
	Total	300.00	140.00	140.00

3.9.2.2. Adoption of recommended Ratoon sugarcane production technology on sample farms

The level of adaptation of different components of recommended sugarcane production technology on ratoon sugarcane farms are presented in table.3.23.

i. Trash management:

At the overall level, 62.18 percent sample ratoon sugarcane growers buried trash in the field for decomposition after harvesting of previous crop. While

the majority of the ratoon sugarcane growers (37.82 percent) used traditional method of trash burning.

ii. Cleaning and tillage operation

The cleaning of tillage operations were carried on by 78.99 percent of ratoon sugarcane growers, as per the recommendation.

iii. Varieties for ratoon sugarcane crop:

The majority of the farmers (80.67 percent) used CO-86032 variety, while 16.81 percent farmers have not used CO-205 variety for rationing.

iv. Weed management

In case of ratoon sequence recommended number of weedings (3 to 5 weedings) was followed by 53.76 percent of ratoon sugarcane growers. About 46.22 percent sample sugarcane growers followed 1 to 2 weeding. The method of chemical weed control was adopted by 37.81 percent of ratoon sugarcane growers.

v. F.Y.M. application:

It is not recommended to use manure for ratoon sugarcane but 6.72 percent farmers use the manure in anticipation of higher productivity.

vi. Fertilizer Application:

The recommended dose for ratoon sugarcane is 300kg, 140kg and 140 kg per hectare of N, P and K respectively. The ratoon sugarcane growers i.e. 73.11 percent, 15.13 percent and 10.08 percent, were adopted more than 75 percent of the recommended dose of N P and K respectively.

The proportion of ratoon sugarcane growers i.e. 10.08 percent, 79.47 percent and 78.99 percent were adopted more than 100 percent of the recommended dose of nitrogen, phosphorus and potash respectively. More than 50 percent of recommended dose of N,P and K were used by 6.72 percent, 1 percent and 4.20 percent of growers respectively, while remaining growers have been used below 50 percent of recommended dose of N,P and K respectively.

Table 3.23: Adoption of recommended Ratoon sugarcane production technology on sample farms			
Sr. No.	**Components of Technology**		**Adoption N=119**
i	**Trash Management**		
	a. By burring		45(37.82)
	b. Trash used as compost in the field		74(62.18)
ii	**Cleaning and tillage operations**		94(78.99)
iii	**Varieties for Ratoon crop**		
	a.CO86032		96(80.67)
	b.CO265		20(16.81)
	c. Other		03(02.52)
iv	**Weed management**		
	a.1 to 2 weeding		55(46.22)
	b.3 to 5 weeding		64(53.76)
	a. Chemical method of weed control		35(37.81)
v	**Application of FYM**		08(06.72)
vi	**Fertilizer management**		
	N	a. Below 50percent	12(10.08)
		b. Above 50Percent	08(06.72)
		c. Above 75 percent	87(73.11)
		d. Above 100 percent	12(10.08)
	P	a. Below 50percent	09(07.56)
		b. Above 50Percent	01(00.84)
		c. Above 75 percent	18(15.13)
		d. Above 100 percent	91(76.47)
	K	a. Below 50percent	08(06.72)
		b. Above 50Percent	05(04.20)
		c. Above 75 percent	12(10.08)
		d. Above 100 percent	94(78.99)
vii	**Methods of Fertilizer application**		
	a. Side dressing		112(94.12)
	b. Crow bar method		07(5.88)
viii	**Use of Micronutrients**		79(66.39)
ix	**Irrigation Management**		
	a. Rainy monsoon		27(22.69)
	b. Winter season		65(54.62)
	c. Summer Season		20(16.81)
	d. Drip Irrigation		07(05.88)
	c. Trash mulching operation		03(02.52)
x	**Diseases and Pests Managements**		
	Woolly aphides		27(22.69)

Note: - N=Number of respondents

Figures in parenthesis are the percentages to the number of respective type of sugar cane cultivated

i. **Methods of fertilizers application**

Regarding the method of fertilizer application, about 94.12 percent sample ratoon sugarcane growers have been adopted side dressing method, while 5.88 percent of sample growers were adopted improved crow bar method of fertilizer application.

ii. **Micronutrients**

Adoption of micronutrients for the ratoon sugarcane was followed by 66.39 percent of sample sugarcane growers.

iii. **Ratoon water management**

Regarding the irrigation schedule, 22.69 percent, 54.62 percent and 16.81 percent sample sugarcane growers adopted proper irrigation schedule during monsoon, winter and summer season respectively. Only 2.52 percent growers followed the trash mulching operation. In ratoon sugarcane, only 5.88 percent growers adopted the method of drip irrigation for efficient water management.

iv. **Diseases and Pests Managements**

Adoption of pest management for the ratoon sugarcane was followed by 22.67 percent of sample sugarcane growers.

3.9.3. Constraints in the adoption of sugarcane production technologies

The production and productivity of crop is mainly governed by the judicious and balanced use of inputs and technology. The timely and proper use of inputs in a scientific manner has significant impact in achieving the optimum productivity. The behaviours of sample growers under different farm situations mainly constrained by various reasons under this pre-test, it is important to assess the causes of non-adoption of recommended technology.

The study depicted a large amount of untapped yield potential (Table 3.12 to 3.15). Various constraints operating at farm level may be partly responsible for the yield gap. Hence, the opinion of sample farmers on the difficulties in realising potential farm yield was collected and it is presented in Table.3.24.

The constraints were grouped under the heads such as preparatory tillage, preparation of layout, use of F.Y.M., season of planting, method of planting, weed control, fertilizer use, micronutrients use and water management and overall level results are discussed below.

i. Preparatory tillage

In regards to preparatory tillage, 62.20 percent sugarcane growers perceived that high cost and scarce labour was the main constraint, while, 25.20 percent sugarcane growers skipped some tillage operations to follow timely planting. About 19.60 percent growers faced the problem of inadequate capital.

Table 3.24: Constraints in the adoption of sugarcane production technology on sample sugarcane farms

Sr. No.	Components of Technology	Size groups			
		Small N=66	Medium N=56	Large N=128	Overall N=250
i	**Preparatory tillage**				
	a. High cost and scare labour	42(63.64)	39(69.44)	82(64.06)	163(62.20)
	b. To follow timely planting skip some operation	16(24.24)	10(17.86)	32(25.00)	58(25.20)
	c. Limited capital	08(12.12)	07(12.50)	34(26.56)	49(19.60)
ii	**Layout**				
	a. Strip method reduced yield	40(60.61)	38(67.86)	79(61.72)	157(62.80)
	b. Unknown about strip method recommendation	01(1.52)	03(05.36)	02(01.56)	06(02.40)
iii	**F.Y.M./Compost**				
	a. Costly or on availability	35.(53.03)	39(69.54)	97(75.78)	171(68.40)
	b. Used for previous season crop	04(06.06)	02(03.57)	13(10.16)	19(07.60)
	c. Shortage of labour	01(01.52)	011(08.59)	19(14.84)	31(12.40)
iv	**Season Planting**				
	a. Harvesting period adjusted by factory	07(10.61)	09(16.07)	29(22.66)	45(18.00)
	b. Delayed harvesting of previous crop	03(04.55)	01(01.79)	07(05.47)	11(04.40)
	c. Lack of resources	02(03.03)	01(01.79)	09(07.03)	12(04.80)

v	**Method of planting**				
	a. One eye bud or two bud technique is laborious and costly	36(54.55)	32(57.14)	85(66.41)	153(61.20)
	b. Sparse plant population	13(19.70)	14(30.36)	31(24.22)	58(23.20)
	c. Reduces yield	19(28.79)	17(30.63)	36(28.13)	75(30.00)
	d. Yield potential is less as compared to extra expenses	18(27.27)	14(25.00)	29(30.47)	61(24.40)
vi	**Weed management**				
	a. Shortage of labour and capital	25(37.86)	34(60.71)	85(66.41)	144(57.60)
	b.1 to 2 weeding sufficient	11(16.67)	13(23.21)	27(21.09)	51(20.40)
	c. doubtful about effect of herbicides	11(16.67)	11(19.64)	31(24.22)	53(21.20)
	d. High cost of herbicides	39(59.09)	43(76.79)	111(86.72)	193(77.20)
vii	**Fertilizer management**				
	a. High cost of fertilizers	46(69.70)	48(85.71)	103(80.470	197(78.80)
	b. Recommended dose not known	21(31.82)	16(28.57)	39(30.47)	76(30.40)
	c. N,P,K combinations difficult to calculate	17(25.76)	19(33.93)	37(28.91)	73(29.20)
	d. shortage of labours	17(25.76)	17(30.36)	38(29.36)	66(26.40)
viii	**Micronutrients**				
	a. High cost of micro nutrients	38(57.88)	31(55.36)	99(77.34)	168(67.20)
	b. unknown about deficiency and soil testing	25(37.88)	16(28.57)	45(35.36)	86(34.40)
	c. Recommendation not known	11(16.67)	15(26.79)	33(25.78)	59(23.60)
ix	**Water Management**				
	a. Irregular supply through cannel and lift irrigation	53(80.30)	47(83.93)	103(80.47)	203(81.20)
	b. Inadequate electricity and load shading	58(87.88)	49(87.50)	109(85.16)	216(86.40)
	c. Drip irrigation system is costly	40(60.60)	35(62.50)	71(55.47)	146(58.40)
	d. Problem of rodents, repair and maintenance	48(72.73)	39(69.64)	98(76.56)	185(74.00)

x	**Ratoon management**				
	a. Trash decomposition is difficult and complicated	38(57.88)	31(55.36)	85(66.40)	157(62.80)
	b. Trash decomposition technique not known	21(31.82)	15(26.79)	39(30.47)	75(30.09)
	c. Obstacle of trash for tillage operation and irrigation	36(54.55)	29(51.79)	61(47.66)	126(50.40)
	d. High cost and shortage of labour for cleaning and tillage operation	29(43.94)	27(48.21)	71(55.47)	127(50.80)
	e. Taking ratoon of sugarcane harvested up to 15th Feb.	27(40.91)	25(44.69)	69(53.91)	121(48.40)
	f. Late harvesting of previous crop	19(28.79)	14((25.00)	34(26.56)	36(14.40)

Note: - N=Number of respondents

Figures in parenthesis are the percentages to the number of respective type of sugar cane cultivated

ii. Preparation of layout

About 62.80 percent sample growers expressed that strip method reduces yield, while 2.40 percent growers were unknown about strip method recommendation.

iii. F.Y.M. or compost use

Regarding the F.Y.M. use, 68.40 per cent sugarcane growers indicated that, F.Y.M. was costly and not available in required quantity. Of the total respondent 7.60 percent respondent used it for previous season crop, while, 12.40 percent growers faced the problem of shortage of labour for F.Y.M .application.

iv. Season of planting

Majority of farmers adopted the proper time of planting, however, 18.00 percent sugarcane growers expressed that, season of planting was managed by factory to adjust the harvesting time. About 4.40 percent sugarcane growers perceived that delayed harvesting of previous crop led to late

planting, while 4.80 percent respondents were lacking in resources like labour, capital or water at the time of planting.

v. **Method of planting**

At the overall level, 61.20 percent respondents indicated that, the one or two eye bud method was laborious, time consuming and costly, while 23.20 percent farmers indicated that this method leads to sparse plant population. About 30.00 percent sugarcane growers expressed that, one or two eye-bud method reduces yield, while 24.40 percent farmers indicated that, yield potential is less as compared to extra expenses.

vi. **Weed management**

Shortage of labour and capital for weeding operation in sugarcane cultivation was one of the major constraint expressed by 57.60 percent farmers, while, 20.40 percent respondents perceived that 1 to 2 weeding were sufficient for sugarcane crop. Regarding the use of herbicides, 77.20 percent growers expressed that herbicides were costly, while 21.20 percent farmers were doubtful about the effects of herbicides on weeds.

vii. **Fertilizer management**

At the overall level, about 78.80 percent sample sugarcane growers reported the reason of high cost of fertilizers. At the overall level, about 29.20 percent farmers perceived that the combination of N, P and K was difficult to calculate as per the recommended dose, whereas 30.40 percent farmers were unknown about the recommended dose of fertilizers. Shortage of labour at the time of fertilizer application was faced by 26.40 percent of growers.

viii. **Use of Micronutrients**

Regarding the use of micronutrients at the overall level, 67.20 percent respondents perceived that high cost of micronutrients is the main constraint for the non-adoption. Moreover, 34.40 percent farmers were unknown about soil deficiency and soil testing, whereas 23.60 percent farmers were

unknown about recommendation. About 20.83 percent farmers were doubtful about the effect of micronutrients on the productivity of sugarcane.

ix. Irrigation management

Water management is a major aspect of sugarcane cultivation. Farmers faced severe problems regarding inadequate electricity or load shading (86.40 %) and irregular supply through canal and lift irrigations (81.20 %). About 58.40 percent respondents expressed that, the use of drip irrigation system for sugarcane crop at the overall level was costly, while 74 percent farmers were reported the problem of rodents or maintenance and repairs of drip irrigation set.

x. Ratoon management

In ratoon sugarcane, trash management was major problem faced by the farmers. At the overall level, majority (62.80percent) farmers think that, trash decomposition is difficult and complicated, while 30.90 percent farmers were unknown about the trash decomposition technique. Obstacle of trash in tillage operations and irrigation were reported by 50.40 percent farmers.

More than 48.40 percent growers were unknown about the recommendation that, only the crop harvested before 15th February should be kept for ratoon, while 14.40 percent farmers reported the problem of late harvesting of cane. About 50.80 percent farmers faced the problem of high cost and labour shortage for cleaning and tillage operations.

Thus, it clearly indicates that sugarcane growers faced various constraints/problems in the adoption of sugarcane production technology. The use of recommended quantity of F.Y.M. and recommended doses of fertilizers were the major constraints, whereas high cost, absence of knowledge and non-availability of the recommended fertilizer dose are also significant constraints. Farmers also neglect the recommended preparatory tillage practices, seed treatment and disease, pest management. Labour shortage was another important constraint faced by the farmers. Because of high cost, the growers showed

negligence towards the use of drip irrigation system. These findings are consonance with observations of Rama Rao (2012), Lahoti *etal* (2010) and Mande and Thombre(2009). The extension agency has to look into these constraints in order to strengthen the adoption process of technology for boosting sugarcane productivity.

4. Conclusions

This paper attempted a quantification of yield gaps in different planting type of sugarcane in Maharashtra during 2011-12. The production of sugarcane in Maharashtra showed significant growth from 1960-61 to 2011-12. This significant growth was attributed to increase in cultivation area of sugarcane. The yield of sugarcane has remained stagnant in last two decades and even starts declining in current decade. Declining yield is a disturbing feature especially because this crop is having largest area under cultivation among all crops in Maharashtra. Also the resources are used extensively for the sugarcane which affects the environmental and ecological balances. Excess use of water through flood irrigation combined with higher doses of fertilizers is resulting in enhanced rate of degradation of land resources in certain parts of state. This has cyclical effect on the yield of the sugarcane and other crops cultivated in particular area.

The magnitude of yield gap-I at overall level, was higher for preseasonal sugarcane (29.73 percent) followed by suru (28.13 percent), adsali (23.00 percent) and ratoon (12.00 percent) which implies that, the technology developed at research station cannot be duplicated on demonstration plots to exploit the full potential of sugarcane. This gap was attributable to environmental differences and non transferable component of technology.

The orthodox practices being followed on farmer's field lead to yield gap-II at overall level. Maximum yield gap-II was observed in ratoon sugarcane (35.34 percent) because of poor management practices followed for ratoon sugarcane. The yield gap-II for adsali, suru and preseasonal sugarcane farms 26.83 percent, 23.86 percent, 22.29 percent respectively. The farmers usually do not adopt a

technology as a package but take up individual practices suitably trimmed to fit into their budget and skills (management and operational) which lead to the variation in the adoption of cultural practices and consequently to the yield gaps. Therefore, cultural practices like preparatory tillage, season planting, recommended dose and balanced use of plant nutrients, weeding and intercultural operations, manure, diseases and pest management, water management have been very crucial for exploiting untapped farm potential incurring little cost.

There existed a great variability in production elasticises of different inputs used in the production of adsali, preseasonal, suru and ratoon sugarcane. Human labour, bullock labour, machine power, fertilizers (Nitrogen, Phosphorous and Potash), manure, planting material and weedicide charges are mainly responsible for the yield gap.

Sugarcane growers faced various constraints in the adoption of recommended sugarcane production technology. Scarce and costly labour for adopting tillage practices, high cost and non availability of F.Y.M., high cost of fertilizers, inadequate supply of electricity and load shading, costly drip irrigation system were the major constraints faced by more than 60.00 percent of sugarcane growers.

The yield gaps cannot be completely eliminated, but can be minimized by efficient and effective resources management. Smaller the input gaps between the demonstration plots and the farmer's fields, larger the productivity gains on farmers' fields. It is also essential to promote collaboration among various institutions engaged in agriculture productivity (research, extension, NGOs and State Agricultural Universities and private sector) to develop appropriate technology with a view to minimize the yield gaps.

4.1. Policies implications for minimizing the yield gaps

The following policy implications were suggested for increasing the productivity of the sugarcane and minimising the yield gaps.

a) **Planting material:** Quality seed assumes a great significance in any crop production. Sugarcane being a vegetative propagated crop, there is a need to change the seed after every three to four years to maintain the purity of the varieties and to avoid the pest and disease spread through the seed. Supply of setts to the farmers is a practice in most of the sugar factory areas following the three-tier seed program (breeder, foundation and certified). There is a need to reduce the seed quantity to cut down the cost of seed and at the same time, germination percent at field should exceed 85%. Planting of two eye bud setts, keeping 10 to 15 cm distance between two setts, instead of three eye bud setts planted end to end, reduces the seed cost by 33%.

b) **Irrigation management:** Water saving strategy should be given prime importance in sugarcane cultivation. Sugarcane being a long duration crop, water management assumes a great significance in maintaining crop productivity and soil health. Drip irrigation system not only the enhanced water use efficiency as compared to furrow irrigation but also reduces the degradation of the soil fertility and also boost the cane productivity. This system increases sugarcane yield by 25-30%, and saves irrigation water by 35% to 55% and fertilizers by 30%. It is becoming popular in areas with water shortage as well as in areas with adequate moisture, since it avoids the soil degradation that results due to the flow irrigation.

c) **Fertilizer management:** Soil health is important for crop health. N, P and K should be applied on the basis of soil test. Due to excess use of inorganic fertilizers and non-judicious use of irrigation water, soils in the canal irrigated areas are deteriorating. It is highly essential to apply organic manures, viz., F.Y.M., vermicompost, biocompost or green manures.

d) **Micronutrients**: Use of soil amendments like sulphur, pressmud compost or F.Y.M. to reclaim alkaline soils is necessary. The cane yield increased by 18.04 % by sulphur application (@ 60 kg/ha) in S- deficient soils. Pressmud should be applied after proper composting once in three years. Biocomposting of pressmud at the factory level has proved fruitful and economic. Many soils have shown response to micronutrients like Fe, Zn and Mn.

e) **Sugarcane trash**: Sugarcane trash can be used as mulch and as a source of organic manure. Use of 80 kg urea, 100 kg SSP and 10 kg decomposing culture/ha on the trash are helpful for better and fast decomposition. Sugarcane trash can also be incorporated with press mud while making organic manure and vermicompost. Trash adds about 25-30 kg N/ha to the soil.

f) **Green manuring**: Sunhemp, dhaincha, green gram, cowpea etc. are grown as green manure crops. Sunhemp and dhaincha can be grown as a sole crop and buried in the field at an age of 1.5 to 2 months followed by sugarcane planting. These can also be grown along with sugarcane by sowing in between two rows of sugarcane and burying in the soil at the time of earthing up. On an average 20 tonnes of green matter (85-90 kg N) are added per hectare by sunhemp and dhaincha.

g) **Crop rotation and intercropping:** It is most essential to follow the proper crop rotation according to the agro climatic conditions to improve the biophysical properties of the soil, maintenance of nutritional status and reduction in pest incidence. Due to monoculture of sugarcane, soil is deteriorating resulting in substantial reduction in sugarcane productivity per hectare. Intercrops control weeds up to 60% in the initial stage, helps in optimum utilization of land and provide extra income to farmers.

h) **Integrated pest, disease and weed management:** Integrated management of borers, woolly aphids, white grubs, scale insects, termites, white fly, black bug etc. needs more attention as per the incidence. More emphasis is

needed to control sugarcane borers with the use of natural enemies. Control of rodents is another important aspect of plant protection. A cooperative approach is needed for rodent control in sugarcane ecosystem. Collection and destruction of adult beetles is the most suitable and economic method to control white grubs in endemic pockets.

Use of weedicides and power tiller/tractor drawn implements has reduced the cost of weed control by 50%. In wider row plantings, inter crops are more useful to reduce the weed problem. In ratoon, trash mulching is found to be helpful in suppressing weed growth.

i) **Labour scarcity and scope for mechanization:** Sugarcane is a labour intensive crop, which requires about 250 to 400 labour mandays per hectare. Most of the cane operations are carried out manually and the use of machinery is limited only for field preparation. The human labor cost constitutes more than 50% for labor intensive sugarcane crop.

Tractor drawn sugar cane planter, trash shredder, intercultural implements, stubble shaver and rotavator etc. are very useful and cost effective in sugarcane cultivation. However, the costs of these equipment's are prohibitive. There is a prime need to make these implements available at cheaper rates for purchase/hiring at the farmer's level without which true farm mechanization is not possible. Use of the sugar cane planter and interculture implements reduce the labor cost by fifty percent.

j) **Extension support and transfer of technology:** There is an urgent need to strengthen the extension mechanism by establishing strong linkages between research institutions, sugar mills and farmers for efficient transfer of improved technologies in sugarcane agriculture. The available technologies should be transferred quickly and efficiently using the modern tools. Conduct of result demonstrations, operational research projects (ORP), problem based training programmes, visits of farmers to research institutes and pilot farms, publication of literature in local language, exhibitions, use of audio visual aids, websites etc. are essential for effective transfer of

technology. It is highly essential to encourage the farmers through awards and felicitations. A production assurance scheme should be implemented by a micro level planning at the village level, pooling of resources, credit supply and active participation of the farmers' groups.

k) **Ratoon management:** Sugarcane ratoon occupies more than 47.60 percent of the total sugarcane area in the study area. However, its contribution to the total cane production is about 25-30 percent. Productivity of ratoon crop is 10 to 30 percent less than the plant crop of sugarcane. One of the major reasons of low yield is the poor management of the ratoon crop. With improved ratoon management, more ratoon crops can be taken by maintaining required plant population through gap filling by settlings. However, the ratoon crop which accounts for 40 to 50 % of sugar cane crop, is in general, neglected by the farmers causing a great loss in cane and sugar production. Stubble shaving, use of trash as mulch either in every furrow or alternate furrows, gap filling with settlings, use of bio fertilizers and micronutrients, irrigation management at appropriate time, plant protection and crow bar method of fertilizer application etc. are important components of the ratoon management.

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APPENDICES-I

Quantification of yield gaps in different planting types of sugarcane in Maharashtra

Schedule

I. General information

1. Name of Sugarcane growers : Shri.
2. Village: Tal. : Dist:
3. Age :
4. Education :
5. Occupation :
   Main : Subsidiary:

II. Details of family

Sr. No.	Name of family member	Age	Education	Relation with head of family	Occupation of earners		Remark
					Main	Subsidiary	

III. Details of land holding

Survey No.	Total holding (ha)	Permanent fallow (ha)	Cultivable area (ha)		Present value (Rs.)	Land revenue & taxes (Rs.)	Leased in/out land (ha)	Rent paid/ received (Rs.)
			Irrigated	Dry				

IV. Details of irrigation structure

Sr. No.	Type	Construction/ purchase		Present value (Rs.)	Total irrigated area (ha)	Actual irrigated area (ha)	Remaining life (yrs)	Annual repairs (Rs.)	Contribution share if common (Rs.)
		Year	Value (Rs.)						
1.	Well								
2.	Boar well								
3.	Electric motor								
4.	Diesel engine								
5.	Pipeline								
6.	Drip/Sprinkler irrigation set								

V. Details of buildings

Sr. No.	Category	Construction/ Purchase		Present value (Rs.)	Remaining life (yrs)	Annual repairs (Rs.)
		Year	Value(Rs)			
1.	Residential house					
2.	Farm house					
3.	Store (Part of house)					
4.	Cattle shed					
5.	Shop for business					
6.	Others					

VI. Implements and machinery

Sr. No.	Category	Construction/ Purchase		Present value (Rs.)	Remaining life (yrs)	Annual repairs (Rs.)
		Year	Value (Rs).			
A.	**Implements**					
1.	Iron plough					
2.	Wooden plough					
3.	Harrow					
4.	Hoe					
5.	Bullock cart					
6.	Seed drill					
7.	Chopper					
8.	Spade					
9.	Weeding hook					
10.	Sickle					
11.	Others					

VI. Implements and machinery

Sr. No.	Category	Construction/ Purchase		Present value (Rs.)	Remaining life (yrs)	Annual repairs (Rs.)
		Year	Value (Rs).			
B.	**Implements**					
1.	Tractor					
2.	Implements					
3.	Sprayer					
4.	Duster					
5.	Ridger					
6.	Other					

VII. Details of livestock

Sr. No.	Type	No.	Breed	Hired/ family	Age (yrs)	Present value (Rs.)	Remaining life (yrs)	Annual expenditure on veterinary aids (Rs.)
1.	Draft Animal							
2.	Milch animal							
a.	Cow							
b.	Buffalo							
3.	Sheep							
4.	Goat							
5.	Poultry birds							
6.	Others							

VIII. Land use and Cropping pattern

(Hectares/ sample)								
Particulars	**Size groups**							
	Small		**Medium**		**Large**		**Overall**	
	Area	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**
A. Land Use Patten								
Total land holding								
Net cultivated area								
Irrigated area								
Unirrigated area								
B. Cropping pattern								
Total sugarcane								
Adsali								
Preseasonal								
Suru								
Ratoon								
Onion								
Total Cereals								
Total pulses								
Total Oilseeds								
Total fodder crops								
Vegetables								
GCA(Gross Cropped Area)								
Cropping Intensity in %								

IX) Cost of cultivation sheet

Method of cultivation: Strip/Conventional. Sole crop : Variety …… Area (ha) …… Intercrop : Main crop : ….. Variety : .....
Area (ha): ..... Intercrop: Variety..... Area (ha) …… Source of Irrigation: Well/Canal/Lift/Well + Canal …. Irrigation charges: Rs….

Sr. No.	Operation	No.	Input used		Labour utilization (days)								Hired wages (Rs.)			
			Qty. (kg)	Value (Rs.)	Family				Hired				M	F	B	Ma (hrs)
					M	F	B	Ma (hrs)	M	F	B	Ma (hrs)				
A.	**Preparatory tillage**															
1.	Ploughing															
2.	Harrowing															
3.	Clod crushing															
4.	Stubble collection															
5.	Manure application															
6.	Preparation of ridges and furrows															
B.	**Planting**															
1.	Seed treatment															
2.	Planting															
C.	**Intercultural operations**															
1.	Hoeing															
2.	Weeding															
3.	Herbicide application															
4.	Earthing up															
a.	First															

b.	Second															
5.	Irrigation															
D.	**Fertilizer application**															
1.	First dose															
2.	Second dose															
3.	Third dose															
4.	Total N															
	P															
	K															
5.	Micronutrients															
E.	**Plant protection**															
1.	Spraying															
2.	Insecticide															
3.	Fungicide															
F.	Harvesting															

Yield: Main crop: Main produce (Qty): …… Value: …… ` By Produce (Qty) ……. Value …….. `
Intercrop: Main produce (Qty.) ……. Value: …… ` By Produce (Qty) ……. Value …….. `

X) Adoption of Recommended production technology for planted type of sugarcane

Sr. No.	Components of Technology	Planting type		
		Adsali adoption	**Preseasonal adoption**	**Suru adoption**
i	**Preparatory Tillage**			
	a. 2. Ploughing + 2-3 harrowing			
	b. 1 Ploughing + harrowing			
	c. 1 Ploughing + 2-3 harrowing			
ii	**Planting methods**			
	a. Ridges and furrow			
	b. Strip method			
iii	**F.Y.M.(Farm Yard Manure)**			
	a. No adopting			
	b. Below 50 Percent			
	c. Above 50 percent			
	d. above 75 percent			
	e. above 100 percent			
iv	**Improved varieties**			
	a.CO 86032			
	b.CO265			
	c. Other			
v	**Season of planting**			
	a. Improper time			
	b. Proper time			
vi	**Planting material**			
	a. One eye bud (nursery bud)			
	b. Two eye bud			
	c. Three eye bud			
vii	**Seed setts treatment**			
	a. Hot water treatment (500C for 2 hours)			
	b. Azetobactar treatment (10 kg/100 lit. water)			
viii	**Weed management**			
	a.1-2 Weedinges			
	b.3-5 weedinges			
	a. Chemical weed control			
ix	**Fertilizer management**			
	I). N (Nitrogen)			
	1.Below 50 Percent			
	2.Above 50 percent			
	3.above 75 percent			
	4.above 100 percent			
	II). P (Phosphorus)			
	1.Below 50 Percent			
	2.Above 50 percent			
	3.above 75 percent			

	4.above 100 percent			
	III). K (Potash)			
	1.Below 50 Percent			
	2.Above 50 percent			
	3.above 75 percent			
	4.above 100 percent			
x	**Intercropping**			
xi	**Use of Micronutrients**			
xii	**Irrigation Management**			
	a.Rainy-14 to 15 days interval			
	b. Winter- 15 to 20 days interval			
	c. Summer- 8 to 10 days interval			
	d. Drip Irrigation			
xiii	Diseases and Pests Managements			
	Grassy shoots (Hot water treatment)			
	Wooly aphids (Initially phorte, after infestation spraying of Methyl Demeton)			
	White grubs (Chlorpyriphos)			
xiv	Trash mulching operation			

XI) Adoption of recommended Ratoon sugarcane production technology on sample farms

Adoption of recommended Ratoon sugarcane production technology on sample farms		
Sr. No.	**Components of Technology**	**Adoption**
i	**Trash Management**	
	a. By burring	
	b. Trash used as compost in the field	
ii	**Cleaning and tillage operations**	
iii	**Varieties for Ratoon crop**	
	a.CO86032	
	b.CO265	
	c. Other	
iv	**Weed management**	
	a.1 to 2 weeding	
	b.3 to 5 weeding	
	a. Chemical method of weed control	
v	**Application of FYM**	
vi	**Fertilizer management**	
	N	
	a. Below 50percent	
	b. Above 50Percent	
	c. Above 75 percent	
	d. Above 100 percent	
	P	
	a. Below 50percent	

	b. Above 50Percent	
	c. Above 75 percent	
	d. Above 100 percent	
	K	
	a. Below 50percent	
	b. Above 50Percent	
	c. Above 75 percent	
	d. Above 100 percent	
vii	**Methods of Fertilizer application**	
	a. Side dressing	
	b. Crow bar method	
viii	**Use of Micronutrients**	
ix	**Irrigation Management**	
	a. Rainy monsoon	
	b. Winter season	
	c. Summer Season	
	d. Drip Irrigation	
	c. Trash mulching operation	
x	**Diseases and Pests Managements**	
	Woolly aphides	

XII) Constraints in the adoption of sugarcane production technology on sample sugarcane farms

Sr. No.	**Components of Technology**	**Size groups**			
		Small N	Medium	Large	Overall
i	**Preparatory tillage**				
	a. High cost and scare labour				
	b. To follow timely planting skip some operation				
	c. Limited capital				
ii	**Layout**				
	a. Strip method reduced yield				
	b. Unknown about strip method recommendation				
iii	**F.Y.M./Compost**				
	a. Costly or on availability				
	b. Used for previous season crop				
	c. Shortage of labour				
iv	**Season Planting**				
	a. Harvesting period adjusted by factory				
	b. Delayed harvesting of previous crop				
	c. Lack of resources				
v	**Method of planting**				
	a. One eye bud or two bud technique is laborious and costly				
	b. Sparse plant population				
	c. Reduces yield				
	d. Yield potential is less as compared to				

	extra expenses				
vi	**Weed management**				
	a. Shortage of labour and capital				
	b.1 to 2 weeding sufficient				
	c. doubtful about effect of herbicides				
	d. High cost of herbicides				
vii	**Fertilizer management**				
	a. High cost of fertilizers				
	b. Recommended dose not known				
	c. N,P,K combinations difficult to calculate				
	d. shortage of labours				
viii	**Micronutrients**				
	a. High cost of micro nutrients				
	b. unknown about deficiency and soil testing				
	c. Recommendation not known				
ix	**Water Management**				
	a. Irregular supply through cannel and lift irrigation				
	b. Inadequate electricity and load shading				
	c. Drip irrigation system is costly				
	d. Problem of rodents and repair and maintenance				
x	**Ratoon management**				
	a. Trash decomposition is difficult and complicated				
	b. Trash decomposition technique not known				
	c. Obstacle of trash for tillage operation and irrigation				
	d. High cost and shortage of labour for cleaning and tillage operation				
	e. Taking ratoon of sugarcane harvested up to 15th Feb.				
	f. Late harvesting of previous crop				