SUSTAINABLE SUGARCANE CULTIVATION UNDER MONOCULTURING IN MAHARASHTRA.

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ABSTRACT

At present the state of Maharashtra produces 30-40% of the total cane sugar produced in India. But in last decade the sugar recovery and cane yield both had drastically reduced mainly because of the monoculturing, the practice of sugarcane cultivation, which is at the same time highly profitable for farmers. Monoculturing is leading to development of phytotoxic microflora and accumulation of several allelochemicals in the soil. Not only this but due to ratoon soil desertification had taken place at the massive level.

The monoculturing process of sugarcane cultivation followed in sugarcane belt of Maharashtra had mainly hampered the soil biochemical processes and enzymatic activities, reducing it'sfertility. The emergence of phytotoxic fungi like *Curvularia, Saccaharomyces, Rhizoctonia, Fusarium* had aggravated the situation. However this problem is not yet attempted in depth. Hence the present study was aimed at the soil improvement through the practice of sustainable sugarcane cultivation.

The results of rhizosphere soil microflora and mineral nutrients analyses revealed that sustainable sugarcane cultivation can improve the soil fertility, resulting into successful ratooning .The overall studies indicated that organic farming had helped to reduce the harmful microflora, leading to development of the beneficial fungal flora like *Trichoderma* and *Paccilomyces*. The rhizosphere soil under organic farming showed richcontent of OC, P, K, Ca Mg S, Zn, Cu and Fe. Finally it can be concluded that monoculturing may become economical when sustainable/organic cultivation of sugarcane is followed in the state of Maharashtra.

Key Words: Sustainable cultivation, monoculturing, rhizosphere microflora, mineral nutrients in soil, pH, EC.

- **Introduction**

Maharashtra state represents one of the largest economies in India.Despite of the industrial growth in Maharashtra agriculture continuous to be the main occupation in the state. Maharashtra has always been a fourth runner in introducing innovative situations to the exiting challenges. The top status of Maharashtra in agriculture is mainly because of innovative, smart and progressive mindset of our farmers. Maharashtra has the mission to help the farmers through the training on new technologies of farming such as organic farming/sustainable agriculture**.**

At present sugarcane is the most important cash crop for farmers in the state of Maharashtra. The total area under sugarcane cultivation is 49.18 lakh hectares (India Agro Net.com) during the year and the total production of sugarcane was 350-355 lakh tons. As on today 143 sugar factories are functioning in the state out of this 77 factories are running on cooperative basis, while 66 are private ones. The sugarcane cultivation in Maharashtra is categorized as (i) Suru/plant cane- (12 months crop) (ii) Adsali– (18 months crop) (iii) Ratoon or monoculturing (long duration crop). Monoculturing is practiced for sugarcane cultivation throughout the stateof Maharashtra which is highly economical and profitable for the growers. Sugarcane ratooning ranges from 1st to 6th as per the zone, sugarcane variety and crop management.

In every successive ratoon, the cane population is decreased by 10-20 % which results into reduction in cane yield. Studies in Taiwan had attributed this to accumulation of allelochemicals exuded from the cane root system leading to soil sickness. In ratoon crop after harvesting, the old roots usually decompose producing phytotoxic compounds, which affect the root and shoot growth of new tillers, causing autotoxicity which is the most serious problem under monoculturing. The trash left behind after harvesting release several phenolic compounds such as P-hydroxybenzoic acid, 2,4,dihydroxybenzonazilone and benzonazinone which additionally affect the growth of sugarcane.

Thomas *et. al.*(1967)indicated that soil sickness is major cause for yield reduction in ratoonformed thephytotoxic metabolites produced by soil fungi like *Fusarium* causes damage to the newly formed active root system of sugarcane also leading to autotoxicity which there by cause severe reduction in cane population and

yield. Narwal (2006)stated various factors responsible for soil sickness due to monoculturingin sugarcane such as one sided nutrients exhaustion, lack of micronutrients, excess use of fertilizers, deterioration of physical, chemical and biological properties of soil, development of phytotoxic microflora, pest multiplication, excessive infestation by invasive weeds in sugarcane field, accumulation of allelochemicals released from old root system or decaying of the sugarcane trash in soil, change in pH and EC of the soil affecting nutrients uptake of the crop . All such problems finally results in to the great reduction and cane yield taking heavy troll of farmer's profit. To overcome these problems sustainable cultivation is one of the best methods. During organic farming the agriculture wastes are converted into cheap, useful and profitable organic manures to improve the soil structure and to reap high benefits from it. It gives sustainability in relation to productivity, soil properties, depletion in water resources and improvement of soil microflora. In sustainable farming farmyard manures, compost, green manures, biofertilizers etc. are used which enhance the fertility of soil. Biofertilizers significantly improved the nitrogen content of stem at 200 and 300 kg N ha^{-1} compared to control (K. Hari and T. R. Srinivasan, 2005).The crop productivity declines due to (i). Crops produce phytotoxic substances in soil and (ii). The accumulation of phytotoxins causes the imbalance of microbial population, such as Fusarium oxysporum in soil (C.H.Chou, 2010).

- **Material and Methods**

1) Analysis of biochemical parameters and mineral nutrients-

Rhizosphere soil samples were collected from 2^{nd} , 5^{th} and 6^{th}ratoon from Kolhapur region. These soil samples were analyzed for pH, EC. Organic carbon, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Zinc, Copper and Iron by using Atomic Absorption Spectroscopy.

2) **Isolation, identification and characterization of rhizosphere microflora-**

Soil dilution method was used for this. The soil solution of desired dilution was inoculated on PDA medium in petriplates, which were incubated for 2-4 days in an incubator. The fungal forms were identified by using the methods of Ellis (1971 and 1979) and Thomas and Raper (1949 and 1965).

- **Results and Discussion:**

The results shown in Table No. 1 indicated that various species of phytotoxic and harmful fungi had developed during monoculturing of sugarcane. These species of fungi*Cladosporium,Verticillium, Curvularia, Saccharomyces, Rhizoctonia, Fusarium, Aspergillus, Rhizoctonia,* secretes large number of harmful chemicals and secondary metabolites into the soil after every successive ratooning, which make the soil unfertile. Not only this but it also creates autotoxicity as well as soil sickness under monoculturing.Amongst these*Fusarium*is most dreadful, because it secrets fusaric acid, which is the main cause of autotoxicity in ratoon sugarcane. Marko (2005) supported the findings of present investigations. According to Kumari&Kohli (1987) autotoxicity is the self-destruction of a species through the production of chemicals that escape into the environment and directly inhibit the growth their own.

The effective solution for such type ofadverse impact on soil is achieved through organic farmingin sugarcaneratoon. The sustainable growth of ratoon achieved inratoons is attributed to the organic farming method. During organic farming the physiological, biological and enzymological activities in the soil switch on to the positive or favourable side and hence it reduces the phytotoxic fungal flora and enhances the beneficial fungal(*Tricoderma*) as well as bacterial flora (N-fixer and P- solubalizers). If the phytotoxic flora in the rhizosphere soil of ratoon is reduced, the rate of release of various harmful and poisonous allelochemicals will be reduced leading to decrease in soil sickness and autotoxicity. These are the main reasons of sustainable ratoon production, due to organic farming. Not only this but the nutrient status of the soil under ratoon is highly improvedby organic farming, which is clearly seen from the results recorded in Table No. 2. Under monoculturing of sugarcane almost all the essential macro and micronutrients were exhausted and the soil was showing desertification. However under organic farming there is balance of nutrients.

The most favorable pH of the soil for absorption of maximum available nutrients by the plant is 5.6 to 6.5 (Taiz and Zeiger 1998). This type of soil pH achieved through organic farming favours the uptake of essential micro and macronutrients. Table No.2 indicated that the soil under successive ratoons was comparatively poor in organic carbon, P, K, Ca, Mg, S, Zn, Cu and Fe, which may be affecting cane and sugar yield. Singh (1974) indicated that ratooning potential of sugarcane depends on levels of nitrogen, potassium, Calcium and many

other nutrients available in the soil. Perumal (1985) also supported the above view and claimed that nitrogen, phosphorous and potassium content were correlated with yield and CCS % in the cultivar CO-671 under ratoon as wellas plant crop. The growth developmentand normal metabolic functionsincluding synthesis of sugar depends onnutrient balance in the soil and leaf itself. Table No. 3 clearly showed that the mineral content like P, K, Ca, Mg, Zn, Cu and Fe, were highly rich in all the ratoons, which were grown through organic farming methods. Ramkrishnarao and Rammalingaswamy (1981) reported the level of micronutrients in plant and ratoon crop of different sugarcane cultivars. They noted that ratoons were showing higher Iron content than plant crop irrespective of the variety. Results of the present study are in agreement with the above findings. They further reported that the level of zinc was also higher in ratoon as compared to plant crop. However, the content of copper exhibited higher values in plant crop and lower values in ratoon.

Prasad Rao et.al. (1987) in theirstudies on macro and micro nutrientcomposition of soil and the plants inratoon cane claimed that maintaining ofadequacy level of macro andmicronutrients is essential for obtaininghigher cane yields. G.Suja et.al.(2017)in their studies reported as organic farming proved to be an eco-friendly alternative to conventional farming in taro for stable yield and quality cormels as well as for maintaining soil health.

This may be thereason for improved cane yield andCCS % in different ratoons, due toorganic farming.The balanced nutrient status of thesoil, enriched beneficial soil microflora,optimum uptake of essential micro andmacronutrients favored the growth aswell as various metabolic process.

- **Summery and Conclusion**

Thus the overall studies have clearly indicated that sustainable cultivation through organic farming may be the most efficient and effective solution to improve the soil fertility and nutrient status of the soil in sugarcane. This will truly enhancethe cane yield and sugar recovery even under monoculturing of sugarcane. The farmers if properly guided for organic farming maybe able to takemore successive ratoons which will increase their economic returns.

The organic farming method as it is sustainable will become the boon for farmers and for sugar industries in Maharashtra.

The present studies recommended integrated organic farming for monoculturing in sugarcane which will help to achieve maximum theoretical cane yield .

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- **Results**

Table No.1: Development of Phytotoxic rhizoshere microflora under monoculturing of sugarcane under different varieties grown in different regions of Maharashtra.

Name of the Variety	Soil Samples	Soil Dilutions	Names of toxic fungal microflora
Co-671 (NOG)	2nd ratoon	10^{-10}	*Cladosporium sp.*
		10^{-8}	*Verticillium sp.*
Co-671 (NOG)	5th ratoon	10^{-10}	*Curvularia sp.*
		10^{-4}	*Saccharomyces sp.*
Co-671 (NOG)	6th ratoon	10^{-8}	*Rhizoctonia sp.,Fusarium sp.*
		10^{-4}	*Aspergillus sp., Rhizoctonia sp.*
Co-740 (OG)	37th ratoon	10^{-3}	*Trichoderma sp.*

- NOG - Non organically grown
- OG - Organically grown

*2nd, 5th and 6thratoon soil samples collected from Kolhapur region under nonorganic conditions.
* 37thratoon soil samples collected from Shimoga (Karnataka) grown under totally organic conditions.

Table No. 2 : pH, EC and mineral contents in soil samples under monoculturing of sugarcane for different cultivars in Maharashtra.

Sugarcane Varieties	No.of ratoons	pH	EC	Organic Carbon (g/kg soil)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (ppm)	Sulphur (%)	Zinc (ppm)	Copper (ppm)	Iron (ppm)
Co-671 (NOG)	2nd	5.5	0.09	0.56	17.2	205.8	0.10	10.32	20.89	1.07	4.99	243.3
Co-671 (NOG)	5th	6.97	0.22	1.08	20.4	195.6	2.45	16.17	25.66	2.20	7.62	202.2
Co-671 (NOG)	6th	7.57	0.26	1.10	17.5	210.5	5.03	17.47	29.35	2.54	10.05	244.4
Co-740 (OG)	37th	6.31	0.27	1.26	30.6	222.8	10.73	26.22	31.25	9.02	12.03	680.6

- NOG - Non organically grown
- OG - Organically grown

*2nd, 5th and 6thratoon soil samples collected from Kolhapur region under nonorganic conditions.

* 37thratoon soil samples collected from Shimoga (Karnataka) grown under totally organic conditions