Received : 05.08.2023 | Accepted : 26.09.2023 | Online published : 01.10.2023
https://doi.org/10.54986/irjee/2023/oct_dec/126-133
IRJEE SOCIETY OF EXTENSION EDUCATION

RESEARCH ARTICLE

Intercropping In Sugarcane by Growers of Kolhapur District, Maharashtra: A Performance Analysis

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ABSTRACT

Every year, due to increase in cost of cultivation, the monetary returns to cane growers decrease significantly. To increase the returns per unit area, growers are advised to take up intercropping in the early stages of crop growth by selecting suitable intercrops. Sugarcane being a long duration crop, it takes 90-120 days for canopy development, during which intercrops can be grown. However, large scale adoption of intercropping in sugarcane is still a reservation and the present study was undertaken in Kolhapur district, Maharashtra, India. Most of the respondents had maize (40%) and groundnut (11.67%) as choice of intercrops as compared to other crops mainly for high remuneration. Correlation analysis indicated that the independent variables viz., occupational status, size of land holding, experience in sugarcane cultivation, farm implement possession, mass media exposure and social participation showed positive significant relation with adoption of intercropping. Farmers with more than a decade experience in sugarcane farming were widely prevalent in the sample and they tried to improve cane productivity by following the latest technologies. The respondent growers were found to adopt varied intercrops best suited to their area. Any intercrop that can be harvested within 90-100 days can be successfully grown in sugarcane. Every respondent who had grown an intercrop with sugarcane had realized an advantage and the advantages as perceived by the farmers in their order of importance include interim income within three months, incorporation of stubbles of intercrops improve soil health, less growth of weeds, fodder availability for livestock, increase in yield, reduction in weed infestation, reduction in cost of cultivation and availability of produce for home use. Intercropping is being promoted in sugarcane cropping system as a means of getting an interim income to the farmers and with wider row spacing the technology is gaining momentum among cane growers.

Key words: *Sugarcane, Intercropping, Advantages, Constraints*

Sugarcane is an important cash crop widely grown in tropical and sub-tropical India and plays a crucial role in national economy. The area under sugarcane in India revolves around 5.0 million ha at the national level with sugarcane productivity of approximately 80 t/ha during 2020-21 and total sugarcane production around 400 million tonnes.

Sociological studies among cane growers have revealed the prevalence of wide technological gap as well as yield gap in sugarcane that leads to reduced production and productivity *(RajulaShanthy et al 2020)*. The recent advances in sugarcane crop management have amply demonstrated that the use of scientific crop management practices and improved varieties have greater potential for improving sugarcane production. However, it is unfortunately true that our farmers in general have not made full use of the new technology in sugarcane cultivation (*Shanmugam, 1985; Sandeep et al, 2013*).

Great potential exists in India for increasing crop production and productivity through wider use of multiple cropping. In long duration crops like sugarcane, intercropping holds much promise. Intercropping refers to growing two or more crops simultaneously on the same piece of land with a definite row-planting pattern to obtain higher productivity per unit area.

Rapidly increasing population, increased demand for food, limited scope for extension of cultivation to new areas, diversified needs of small farmers for food and cash, etc. have necessitated the adoption of intercropping systems. Due to slow establishment of sugarcane during the first 90-120 days, the greatest scope for complementary effect lies in the addition of annual intercrops to the temporal system to improve resource use efficiency in the early crop growth period (*Singh et al, 2002*).

Companion cropping offers an opportunity for profitable utilization of available space. Sugarcane growers take advantage of this and grow various short duration crops like cereals, pulses, vegetables and spices as intercrops to obtain interim return. Small sugarcane growers need not wait until the harvest of the sole crop to obtain financial returns. Intercropping of economically important short duration crops with sugarcane through utilization of the present limited land resources would help to sustain sugarcane cultivation and provide interim return to marginal and small farmers, besides meeting the ever-increasing demand for vegetables and pulses (*Dhaliwal, 2017*).

With the introduction of very high tillering and high yielding varieties of sugarcane, there is a possibility to adopt wider row spacing and still sustain cane productivity. Such wide row spacing permits intercropping without adversely affecting the cane yield and thus increases the overall productivity and profitability of the system. The present problem of labour shortage may worsen in future affecting the survival of sugar industry and cane growers. Wide row spacing becomes an important agronomic consideration in future in developing countries (*Mahadevaswamy, 2001*).

Wide row spacing of 150 cm is preferable for sugarcane based intercropping systems and both soybean and black gram could be raised as profitable intercrops (*Gopalasundaram et al. 2012*).

Every year, due to increase in cost of cultivation and diminishing productivity, the monetary returns to growers also decreases significantly (*Saravanakumar and RajulaShanthy, 2022*). To increase the monetary returns per unit area, growers are advised to take up intercropping in the early stages of crop growth by selecting suitable intercrops. However, large scale adoption of intercropping in sugarcane is still a reservation.

Keeping this in view, the present investigation attempted to know the profile of farmers who had adopted intercropping, their perception related with the technology in sugarcane, the profit/loss incurred due to intercropping and further to help to understand the field level problems in intercropping.

METHODOLOGY

Maharashtra state in India is known for sugarcane production and more so, Kolhapur district Sugarcane is the main crop grown in Kolhapur district in considerable area and along with that paddy, vegetables, groundnut, sunflower, soybean, maize and pulses are also cultivated in the district. Sugarcane is widely grown in Kolhapur district for jaggery production. The soil in Kolhapur district varies in colour from region to region from brownish to reddish to black. Due to the presence of phosphorus in the soil the overall land of Kolhapur district is very suitable for plantation of sugarcane and tobacco. Silica and iron are also found in abundance in the soil of Kolhapur district. The average temperature in Kolhapur district throughout the year ranges from 16^0 C to 37^0 C. making sugarcane cultivation possible profitably. Hence, the study was purposively conducted in Kolhapur district, Maharashtra state. A sample of 120 sugarcane farmers growing intercrops were selected from the villages of Vhangutti, Waghapur, Malawe and Kasarwada in Bhudargad and Radhanagari taluks of Kolhapur district. The particulars were collected using a well structured pilot tested interview schedule, sociological appraisal was done through focus group discussions / observations, and yield data were recorded from the individual farms. The data collected were tabulated and analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Profile characteristics of sugarcane farmers : Demographic profile of the participants of the study indicated that one-half of the respondents were old aged and another 45 per cent were middle aged of 35 to 50 years. Hardly 5 per cent of the respondent farmers were of young age of below 35 years old clearly revealing the current agrarian scenario. Almost 98 per cent of the respondents were literates at varied levels of education, wherein 13.33 per cent had primary level of education, 43.33 per cent had secondary education and 41.67 per cent were graduates; this is a positive sign showing that educated people have opted for sugarcane farming with intercropping.

Occupational status: A total of 98.33 per cent of respondents had agriculture and allied farming as their main occupation and hardly two respondents (1.67%) had diversified occupation in addition to agriculture. As majority of the respondents were full time engaged in agricultural activities, they had high economic motivation and managed their farm in a better way.

Farming experience: A vast majority of 98.33 per cent were farmers with more than 10 years of cultivation experience, of which 40 per cent had 11-25 years of experience and majority of 58.33 per cent had over 25 years of experience in farming, their rich experience in farming made them to try new ideas.

Experience in sugarcane farming: Also, 98.33 per cent of the respondents had more than 10 years of experience in sugarcane cultivation correlating with the fact that more the years of experience, more their knowledge about sugarcane crop management.

Size of land holding: Regarding land holding, less than ten per cent (6.67%) of the respondents were medium land holders whereas 55 per cent were small farmers and 38.33 per cent were marginal holders and no large farmer.

Crop rotation: Sugarcane-paddy-sugarcane was the crop rotation followed by majority (98.33%) of the respondent farmers. Next to sugarcane crop, paddy is the major crop cultivated by the respondents. Crop rotation with other crops like groundnut and soybean were followed by just 6.67 per cent of the respondents.

Area under sugarcane: Less than half (41.67%) of the respondents were farmers who owned less than one acre area cultivated under sugarcane. Over half of the respondents (55%) had cultivated sugarcane in 1-5 acres of land and just 3.33 per cent had cultivated sugarcane in 5-10 acres of area. However, the size of holding has an influence on the area under intercropping and package of practices including intercropping followed in sugarcane.

Season of planting: Sugarcane is being planted during October-February months in the study area and majority of the respondents (81.67%) had planted sugarcane in the month of November coinciding with the North East monsoon. This is followed by planting in other months by 18.34 per cent, whereas in December by 10 per cent of the farmers followed by October, January and February planting.

Choice of varieties: Most of the respondents (68.33%) grow only one sugarcane variety, namely Co 86032. One to two varieties were grown by 30 per cent of farmers and just 1.67 per cent respondents had grown more than two varieties. Though Co 86032 was released in 2000, the variety is still preferred by the sugarcane farmers due to its excellent characters like high yield, high sucrose and best suited for jaggery making. CoM 0265 is a variety released for Maharashtra state and it was preferred by 3.33 per cent of the respondents. Co 92005 is well suited for jaggery making; Farmers opting for jaggery making preferred Co 86032 and Co 92005.

Source of information on sugarcane: Major source of information was friends as reported by 61.67 per cent; Nearly half (46.67%) of the respondents reported that they received information on new sugarcane varieties and technologies from neighbours. This was closely followed by 23.33 per cent of the respondent farmers who had most of the information from input dealers wherein they had exchange of information whenever the farmer had visited the dealers to procure some inputs.

Source of information on intercropping: Over half (53.33%) of the respondents reported that they received information on intercropping from friends. This was followed by 31.67 per cent of the respondents who had reported that neighbours were the source of information about intercropping. Less than a quarter (23.33%) of the respondents had obtained information on intercropping in sugarcane from department staff during meetings and training programs conducted. The other sources of information were input dealers and online.

Farm implement possession: Most of the respondents had the basic implements like spade, sprayer and some had cultivator, rotavator, plough and ridger. Spade and knapsack sprayer were owned by all the respondents. Most of the respondents hired bullock cart and power tiller from neighbours and friends on loan for their use. Country plough, cultivator, rotavator and ridger were owned by 80 per cent each of the respondents and the rest hired for their use along with tractor hiring.

Livestock possession: Most of the respondents (56.67%) had one to two draught animals as they work on farming as well as allied field of agriculture. Some farmers had more than three animals mainly mulching cattle, they run their small dairy business apart from agriculture. However, 10 per cent of the respondents reported that they possess no farm animals as they feel it as a liability and maintenance cost is high.

Annual income: The respondents were spread across all categories of income groups. The income level of farmers does not have any relationship for adoption or non- adoption of technologies. Over half of the

respondents (58.33%) had up to one lakh of annual income followed by 21.67 per cent with 1 to 2.50 lakhs and one-fifth of them had over 2.50 lakhs as annual income.

Mass media participation: Mass media is playing a remarkable role in disseminating information of a new technology to many audiences within a stipulated period. In this survey, the impact of three mass media *viz.*, radio, television, newspapers were analysed. Nearly 100 per cent of the respondents indicated that they have good mass media access. Mass media like radio and television have penetrated even into the most remote villages in the country and 98.33 per cent of them owned television or radio and listened to programs regularly. This indicates that mass media can be used for popularising the latest technologies among cane growers.

Social participation: Most of the respondents (66.67%) were members in more than one of the social organization like co-operative bank, self help group, Farmer Producer Company, milk society and local bodies. Less than one third (30%) of the respondents had membership in one organization. Out of them only two (1.67%) were office bearers.

Reasons for opting intercropping in sugarcane : The respondent farmers, of which, 91.67 per cent had more than 10 years of experience in intercropping in sugarcane. It is likely of such a result because the farmers were mostly chosen to have grown intercrops in their sugarcane fields. Each farmer had a reason for adopting intercropping. Nearly 91.67 per cent of the respondents adopted intercropping for getting an extra income and they see the intercrop as a bonus crop. Over one-tenth (13.33%) of them adopted intercropping to fulfil the basic needs of their family, 6.67 per cent reported that they go for intercrops to use as fodder for cattle. Around 8.33 per cent of the respondents felt that growing intercrops help in smothering weeds. Soil health as a factor for intercropping was indicated by 3.33 per cent of the respondents.

Intercrops grown: Most of the respondents had maize (40%) and groundnut (11.67%) as choice of intercrops as compared to other crops mainly for high remuneration. Few respondents (around 10%) grow other crops like vegetables, soybean, blackgram, greengram, chickpea, greenpeas as intercrop to fulfil their household needs as well as to get some extra income. Though meagre percentage of respondents opted for crops like marigold, watermelon, sesame, sunflower, cucumber, onion and lentil, it's heartening to note that intercropping in sugarcane is tried by the farmers with a wide number of crops.

Quick economics of intercropping in sugarcane : Profile analysis of the respondents indicated that nearly 93 per cent were small to marginal farmers; the range of land under sugarcane cropping was 1.75 to 14.50 hectares. Most of the farmers had gone for intercropping in part of the area, ranging from 0.14 ha to 1.30 ha.

The yield of sugarcane obtained under intercropping varied widely, ranging from 73.33 t/ha with sesame to 143.80 t/ha with watermelon. The average cane yield (t/ha) obtained with other intercrops in the study sample are greenpeas (133.33), soyabean (130.44), blackgram (125), sunflower (110), chickpea (109), vegetables (104.35), greengram (102.17), marigold, brinjal and onion (100), maize (99.48), cucumber (98.59), lentil (97.72) and groundnut (93.08). The yield variation was mainly with the crop management practices followed in the individual farms and not related with the intercrops grown.

The cost of cultivation incurred by the respondents (85%) for sole sugarcane ranged from Rs 80000 to one lakh twenty thousand per hectare and the rest 15 per cent had spent more than 1.20 lakhs per hectare. Whereas under intercropping, 66.67 per cent farmers had incurred additional cost of cultivation under intercropping around 25000 rupees and the rest had spent far less.

Relationship between socio-economic profile of respondents and adoption of intercropping in sugarcane : Correlation analysis done to find out the relationship between the socio-economic characteristics of the respondent farmers with their level of adoption of intercropping was worked out using correlation analysis as given in Table 1.

All the 12 independent variables selected for the study had positive correlation with the level of adoption of intercropping in sugarcane. The respondents had a wide choice of crops and generally it depends on the water availability and marketability of the produce in local markets.

Independent variables *viz.,* occupational status, size of land holding, experience in sugarcane cultivation, farm implement possession, mass media exposure and social participation showed positive significant relation with adoption of intercropping. Farmers with more than a decade experience in

Table 1. Relationship between profile of sugarcane farmers with level of adoption of intercropping (N=120)

Independent variable	('r' value)
Age	0.217^{NS}
Educational status	0.259^{NS}
Occupational status	0.479*
Size of land holding	0.458*
Experience in farming	0.146^{NS}
Experience in sugarcane cultivation	0.378*
Economic motivation	0.431^{NS}
Crop rotation followed	0.416*
Farm implement possession	0.416*
Income level	0.081^{NS}
Mass media exposure	0.557*
Social participation	0.452*

*Significant at 0.01 percent level; ^{NS} Non-Significant

sugarcane farming were widely prevalent in the sample and they tried to improve cane productivity by following latest technologies. Many respondents had owned almost all the farm implements needed for sugarcane cultivation and others had hired on lease from neighbours and custom hiring centres available locally. Sugarcane and intercrop related messages gained through mass media like radio, television channels, social media and farm magazines help to create awareness on new technologies as seen in the study. Most of the respondents in this study were involved in social organizations either as members, if not office bearers in at least one organization in the village leading to exchange of information and thereby increased adoption.

Advantages of adopting intercropping in sugarcane : In a long duration crop like sugarcane, intercropping holds much promise. The farmers in the study area were found to adopt varied intercrops best suited to their area.

Every respondent farmer who had grown an intercrop with sugarcane had realized an advantage. Most of the sugarcane farmers are used to getting an income from sugarcane crop after 11-12 months of planting. Intercropping is being promoted in sugarcane cropping system as a means of getting an interim income to the farmers. Any intercrop that can be harvested within 90-100 days can be successfully grown in sugarcane.

The advantages of intercropping in sugarcane as perceived by the farmers in their order of importance include interim income within three months, incorporation of stubbles of intercrops improve soil health, less growth of weeds, fodder availability for livestock, increase in yield, reduction in weed infestation, reduction in cost of cultivation and availability of produce for home use

All the farmers reported that the advantages of intercropping in their sugarcane field were possibility of getting an interim income within three months, incorporation of stubbles of intercrops improve soil health and there is less growth of weeds. Most of the times even if there is little weed growth, it gets killed due to smothering effect. Availability of fodder stock was an advantage of intercropping as reported by 98.33 per cent of the respondents. The haulms of intercrops can be easily fed to cattle. Reduction in weed infestation, in an otherwise highly weed incidence plot was an advantage as realized by 86.67 per cent of the respondents. On the whole, due to less or no cost on weed management and an interim income from intercrops, there is reduction in cost of cultivation by intercropping as reported by 85 per cent of the respondents. Availability of produce like pulses, vegetables, maize, groundnut etc. was an advantage as proclaimed by 81.67 per cent of the respondent farmers.

Intercropping offers an opportunity for profitable utilization of available space. Sugarcane growers take advantage of this and grow various short duration crops like cereals, pulses, vegetables and spices as intercrops to obtain interim return (*Singh et al, 2018*). Maize and soybean intercropping system in rainy season could be grown successfully and found superior over sole cropping system in Chitwan, Nepal (*Khatri et al, 2014*).

Legume intercrops in cropping systems enhance soil fertility through the excretion of amino acids into the rhizosphere. The nitrogen fixed by the legume intercrop may be available to the associated sugarcane in the current season itself, as sugarcane remains in the field for over nine months after the harvest of the legumes. A further possibility of soil fertility improvement is through addition of crop residues, which on decomposition adds to the fertility of the soil. Since considerable addition of nutrient occurs through intercrop, there is a possibility of reducing N application through fertilizer (Kailasam 2008). When nitrogen fertilizer is limited, biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems (*Fujita et al. 1992*).

Growing of soybean as an intercrop and incorporation of *in-situ* green manures like sunnhemp

and cowpea improved the soil chemical properties to help sustain the cultivation of sugarcane (*Khandagave 2010*).

Use of leguminous intercrops leads to natural increase in the available soil nitrogen thereby reducing the use of inorganic fertilisers (*Tosti and Guiducci 2010*). Compared to other crops, onion exerted least detrimental effect on the emergence, tiller, millable cane and yield of sugarcane (*Hossain et al. 2004*).

Intercropping of sunnhemp, maize, radish, linseed, pea, cucumber, wheat, soybean, onion, amaranth, green gram and french bean in sugarcane increases the equivalent yield of sugarcane with better economic return. It also improves quality, nutrient status and physical and chemical properties of soil in sugarcane based intercropping system (*Nazir and Pankhaniya, 2017*).

From the above findings of the study and review, it is clear that, intercropping is advantageous in a long duration crop like sugarcane.

Constraints faced by growers in adopting intercropping : For maximizing the monetary returns per unit area, growers are advised to adopt intercropping with appropriate production technologies. In reality, more often farmer face specific constraints in adopting intercropping resulting in decreased productivity and monetary returns.

The study shows in Table 2 that 98.33 per cent of the respondents reported scarcity of labour as the major constraint in adoption of intercropping. Intercrops as their life cycle gets over by 90-100 days, the intercultural operations are to be done within the time and in many places, farmers feel scarcity of labour as a major problem.

Table 2. Constraints in adoption of intercropping (N=120)

Categories	No.	%	Rank
Scarcity of labour	118	98.33	1
Growing intercrops under drip irrigation is difficult	114	95	2
Needs more labour for intercropping	112	93.33	3
Intercropping is profitable under wide row spacing alone	111	92.50	4
High cost of labour	110	91.67	5
Lack of knowledge about fertilizer requirement for intercrops in sugarcane	100	83.33	6
Difficulty in carrying out intercultural operations	78	65	7
Increase in pests and diseases	72	60	8
Additional requirements of inputs	44	36.67	9
Increase in cost of cultivation	14	11.67	10
Reduction in sugarcane yield	12	10.00	11
Climatic change	2	1.67	12

Drip irrigation is widely prevalent in sugarcane cropping and, in such conditions, possibility of intercrops is little difficult. Separate laterals need to be made available which is not possible in many fields. Subsoil drip irrigation further mounts to this issue.

Labour cost is more and not affordable for growing intercrops as it incurs more cost as expressed by 93.33 per cent of the respondents. And most of the times labour cost is unaffordable as well. Lack of knowledge about fertilizer requirement for intercrops in sugarcane is a constraint as expressed by 83.33 per cent of the respondents. For reaping a good harvest from the intercrops, the fertilizer requirement of the specific intercrop must be applied and separately given for the sugarcane crop.

Difficulty in carrying out intercultural operations is a constraint experienced by 65 per cent of the respondent farmers. When sugarcane is grown in wider row spacing of over150 cm row spacing and intercrops are grown in two rows in between, this problem does not arise. Increase in pests and diseases is yet another constraint as reported by 60 per cent of the respondents; however, it depends on the choice of intercrops made.

An additional requirement of inputs for the intercrops is yet another constraint as expressed by 36.67 per cent of the respondents. This includes seeds and fertilizer for the intercrops; however, this would commensurate with the additional income obtained. Due to the increased inputs, the cost of cultivation also increases as told by 11.67 per cent of the respondents.

It is a myth that sugarcane yield gets affected due to intercrops as told by 10.00 per cent of the respondents. This happens when the fertilizer needed for intercrops is not provided and the intercrops would compete with sugarcane for nutritional requirement. Hardly one respondent has felt that climate change has an influence on growing intercrops in sugarcane.

In support of the results of the present study, literature suggests that, wide row spacing of 150 cm is preferable for sugarcane based intercropping systems and both soybean and black gram could be raised as profitable intercrops (*Gopalasundaram et al. 2012*). *Singh et al. (1999)* observed that lentil as intercrop reduced cane yield by 11.3 per cent.

Suggestions to increase the adoption of intercropping in sugarcane : Due to the introduction of scientific approach towards agriculture, many new technologies are available for boosting productivity. Intercropping in sugarcane is being widely recommended but with limited adoption, though it's a technology with high relative advantage. The suggestions as indicated by sugarcane growers are given below.

At farmer's level

- Awareness campaigns on the importance of intercropping
- Knowledge on the use of recommended varieties of intercrops
- Supply of adequate literature on intercropping
- On-farm training programs on the package of practices for intercrops in sugarcane
- Make farmers realize the adoption of intercropping
- Arranging study tours to model farms in the vicinity
- Create opportunities for farmers to share experiences related to intercropping
- Motivating farmers to accelerate adoption of intercropping

At sugar mill level

- Conducting pre-season campaigns
- Conducting frequent / periodical village meeting to popularize intercropping
- Provide printed literature in local languages
- Farmers should be informed about its advantages and disadvantages by creating an ideal intercrop model farm in villages at vantage points.
- Make availability of seeds of high yielding varieties of intercrops
- Develop short video films on success stories in the village on intercropping.

At government level

- Provide subsidy for inputs for intercrops
- Arrangement for training programs and demonstration to cane growers
- Provide market to intercrop production
- Financial support for growing intercrops
- Implement various schemes relevant to intercropping
- Provide exact schedule of intercropping through Agriculture Department

At research level

- Crop management techniques that will not harm main crop due to intercrops
- Develop simple equipment for harvesting intercrops
- Research on high yielding short duration varieties of intercrops
- Package of practices for best suited intercrops in sugarcane
- Develop new machineries for intercultural operations in intercropping

The suggestions given at farmers level, factory level, government level and research level in the research institutes vary widely in their emphasis. At the farmers level, the emphasis is mainly on providing knowledge on growing intercrops, availability of inputs in the village level, providing assured market facilities for the produce. At the factory level, it is better to have model farms, one each at the Section or Division level and create awareness among sugarcane farmers on the package of practices. At the government level, it is expected to provide subsidy for the inputs, provide funds to factory and research institutes to conduct model farms, training programs and other outreach activities. At the research level, it is highly needed to develop varieties best suited for intercropping, suitable machineries for intercultural operations and make extension literature in popular languages to have more reach.

CONCLUSION

Intercropping has been practiced traditionally and is widespread in many parts of the world, yet, it is poorly understood from an agronomic perspective and research in this area is far less than comparable work in monoculture, be it in any crop. This is due in part to the wide use of pure crop cultures in the developed world, in part to the relative lack of resources in the developing world, but not least to the complexity of the problems involved (Geetha et al, 2015). For an intercrop combination to be biologically advantageous, agro-techniques such as fertilizer application, seed rate of intercrop and base crop, and selection of suitable genotypes must be taken care of to reduce the depressing effect of intercrops on sugarcane and to increase the productivity and profitability of the intercropping system. Maharashtra, being an upcoming state in sugarcane cultivation, the study indicated that farmers are quite progressive and take advantage of the available technologies to increase their income from sugarcane cultivation.

CONFLICT OF INTEREST

The authors have no conflict of interest.

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