

REVIEW ARTICLE

SUGARCANE BASED INTERCROPPING SYSTEM AND ITS EFFECT ON CANE YIELD

P. Geetha*, K. Sivaraman, A.S. Tayade and R. Dhanapal

Abstract

World population is growing exponentially and there is a need to fulfil its' food requirements. An important strategy for increasing labour utilization per unit area of available land and productivity is to intensify land use. Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time, is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labour. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources. Sugarcane is a long duration crop and takes about 90-120 days for canopy development, which allows for growing intercrops during the early stage. Taking advantage of this, sugarcane cultivators grow various short duration crops like pulses, vegetables, etc. as intercrops to get interim return since small sugarcane growers cannot wait for a long time to get financial return from sole sugarcane crop. Since sugarcane is an important commercial crop all over the world and is most suitable for intercropping, this review focuses on sugarcane based intercropping system.

Key words: Sugarcane, intercrops, tropics, subtropics, intercropping effects, yield

1. Introduction

India is the second largest producer of sugar after Brazil with a global share of 17% in 2014-15. Over five million farmers are involved in the cultivation of sugarcane in tropical and subtropical India, the two distinct agro-climatic regions of the crop in the country. At present, the area under sugarcane is 5.03 million hectare with production and productivity of 356.56 Mt and 70.8 t/ha, respectively (Anonymous 2015). Tropical region shares about 45% and 55% of the total sugarcane area and production in the country, respectively along with the average productivity of 70 t/ha. Tamil Nadu stands first in average cane productivity, i.e. 105 t/ha during 2014-15. Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu account for nearly 85%

of total sugar production. Tropical India has even sunshine all through the year, well distributed rainfall and ideal conditions for good growth of the crop leading to high productivity. There had been considerable improvement in the productivity levels in the past, but they have more or less stagnated over the last two decades (Sundara 2011).

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. In the case of sugarcane, much of the space

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between two rows of sugarcane remains unutilized for an initial period of 90-120 days, due to slow crop growth. 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. In this review, information on various aspects of intercropping in sugarcane is presented.

2. Scope for intercropping in sugarcane

Great potential exists in India for increasing crop production and productivity through wider use of multiple cropping in cereals, millets, oilseeds, legumes and fibre crops. In long duration crops like sugarcane, intercropping holds much promise. 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 (Gopaldasundaram and Kailasam 2003).

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 1994).

In general, the optimum row spacing recommended for sugarcane is 90 cm which is widely followed in tropical India. Reduced row spacing is often preferred to accommodate higher cane population and increase cane yield in short duration and early maturing varieties (Sundara 1994). 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). For example, 150 cm row spacing was successfully attempted in the cane area of M/s Sakthi Sugars Ltd, Erode district, Tamil Nadu state, India, which recorded higher yield than 75 cm row spacing. High tillering and low tiller mortality in wide row spacing helped achieve such high yields in spite of the lower seed rate used (Nagendran and Palanisamy 1997). 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 (Gopaldasundaram et al. 2012).

3. Sugarcane based intercropping systems

3.1. Tropical region

The main planting season for sugarcane in the tropical region is from December to March. The crop completes its germination in about five weeks from planting and attains the stage of canopy closure by

about the 15th week after planting. Since the underutilized growth resource prevails only for a short time, the intercrops and cultivar selected should be of dwarf type with compact canopy and short duration. Short duration legumes, oilseeds and vegetables are the most suitable intercrops in main season planted sugarcane (Kailasam 2008).

In tropical India, maize was studied as an intercrop, especially in north Karnataka and Maharashtra (Nigade et al. 1999), basically for fodder purpose. Attempts to diversify agriculture production through exploitation of inter row by raising maize and potato have been made in Mauritius also (NG Kee Kwong et al. 1996). Finger millet was studied as an intercrop at Coimbatore, Tamil Nadu (Anonymous 2014). Soybean intercropping positively influenced the cane yield depending upon the cultivar used, intercrop density and planting geometry in Tamil Nadu (Kailasam 1994), Uttar Pradesh (Singh and Chauhan 1998) and Karnataka (Biradar and Reddar 1996; Sankaraiah et al. 2000).

Intercropping of sunflower was studied extensively in Tamil Nadu (Kannappan et al. 1990; Kathiresan and Rajasekaran 1990; Sathyavelu et al. 1991). All the results showed a negative effect on the growth parameters and cane yield. The performance of groundnut as an intercrop in sugarcane was examined in Andhra Pradesh (Raju et al. 1986), Karnataka (Shinde et al. 2009), and Tamil Nadu (Kannappan et al. 1990; Kathiresan and Rajasekaran 1990; Sathyavelu et al. 1991).

Among pulses, black gram was reported to be compatible with main season planted sugarcane in Tamil Nadu (Kannappan et al. 1990; Kathiresan and Rajasekaran 1990; Ahamed et al. 1991; Sathyavelu et al. 1991; Rajendran 1999), Andhra Pradesh (Raju et al. 1986) and Maharashtra (Pawar and Bhosale 1987). Green gram was reported to be a suitable intercrop in main season sugarcane in Tamil Nadu

(Kannappan et al. 1990; Kathiresan and Rajasekaran 1990; Sathyavelu et al. 1991; Karamatullah et al. 1992).

Vegetable crops experimented as intercrops with sugarcane include amaranthus (Dixit and Misra 1991), tomato (Kumar et al. 1990), bhendi (Saini et al. 2000), cucumber (Pawar and Bhosale 1987), radish, turnip and carrot (Parashar et al. 1979; Kanwar et al. 1990), knolkhol (Jayabal and Chockalingam 1990), cowpea (Kumar et al. 1990), pea, *palak* (Indian spinach), cauliflower (Parashar et al. 1979), chillies and brinjal (Randhawa 1976).

Growing of soybean as an intercrop and incorporation of *in-situ* green manures like sunhemp and cowpea improved the soil chemical properties to help sustain the cultivation of sugarcane (Khandagave 2010). When nitrogen fertilizer is limited, biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems (Fujita et al. 1992). Moreover, because inorganic fertilizers have contributed to environmental damage such as nitrate pollution, growing legumes as intercrops is regarded as an alternative and sustainable way of introducing N into lower input agro-ecosystems (Fustec et al. 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).

3.2. Subtropical region

In the subtropical region, sugarcane is normally planted in autumn (September- October), i.e. before the onset of winter or during the spring season (February-April), i.e. after the cessation of winter. The cane planted in the autumn season germinates before the onset of winter and remains in the field without much growth until the spring sets in. During this period, the cane does not make much demand for the growth resources. This facilitates raising of

any *rabi* crop as intercrop with autumn planted sugarcane (Kailasam 2008). Several studies demonstrated that the total productivity of crops in sugarcane + *rabi* crop intercropping system is substantially higher than the total productivity of sole *rabi* crop in winter followed by sole sugarcane planted in spring season.

As in the case of tropics, sugarcane planted in spring season completes its germination in about five weeks from planting and attains the stage of canopy closure by about 15 weeks after planting. Dwarf type crops with compact canopy including legumes, oilseeds and vegetables are suitable as intercrops in spring planted sugarcane (Kailasam 2008).

Several short duration crops have been attempted as intercrops in the subtropical region. Maize, especially with autumn planted sugarcane, was evaluated at Bansiwar, Haryana (Panwar et al. 1990). Wheat has been extensively tested as an intercrop in autumn planted sugarcane and reported to be advantageous compared to sole cropping of cane (Singh and Sharma 1996; Gangawar and Sharma 1997).

Several studies have been conducted to evaluate the performance of mustard as an intercrop in autumn planted sugarcane in subtropical India (Kanwar et al. 1990; Shukla and Pandey 1999; Chaudhary et al. 1999; Shivay and Rathi 1999). Even though there was reduction in cane yield due to intercropping, the combined yield was found to be more remunerative depending upon the varieties. Kothari et al. (1987) reported the performance of Japanese mint as an intercrop in spring planted cane near Pantnagar, Uttar Pradesh.

Cowpea was reported to be suitable as an intercrop in spring planted sugarcane in Haryana (Kumar et al. 1990) and Orissa (Dixit and Misra 1991). Cowpea as an intercrop has also been evaluated

and found remunerative in Jamaica, West Indies (Stanford 1988) and Nigeria (Afolabi 1999).

Potato has been reported to be a promising intercrop in autumn planted sugarcane in subtropical India. The results of the experiments carried out on the effect of intercropping of potato in sugarcane were reviewed by Rathi and Singh (1979). There have been several studies on intercropping of potato in sugarcane in Uttar Pradesh (Yadav and Prasad 1991), Punjab (Kanwar et al. 1990), Maharashtra (Nankar, 1990; Solanke et al. 1990), Madhya Pradesh (Sharma and Dubey 1994) and north Karnataka (Roodagi et al. 2000). Potato has also been reported to be a successful intercrop in sugarcane in other countries like Bangladesh (Imam et al. 1990) and Mauritius (Govinden 1990).

Onion as a spice and vegetable was evaluated as intercrop by Kirtikar et al (1972), Mathur (1980) and Singh and Rani (1996). The yield of onion could be increased under paired row system of cane plantation by accommodating higher intercrop population compared to the single row system. The yield of onion under paired row systems was 4.4 t/ha while it was 2.25 t/ha under single row system. Intercropping onion with paired row cane showed the highest potential for increasing the net returns per unit area (US\$ 562/ ha) under intercropped systems (Imam et al.1990). Compared to other crops, onion exerted least detrimental effect on the emergence, tiller, millable cane and yield of sugarcane (Hossain et al. 2004). Higher yield of cane due to intercropping with onion was reported (Parashar et al. 1979). Onion was found to be a remunerative intercrop in studies at Sehore, Madhya Pradesh (Sharma and Dubey 1994; Sharma et al.1986). Growing of onion in the intercropping system with sugarcane was also studied in Indonesia (Darmodjo 1991) and Egypt (Zohry 1999). Therefore, cultivation of short duration spices and

vegetables like onion, garlic and coriander as intercrops in sugarcane can be a successful package as it provides the needed income during the early stages and increases the total productivity without affecting the cane yield in the system.

4. Effect of intercropping systems on cane yield

4.1. Negative influence of intercrops on cane yield

Although few studies have indicated positive influence of intercrops on the yield of sugarcane, several reports have indicated moderate to heavy reduction in the cane yield depending upon the crop and variety used, and the cultivation practices followed.

Cereals: Cereals as intercrops generally have adverse effects on the tillering of the base crop of sugarcane during the tiller development stage. Porwal and Kumperwat (1985) reported reduction of 9.1 and 27.0% in cane yield when sorghum was grown for fodder with and without fertilizer, respectively. Panwar et al. (1990) noted that cane yield was only 61 t/ha when intercropped with maize while it was 70 t/ha in sole cane. Roodagi et al. (2000) observed a reduction of 40% in cane yield when maize (cv. JMH 240) was grown as intercrop in sugarcane (cv. CoC 671).

Pulses: Yadav et al (1987) reported cane yield reduction of 5.5 and 12.1% when intercropped with black gram and green gram, respectively in spring planted sugarcane. Intercropping of French bean (cv. sakthi PDR 14) brought about 13.1% reduction in cane yield (Yadav and Prasad 1990). Kumar et al. (1990) observed a reduction of 11.5% in cane yield when intercropped with cowpea at Karnal. Sharma and Dubey (1994) reported about 5.4% reduction in cane yield with chickpea intercropping. Rao and Veeranna (1998) reported 13.7% reduction in cane

yield with cowpea as intercrop. Singh et al. (1999b) observed that lentil as intercrop reduced cane yield by 11.3%.

Jayabal et al. (1991) recorded a reduction of 30.5% in cane yield when two rows of Co 1 soybean were intercropped in between cane rows (cv. Co 6304). The reduction was only 16.8% when one row of Co 1 soybean was intercropped. Kailasam (1994) reported a reduction of 13.14% in cane yield when Co 1 variety of soybean was intercropped whereas the reduction was only 3.7% under Monetta variety. Planting of cane in paired rows and intercropping three rows of Co 1 soybean in the wider inter row spaces also reduced the cane yield by 9.0% (Anonymous 1990).

According to Kathiresan and Rajasekaran (1990), there were no significant differences in yield of cane when two rows of green gram or black gram were grown in between rows of sugarcane (cv. CoC 671). Growing of soybean cultivar PK-142 did not affect the cane yield of short duration sugarcane variety Co 8338 at Coimbatore (Kailasam 1994). Mahendran et al. (1996) found that soybean intercropped with sugarcane in different inter-row spaces did not affect cane yield.

Oilseeds: Kadirvel and Devaraj (1977) observed that sugarcane yield was lower by 10.7 t/ha when sunflower was intercropped with sugarcane compared to sole cropping. The cane yield reduction was 8.8% with sunflower as intercrop while the reduction was only 3.9% with groundnut in sugarcane variety CoC 671 (Kannappan et al. 1990). Sunflower as intercrop drastically reduced the cane yield by 31.8% in Uttar Pradesh (Singh and Chauhan 1998). The reduction in cane yield was 27.0, 14.7 and 14.9% when intercropped with safflower, linseed and mustard, respectively in autumn planted sugarcane (Chaudhary et al. 1999). Roodagi et al. (2000) observed a reduction of 6.2% in cane yield

of sugarcane variety CoC 671 when intercropped with groundnut.

Spices, condiments and other crops: Many spices and condiments have been reported to reduce the cane yield when grown in association with the sugarcane crop. The cane yield reduction was 26.6, 13.8, 11.0, 3.7 and 7.3%, respectively when okra, cluster bean, French bean, cucumber and radish were intercropped in sugarcane (Pawar and Bhosale 1987). Tomato, cowpea, cluster bean and okra as intercrops with sugarcane reduced the yield by 15.8, 19.3, 12.7 and 22.4%, respectively (Kumar et al. 1990). Knol kohl, okra and carrot reduced the cane yield of the associated sugarcane by 12.5, 15.8 and 4.4%, respectively (Jayabal and Chockalingam 1990). Tobacco as intercrop reduced the sugarcane yield by 14% (Verma et al. 1981). Intercropping of bergamot mint, pepper mint and spear mint caused reduction in sugarcane yield to the extent of 17.8, 18.1 and 30.7% respectively (Kothari et al. 1987). Randhawa et al. (1989) observed that the cane yield was lower when mentha, an essential oil crop was grown as intercrop with sugarcane.

Vegetables: Parashar et al. (1979) reported a yield reduction of 23.7, 22.2, 29.6, 17.1 and 4.9%, respectively when radish, carrot, *palak*, cauliflower and onion were intercropped with sugarcane. Zohry (1999) observed that cane yield was slightly decreased by onion grown as intercrop, the greatest yield reduction of 9.0 % being with five rows of onion. The cane yield was reduced by 5.8 and 31.8% when one and two rows of okra were intercropped, respectively in spring planted sugarcane (Saini et al. 2000). Singh et al. (1999a) reported that one row of cabbage as intercrop did not affect the cane yield in autumn planted sugarcane crop. Singh et al. (1986) and Verma and Yadav (1988) recorded a reduction of 5.2 and 7.2% respectively in the yield

of sugarcane intercropped with potato in autumn planted cane. In the review on intercropping of sugar beet with autumn planted sugarcane, Rathi and Singh (1980) reported a reduction ranging from 3.6 to 39.0%.

4.2. Positive influence of intercrops on cane yield

Positive influence of intercrops on the yield of sugarcane grown as base crop has also been reported. Veerabhadraiah et al. (1986) observed 17% more cane yield in sugarcane intercropped with soybean. Similarly, large scale field demonstrations at M/s Sakthi Sugars Ltd indicated beneficial effect of soybean intercropping under 150 cm wide row spaced sugarcane compared to sole crop of sugarcane spaced at 90 cm (Nagendran and Palanisamy 1997). Raising sunhemp as intercrop in continuous sowing or at 30 cm spacing increased the cane yield significantly in sandy loam soils (Ahmed 1999). Guru et al. (2000) also observed significant increase in yield of sugarcane when intercropped with the green manure crop *daincha* in sugarcane variety CoC 85061 in sandy loam soils.

Intercropping of short duration French bean cv. VL-63 with nitrogen application at 80 or 120 kg/ha for the intercrop increased cane yield (Yadav and Prasad 1990). Similarly, Jayabal and Chockalingam (1990) observed 7.6% increase in cane yield when French bean was intercropped with sugarcane.

Rasool et al. (2011) reported that planting of sugarcane alone resulted in significantly higher cane yield (130.5 t/ha) followed by cane intercropped with gram (111.8 t/ha). Cane yields in the case of cane intercropped with wheat, lentil and gram were statistically at par with one another. Similar results were also observed by Imran et al. (2000), Santanu and Ray (2003), Singh et al. (2002), and Nazir et al. (2002).

5. Conclusion

The review clearly brings out the positive, neutral and negative effects of combining crops in sugarcane based cropping systems. Though there are overall biological advantages in intercropping system, most of the studies have indicated depressing effect of intercrops on the base crop of sugarcane. Although intercropping has been practiced traditionally for thousands of years and is widespread in many parts of the world, it is still poorly understood from an agronomic perspective and research in this area is far less advanced than comparable work in monoculture. 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. Thus, more research is needed to better understand how intercrops function and to develop intercropping systems that are compatible with current farming systems. 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.

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