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Intercropping in Sugarcane (*Saccharum officinarum* L.): A Review

Shilpa V. Chogatapur[1*], Deepa G. S[2]. and H.T. Chandranath[1]

[1]Ph.D. Scholars, [1]Professor,

Department of Agronomy, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka

[2]Subject Matter Specialist Agronomy, KVK Mudigere, Karnataka

*Corresponding Author E-mail: chogatapurshilpa@gmail.com

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ABSTRACT

Sugarcane (Saccharum complex hybrid), an important agro-industrial crop in the country, plays a pivotal role in national economy by contributing 1.9 per cent to gross domestic product. However, plateauing yield level, declining factor productivity, increasing production cost, slashing sugar prices in international market and decreasing profitability in recent years indeed pose the real concerns before cane growers and mill owners. These necessitated the intensification of sugarcane-based production system through diversification in space and time to meet the multiple needs of cane farmers and maintain long-term soil health. Sugarcane characteristically widely spaced, initially slow growing, of long duration and one-time income generating crop - lends ample scope for intercropping with short-duration, high-value and mid-season income generating crops for household nutrition and economic security, especially of small and marginal cane growers. Intercropping is an age old practice of growing two or more crops simultaneously on the same piece of land. It is a technique of crop intensification in both time and space wherein competition between crops may occur during a part or whole growth period. Intercropping in sugarcane is localized, depending on soil environment and market demands.

Key words: *Legume, Net return, Intercrop, sole crop, Commercial cane sugar, Vegetable*

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) crop occupies an important position in Indian agriculture and plays a pivotal role in national economy by sustaining the second largest organized agro industry in the country next to textile. In India it is grown in 5.00 million hectares area with a production of 350.00 million tonnes and the average productivity is 70.00 t ha^{1}. In order to meet the per capita requirement of 35 kg sweeteners year $^{-1}$ by 2020, India would need to produce 415 million tonnes of sugarcane having a sugar recovery and cane productivity of 11 *per cent* and 100 tonnes ha^{-1}, respectively[2]. Besides for manufacturing sweetening agents, it is the crop of several uses such as production of alcohol, energy generation, paper production etc.

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But in recent years sugarcane farming is facing serious challenges in terms of sustainability and severely affected by multiple factors like climate change, escalating cost of production, labour scarcity, slashing sugar prices in the market, declining soil health etc. There is a little scope of increasing area under sugarcane due to heavy competition for food, fiber, oilseed, pulses etc. Therefore, the only alternative left is to increase the vertical production of sugarcane and sugar by finding out the efficient agronomic management practices.

In recent years the emphasis has been shifted from sole cropping to intercropping. Sugarcane-based intercropping system is one of the productive, sustainable and economically viable systems as sugarcane is a long duration, widely spaced (75 to 150 cm) and slow-growing crop up to 80 to 90 days and its efficient root-system helps to tap plant nutrients and moisture from deeper layers allowing the intercrops to feed at top layers of the soil. The major objectives of intercropping are to produce an additional crop, to optimize the use of natural resources and to stabilize the yield of crops[16]. In order to meet the growing demand of diverse crop and to arrest further decline in factor productivity and to make the sugarcane production system more viable, it is necessary to enhance the productivity of the system as a whole[5]. The wide space of inter-row 90 cm available between 2 rows of sugarcane, long duration for bud sprouting, initial slow rate of growth and its ability to compensate for any loss of tillers due to intercrop competition have helped in successful intercropping of grain legumes, oilseeds, potato and maize, in plant crop and forage legumes in winter initiated ratoon[6]. The pulses like green gram and black gram have also been recommended as intercrop in spring sugarcane and ratoon[11]. The companion cropping of sugarcane with high value medicinal, oilseeds and vegetable for seed purpose were found remunerative rather than growing the sole crop of sugarcane. Rehman *et al*[10]., and Li *et al*[7]., have also established the yield advantages of intercropping of sugarcane with vegetable and oilseed crops.

Sugarcane intercropped with Legumes

Growing pulses with sugarcane crop not only increases the area under pulse crop but also reduces the intensity of weeds and provides mid-season income to house-holds for further use of critical inputs to sugarcane along with additional employment opportunities. The compatibility of French bean in autumn sugarcane has also been reported by Singh and Lal[11]. Kumar *et al*[4]., conducted flied experiment to study the effect of dual-purpose legume intercropping with spring sugarcane and stated that all intercrops, except Sesbania reduced the cane yield significantly. The reduction in cane yield was 14.0, 8.9 and 11.4 *per cent* with cowpea [*Vigna unguiculata (*L.) Walp.], mungbean (*Vigna radiata*) and urdbean (*Vigna mungo*) intercropping respectively. Sugarcane intercropped with Sesbania (GM) yielded similar to that of sole sugarcane. Sugarcane + cowpea gave 17.2, 15.8, 19.0 and 26.5 *per cent* higher mean cane-equivalent yield (118.4 tonne ha^{-1}) than sole sugarcane, sugarcane + mungbean, sugarcane + urdbean and sugarcane + Sesbania intercropping respectively. Singh *et al*[12]., carried out filed experiment to assess the production potential and economic viability of autumn-planted sugarcane–based intercropping systems, viz. sugarcane sole and sugarcane intercropped with lentil (Lens esculentus), rajmash (*Phaseolus vulgaris* L.), Indian mustard (*Brassica compestris*), rapeseed (*Brassica sp.)* and maize (*Zea mays* L.) The intercropping with rajmash had no adverse effect on the number of millable canes (117.6 thousand/ha), cane length (213 cm) and cane yield (83.4 t ha^{-1}) compared with sole cane. The juice-quality parameters, viz. brix, pol purity and commercial cane sugar (CCS) were not affected by different treatments. However, the value of commercial cane-sugar yield remained primarily a function of cane yield and was the maximum under sugarcane + rajmash intercropping system.

Sugarcane intercropped with Forage Legume

Intercropping of berseem in winter-initiated sugarcane ratoon significantly increased the number of millable canes (117.8 thousand

ha^{-1}), cane yield (72.4 t ha^{-1}), cane-equivalent yield (90.81 t ha^{-1}) and commercial cane sugar (8.81 t ha^{-1}) compared with sole cropping (7.66 t ha^{-1})[11].

Sugarcane intercropped with Vegetables

Intercropping of cereals, legumes, oilseeds, vegetables and spices in autumn sugarcane have been found to enhance natural resources use efficiency, productivity and profit margins[11,12]. Vegetable crops form the most important component of a balanced diet and are highly economical. They are the rich sources of vitamins, minerals and plant fibers which provide food and nutritional security. They also generate high income and employment, particularly for small farmers. Singh *et al*[13]., stated that Sugarcane intercropped with radish recorded the highest number of shoots and was at par with sugarcane intercropped with garlic, turnip as vegetable, turnip and radish as vegetable followed by seed, metha as vegetable followed by onion as vegetable. The intercropping of wheat, raya, metha as seed crop, sugarbeet as vegetable and linseed suppressed tillering and significantly reduced the shoot production of autumn sugarcane. The vertical planted sugarcane intercropped with garlic and metha as vegetable followed by onion as vegetable produced similar cane yield and were significantly better than rest of the intercropping systems.

Sugarcane intercropped with other crops

Rana *et al*[9]., studied the feasibility of various intercrops with autumn sugarcane, revealed that Sugarcane + maize gave the highest mean cane-equivalent yield (200.6 tonnes ha^{-1}) being 52.5, 45.4, 55.7, 50.0 and 48.6 per cent higher than sole sugarcane and its intercropping with lentil, mustard, rajmash and rapeseed, respectively. However, all the intercrops except maize, reduced cane yield attributed to decline in number of millable canes. Mean reduction in cane yield was 8.7 per cent with lentil, 14.8 per cent with mustard, 13.3 per cent with rajmash and 8.7 per cent with rapeseed. Kumar *et al*[5]., to assess the profitability of intercropping of medicinal and high value crops in autumn planted sugarcane(*Saccharum* spp. hybrid). Gobhi sarson *(Brassica napus* L.*)*, canola type 'GSC 5' and 'GSC 6' and non canola type varieties 'GSL 2', celery *(Apium graveolens* L.*)* 'local', barley (*Hordeum vulgare* L.*)* 'VJM 201' and radish (*Raphanus sativus* L.*)* 'Punjab Pasand' for seed purpose were evaluated as intercrops. Out of 9 combinations of intercropping, sugarcane+ gobhi sarson 'GSL 2' (1: 1) recorded the highest cane equivalent yield of 87.95 t ha^{-1}, which was 22 per cent higher than that of sole crop of sugarcane. Singh *et al*[11]., carried out filed experiment with seven treatments consisting of six intercropping systems i.e. sugarcane with wheat *(Triticum aestivum)* (1:2), raya *(Brassicajuncea)* (1:2), pea *(Pisum sativum)* (1:2), gobhi sarson *(Brassica napus)* (1:1), barley *(Hordeum vulgare)* (1:2), gram *(Cicer arietinum) (1:2)* and sole sugarcane. Averaged over two years, sole sugarcane recorded the highest cane yield (71.2 t ha^{-1}). The intercropping of gram, peas, wheat, barley, gobhi sarson and raya reduced the cane yield by 3.5, 7.6, 9.5, 15.3, 15.3 and 21.3, respectively, as compared to sole cane crop. Sugarcane quality was unaffected by cropping systems. All the intercropping systems, except sugarcane + barley, recorded higher cane equivalent yield over sole cane crop. Sugarcane +gram recorded the highest cane equivalent yield (91.7 t ha^{-1}). Similar results 36.4 and 13.7 per cent reduction in cane yield with intercropping of wheat and mustard, respectively, as compared to sole cane were obtained by Kumar *et al*[3]. Significantly higher number of tillers (318.9 thousand ha^{-1}), plant height (324.9 cm), number of millable canes (120.9 thousand ha^{-1}), cane length (248.2 cm) and the cane yield (75.7 t ha^{-1}) were recorded in sugarcane planted in paired rows of 45:135 cm accommodating 2 rows of grain amaranth intercrop (2:2)[13].

Economics

Sugarcane intercropped with maize gave highest net return of Rs 124,874 ha^{-1} followed by sugarcane alone (Rs 71,145) as against Rs 62,104; 65,067; 67,138 and 69,040 with intercropping of mustard, rajmash, rapeseed and lentil respectively[9]. Kumar *et al*[4]., stated that Sugarcane + cowpea also gave the highest net return of Rs 57,772 compared to Rs 41,449

with urdbean and Rs 48,330 with sole sugarcane. Respective benefit: cost raio was 2.06, 1.78 and 2.01.Singh *et al*[12]., stated that intercropping of rajmash and maize for green cobs resulted in highest net profit (Rs 89,883 and 83,815 ha^{-1}) and benefit: cost ratio (B : C) (2.53 and 2.34) compared with sole sugarcane (Rs 50,199 ha^{-1}). The economic analysis also indicated that sugarcane+gobhi sarson 'GSL 2' (1: 1) recorded the highest net profit of Rs 80,894 ha^{-1}, followed by intercropping of sugarcane + celery (1:2) and sugarcane + gobhi sarson 'GSC 5' (1:2) + with 29.0 per cent, 26.9 per cent and 22.2 per cent higher net returns over sole crop of sugarcane, respectively[5].

Singh *et al*[11]., reported that Sugarcane +gram it turned out to be the most profitable intercropping system with the highest net returns (Rs 47,100 ha^{-1}) and the highest B: C ratio (1:06). Sugarcane + peas was the next profitable intercropping system that gave net returns of Rs 42,900 ha^{-1}. The intercropping of sugarcane with barley was found economically unviable. The gross monetary returns were higher in sugarcane + potato intercropping system. However the highest net monetary return (NMR) was recorded in sugarcane + wheat (44,128 Rs. ha^{-1}). Sugarcane and wheat intercropping was thus more remunerative[15].

Singh *et al*[14]. The intercropping system of sugarcane and radish (*Raphanus sativus* L) as vegetable followed by as seed crop recorded the highest net returns of Rs 1.25 lac ha^{-1}. It was immediately followed by sugarcane + garlic (Rs 1.23 lac ha^{-1}). The intercropping systems of sugarcane with turnip (*Brassica rapa* L.) as vegetable followed by seed crop, followed by radish metha and onion as vegetable recorded higher net returns as compared to standard.

Soil fertility status after harvesting of sugarcane and intercrops

Significant improvement in O.C. *i.e.*, from the initial level of 0.60 to 0.85 per cent and available N from 256.0 to 296.7 kg ha^{-1}was found due to paired row intercropping of flora bean in sugarcane[8]. Intercropping improved the soil inorganic nitrogen and phosphorus in the intercropping sugarcane and soybean. The inorganic nitrogen content of soybean rhizospheric soil in the intercropping system was 217.02 mg kg^{-1}, approximately 66 per cent higher than those in the monoculture system[7], (Fig 1). The physico-chemical properties of the soil observed initially and after harvest of plant and ratoon crop decreased slightly in bulk density of furrow-slice soil (0-15 cm) under sugarcane + lentil intercropping system. The highest rate of infiltration after plant-crop harvest (4.75 mm ha^{-1}) and after ratoon harvest (4.25 mm ha^{-1}) was also recorded under this system[14].

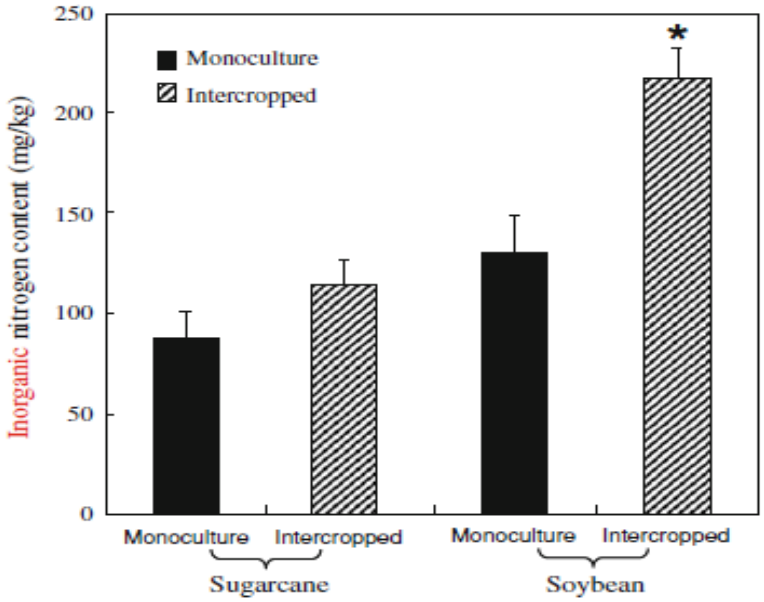

Fig. 1: Inorganic nitrogen contents of two crops in the sugarcane+soybean intercropping. Asterisk indicate significant difference against monoculture at the 5 % level Student's t test

CONCLUSION

Thus, the inclusion of short-duration intercrops like rajmash, lentil and maize for green cobs in autumn-planted sugarcane may improve the socio-economic status of small and marginal cane growers by generating mid-season income. Besides providing higher system profitability, intercropping of legumes also improves soil health and makes the plant–ratoon system sustainable.

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