Introduction

Intercropping of two or more crops is an old practice in India, especially under rainfed conditions. The system helps to improve utilization of natural resources, i.e. sunlight, land and water, and to combine cultural practices, often resulting increased productivity per unit area and time. With the limits on the availability of arable land and rapid increase in the population, intercropping needs to be adopted by farming systems in developing countries for producing more food and other agricultural commodities from the same available area.

Sugarcane is mainly grown in the states of Uttar Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka and Gujrat, which together command an area of 3.7 million hectares, 89% of the total area under sugarcane in India. It is 100% irrigated in Gujrat, Rajasthan, Maharashta and Tamil Nadu and 80-90% in Andhra Pradesh, Karnataka, Madhya Pradesh, Haryana and Punjab. In Uttar Pradesh and Bihar, about 60 to 70% is irrigated.

Potato as a sole crop is mainly confined to Uttar Pradesh, West Bengal, Bihar, Assam, Punjab, Madhya Pradesh, Karnataka and Gujrat, commanding an area of 1.2 million hectares, which is 89% of the total potato area in the country. However, there is a scope for expansion of the potato crop not only in the above mentioned sugarcane-growing states, but in a number of other states also, where sugarcane cultivation has just been introduced and where winters are reasonably cool. In the plains of India, potato in grown mostly under irrigation, while in the hills, the crop is predominantly rainfed.

Seasons of sugarcane planting

In India, sugarcane is planted in three season viz., adsali (July-August), pre-seasonal, autumn (October-November) and suru (January-March). However, in most parts of the country, the usual practice is to grow sugarcane as a seasonal crop from January onwards.

To obtain better tonnage and sugar recovery than is obtained with seasonal sugarcane and to extend the supply of mature sugarcane to sugar factories, efforts are being made to popularize the pre-seasonal, i.e. earlier planting of sugarcane. The pre-seasonal sugarcane yields about 15 to 20% more, cane matures earlier and has 0.5-1.0% higher sugar recovery than the spring planted crop (Kanwar, 1975). Similar results were also reported by Tripathi and Singh (1977). Age of the crop is closely related to yield of sugarcane and juice quality. If the factory starts operation in November, a crop planted in February and March is hardly 8-9 months old by harvest, whereas a crop planted in October is 13 months old. During the winter, sugarcane grows very slowly. However, before the cool weather sets in, a good stand is already established. This early stand provides an excellent start when the weather begins to warm up in early February.

Intercrops in sugarcane

Sugarcane is a long duration crop, planted in widely spaced (80-120 cm) furrows and usually irrigated with well and/or canal water. In autumn planted crops, emergence starts 2-3 weeks after planting and is complete within the next 3 weeks. The initial crop growth for the first 12 weeks is slow, and the crop requires first earthing 12-16 weeks after planting.

To take advantage of the slow initial growth and lack of lateral spread across the vacant space between rows of sugarcane, and of good amount of moisture available in ridges between sugarcane planted furrows, a number of crops have been tested by planting simultaneously with sugarcane in different parts of India. Aiyer (1949) recommended vegetable crops for intercropping with sugarcane, while Arakeri et al. (1956) found lucerne (Medicago sativa), a good crop for this purpose. Gill (1963), in his exhaustive countrywide review of intercropping in sugarcane, concluded that although on numerous occasions, the number of tillers and of millable canes and the yield of sugarcane were reduced, juice quality was unaffected by companion crops. In autumn planted sugarcane,
various rabi crops such as wheat, potato, onion (for seed and for bulbs), cabbage, cauliflower, sugarbeet, peas, radish, turnips, raya, toria, berseem, gram (chickpea), garlic, linseed, lentil, coriander, tobacco etc. were tried with varying success (Rathi et al., 1974, Rathi and Tripathi, 1975, Behl and Narwal, 1977, Tripathi and Singh, 1977, Varma et al., 1981 and Nankar, 1990). The inter-row space of autumn planted sugarcane was fruitfully utilized by these intercrop, as was the irrigation water. In addition, the suppression of weeds by the associate crops and the extra income within 3 to 4 months of planting sugarcane initially favoured adoption of these intercrops. Incompatibility of cultural operations, irrigation regimes e.g. stimulation of vigorous vegetative growth in pulse crops (Kishan Singh, 1971) by the sugarcane irrigation schedule, and intercrop harvesting patterns e.g. trampling due to sequential harvest have, however, diminished the acceptance of some of these intercrops by farmers. Hence, appropriate agronomic management for the system was required to be developed to capitalize on the above-mentioned advantages, without the attendant drawbacks.

**Sugarcane potato intercropping**

Potato is a short-duration, cool- climate crop grown from October- November to January- February in most parts of the country, though it is raised in summer in the high hills or in spring in the plains of Punjab, or in kharif (monsoon) in parts of Maharashtra, Karnataka and Chhattisgarh. It is planted in ridges 60 cm apart, and irrigated immediately after planting, with the second irrigation 4 to 5 days later for uniform emergence. From then on, it is irrigated every 10 to 12 days. Emergence starts 7-8 days after planting and is complete a week later.

Sugarcane is planted in furrows and is irrigated initially almost according to a schedule similar to that of potato. Both crops grow well in medium to heavy, fertile well-drained soils of pH 6.0-8.5. They are of such contrasting maturity dates that if planted together in an intercropping system, the quick growing potato completes its life-cycle before the grand period of growth of sugarcane sets in.

Changes in the microclimate of the canopy of each crop induced by intercropping and the different canopy architecture may beneficially influence the potato crop and reduce the incidence of insect pests and diseases with the exception perhaps of the white fly (*Bemesia tabaci* Genn).

**Work done**

Most of the earlier research work involved planting potato, a few days after planting sugarcane. This required additional expenditure to that for sugarcane alone, and resulted in trampling of the sugarcane fields during planting of potato.

Also, with planting on the side of ridge, the potato rows were very close to the sugarcane rows resulting in some interspecific competition. Due to this proximity, harvest was also difficult and large labour contingent was required for digging the potato manually. Fertilizer application to potato was also difficult. In spite of all this, a number of workers (Mathur et al., 1968, Rathi and Tripathi, 1974, Akhade et al., 1975, Dakshindas, 1975, Kirtikar et al., 1975) demonstrated the remunerative benefits of intercropping potato with sugarcane with little or no adverse effect on the main crop. Though experimental results were promising, in practice, it was rather difficult for the farmer to adopt this technology.

A research project was initiated at Marathwada Agricultural University, Parbhani in 1980, to develop a more acceptable system and to solve the logistic difficulties of cultivating two crops at the same time, in the same piece of land, so that the end result would lead to a synchrony between the main cultural operations of two crops within the intercropping system.

The system, as developed, permits the combination of various cultural practices necessary for the sugarcane and potato crops, with concomitant reduction in total expenditure. Following is the summary of the field procedure.

**Planting:** Considering sugarcane as a main crop, land is marked at 90 cm inter-row spacing with a moghda (seed drill) behind which bamboo tubes are attached for fertilizer application at the full recommended dose for potato. Tubers are then placed at 20cm intra-row on the marked lines. The single-share plough is worked in between the adjacent rows of potato so that tubers are covered in the ridges that are automatically formed when the furrows are made for sugarcane planting (Fig. 1) The tubers are covered to a depth of 8-10 cm beneath the center of ridge which is fully formed as the plough returns to open subsequent furrows. The cross furrows are then made and thereafter the field is made ready for irrigation. Sugarcane setts are arranged on ridges lengthwise and irrigation is started. The setts are then lifted one by one, and inserted into furrows for the establishment of sugarcane. Furrow irrigation is done simultaneously (Fig. 2).
Earthing up: Earthing of sole potato crop is normally done one month after planting to cover stolons and developing tubers at 50-60cm inter-row spacing. This is not required for potato in the intercropping system because, ridges are bigger and wide apart, and the likelihood of stolons emerging out is considerably reduced. This, therefore, eliminates one of the major costs of cultivation of the potato.

After first common weeding, the potato crop canopy serves the purpose of biological weed control as this reduces the subsequent weed intensity and weed growth, by 80% than in the sole sugarcane crop (Nankar et al., 1985). Greening of harvested tubers in the intercropping system in black cotton soils is reduced to 4.6% compared to 15% in the sole-potato cultivation, thus increasing the market value of the produce (Nankar, 1984).

In black cotton soils, which upon drying, normally develop cracks well before potato harvest, potatoes shaded by sugarcane foliage in the intercropping system are definitely of superior quality. Also it is probable that the attack by tuber moth may be reduced in such soil types in the intercropped system due to the deeper position of tubers within ridges.

Harvesting: By the time maximum tillering of the sugarcane has taken place, harvesting of the potato is done with a bullock-drawn plough, which besides exposing potato for hand collection, also earths up sugarcane crop and controls weeds (Fig. 3).

The results of some experiments conducted by the author for logistic management of the intercropping system are:

1. Without any adverse effect on the sugarcane yields or on yield contributing characters, intercropping of potato in ridges, 90 cm apart, with intra-row spacings of 20 and 13.3 cm (equivalent to recommended 60 cm X 20 cm sole potato spacing) gave 163 and 191 quintal potatoes/ha, respectively, resulting in increase in monetary returns to the tune of Rs. 9115 and Rs. 9873/ha, respectively, over the sole sugarcane cropping (Nankar, 1984). Timely extra income from intercropping potato helps to meet the cost of cultivation of sugarcane for the whole season (Nankar, 1990).
2. True Potato Seed (TPS) Technology was fitted in the intercropping system to reduce the cost of potato seed material. Use of seedling tubers showed net returns of Rs. 8186/ha from sugarcane alone with an additional net return of Rs. 12687/ha from potatoes grown as intercrop.

3. A large number of field trials were conducted on cultivators’ fields throughout Maharashtra as well as part of Karnataka for 20 years for demonstrating this technology. In one case study, in Kannad sugar factory area (Aurangabad District), 204 cultivators adopted the technology on 50.45 hectares producing 6815 quintals of potatoes in 3 years, the average yield coming to 137q/ha. The yield (q/ha) obtained ranged between 176 to 200 of 5% farmers, 150 to 175 of 12.7% farmers, 126 to 150 of 40.7% farmers, 100 to 125 of 40.2% farmers and of 1.4% farmers below 100 (Nankar and Chhanwal, 1991).

The reasons for low yields can be attributed to improper selection of soils, very late plantings even up to end of December, low level of management viz., low fertilizer application, improper planting method and irrigation schedule, and non adoption of proper plant protection measures. Selecting well drained loamy soils, planting from last week of October to third week of November, and good management are bound to increase the yield levels to 150-200 q/ha.

Scope and prospects

A number of sugarcane growing states in India have comparatively mild winters, and are endowed with an abundance of sunshine which partially compensates for the low temperatures. Provided good seed material is available and planting is timely, potato yields in such states are comparable with those in the traditionally potato growing northern states. Potato can be profitably grown wherever it can fit well as an intercrop in autumn sugarcane. Where kharif potato planting is practiced, intercrop of potato can also be undertaken in early adsali sugarcane.

A number of sugarcane growing states, where there is a great potential for cultivation of potato could become self sufficient in potato production, if about 15% sugarcane area is brought under this intercropping system with the available technology.

In spite of all the advantage in favour of intercropping of potato and sugarcane, there are still two limitations to the success of the potato cultivation in a number of non-traditional sugarcane growing states; the timely acquisition of high quality potato seed, and the storage and marketing of the perishable produce after harvest.

Role of sugar factory

For a regular and extended supply of mature sugarcane with good tonnage and sugar recovery, and for efficient and economic functioning of sugar factories, proper planning of the sugarcane planting seasons is imperative. For this, it is estimated that about 30-40% area under sugarcane has to be under pre-seasonal planting.

The sugar factories can give incentives in various forms to the growers’
(i) Encourage planting of pre-seasonal sugarcane.
(ii) Arrange the purchase of good quality disease free seed potatoes in bulk from reliable sources.
(iii) Arrange storage of potatoes in local or cold-stores for a few months to avoid glut in the market.
(iv) Take up the potato processing work simultaneously, as required raw material will be available locally.
(v) Link up the intercropping programme with some reliable potato processing units so that the harvested potatoes are purchased at pre-determined rates by the processors who will receive assured supplies of raw material of desired quality.

If 10% of the present 4.4 million hectares sugarcane area in India is intercropped with potatoes, it will result in production of about 6.6 million tones i.e. about 25% additional produce of potatoes. This can be a big step towards brown revolution in India.

Literature cited:


