

**EVALUATION OF SUGAR BEET CULTIVARS AT
DIFFERENT ROW PROPORTIONS IN INTERCROPPING
WITH SUGARCANE AND ITS NITROGEN MANAGEMENT**

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INTRODUCTION

Sugar is an essential commodity and an integral part of the 'food chain' and the cheapest source of energy. More than 100 countries in the world produce sugar, 60 per cent of which comes from sugarcane growing countries while, the rest (40%) comes from sugar beet growing countries (Leilah *et al.*, 2005). Brazil is the largest producer of sugar with 31.35 million tonnes with 20.95 million tonnes of exports. India, the second largest producer with 28.80 million tonnes of sugar, exports 3.29 million tonnes (Anon., 2011). An overview of sugar beet (*Beta vulgaris* L.) indicates that it is an important commercial biennial root crop of the world, extensively grown for sugar and ethanol production. Sugar beet plant is one of the most efficient convertor of solar energy into stored energy and has great potential for augmenting sugar production at lower cost (Ahlawat *et al.*, 2002). Sugar beet is produced in 121 countries and European Union dominates in its production with France as the major producer of sugar beet (29 mt) followed by Germany (25 mt). Total world production of sugar beet is 266 million tonnes from an area of 7.8 million hectare (FAO, 2006). Asia accounts with a production of 31.63 million tonnes on an area of 0.87 million hectare with productivity of 36.89 tonnes per hectare.

Originally sugar beet is a temperate crop, with the development of tropicalised and thermoinsensitive varieties of sugar beet, it has been possible to grow the crop in the tropical and subtropical areas and making it a vital commercial crop. Sugar beet can be potential competitive crop with sugarcane on account of unique characteristics of shorter crop period of 5 to 6 months, moderate water requirement of 60-80 cm, tolerance to soil water stress (Mohamad and Pimentel, 2001), lesser fertilizer requirement, with production potential of about 60-80 tonnes of tuber yield per hectare and higher recovery percentage in comparison to sugarcane. Further, sugar beet gives the same amount of sugar as cane per land unit in half the time with one third of water and wide adaptability to alkaline soils spoiled by years of cane cultivation. Additionally due to uncertainty of monsoon, water requirement round the year, problem of salinity, pest problems (wooly aphid), high labour requirements and labour problems particularly during planting and harvesting, low productivity of ratoon crop *etc.* sugarcane is losing ground as unique cash crop in sugar belt in India. Sugar beet is known to be salt tolerant and can be grown successfully in salt affected soils. Therefore, cultivation of sugar beet in such salt affected soils will be a viable option for efficient use of resources.

Concurrently owing to inadequate cane supply, the factories could not run for a full period during the crushing season. Running the factories below the desired period increases the overhead costs, resulting in heavy economic losses. The alarming situation calls for an immediate exploitation of supplementary sources of raw material for the production of white sugar and ethanol. Under these circumstances, sugar beet can be bestowed as an alternative for continuous functioning of the sugar mills. Sugar beet crop matures in March – April month when the crushing season is nearly over and the harvesting period of sugar beet coincides with the off season of sugar factories. Thus, supply of sugar beet can extend the crushing period of mills by nearly 2 months in the off season.

Recurrent increase in prices of petroleum products have incited major sugar producing countries such as Brazil and U.S.A. to divert their sugarcane for ethanol production to meet their burgeoning energy demands. In recent years, Government of India also has advocated admixing of ethanol (anhydrous alcohol) up to 5 and 10 per cent in petrol and diesel, respectively, thus the requirement of ethanol is going to increased by 2-3 fold. These developments may limit the availability of sugarcane for production of sugar. Therefore, production of ethanol from beet juice has great scope.

Sugar beet being a new crop to Karnataka, in order to promote its cultivation, it is often difficult to replace the existing sugarcane. One of the options is to grow it as a intercrop in sugarcane. Since sugarcane crop is relatively a long duration one with initial slow growth for 3-4 months which facilitates growing of intercrops with sugarcane by using temporal and spatial dimensions. This helps in effective use of both the natural and the applied nutrients thereby improving productivity and profitability of the system. Several short duration crops have been tried as intercrops in sugarcane under normal row spacing of 90 cm have proved beyond doubt the intercrops had deleterious effect on growth and yield of sugarcane in majority of the cases (Roodagi *et al.*, 2005). One of the recent agro techniques that can be employed to reduce the intercrop competition is the introduction of wide row spacing in sugarcane cultivation. Basically the concept of wide row spacing was developed to facilitate mechanical harvesting of the cane. This technique would greatly facilitate not only easy management of intercropping with minimal competition effects, but also provide enough space for greater population of intercrops to get higher productivity.

The experiments conducted in the University of Agricultural sciences, Dharwad (Salimath and Lamani, 2010), proved that the sugar beet can be cultivated in different agro-climatic zones of Karnataka under tropical condition with excellent yield potential. However, the information on growing of sugar beet as intercrop in sugarcane is meagre in the northern region of Karnataka. Many varieties of sugar beet have already emerged and the suitability of these varieties in intercropping for northern region of Karnataka is yet to be established. Thus, development of suitable intercropping system by evaluating the performance of sugar beet cultivars in different row proportions with wider spacing of sugarcane (150 cm) is needed to increase the sugar production per unit area and net income of the farmer. Besides this, sugar beet as an intercrop in sugarcane helps to augment ethanol requirement. Research conducted by Chattha *et al.* (2003) and Bahadar *et al.* (2007) has clearly indicated that sugar beet with sugarcane will help to enhance the income per unit area, which will ultimately improve the economic status of growers and sugar industry. Thus, obviously sugar beet crop can not only be the supplement crop of sugarcane but can also be grown along with the sugarcane.

Sugar beet is a highly input intensive crop and a heavy feeder of all the major plant nutrients particularly the nitrogen from the beginning of the crop growth. Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the crop. However, sucrose yield decreases by over-fertilizing sugar beet with higher N than needed for maximum sucrose production (Hassaneina and Elayan, 2000). Further, fertilization with higher amount of inorganic sources of nitrogen will result in increased cost. So, integrated nitrogen management by using biodegraded wastes (vermicompost, poultry manure, liquid manures *etc.*) along with chemical nitrogen is essential in sustaining crop productivity besides improving sugar yield. The information on integrated nitrogen management through combination of organic and inorganic sources for sustainable sugar beet production is meagre.

Keeping these points into consideration, two field experiments namely the intercropping of sugar beet cultivars with different row proportions in sugarcane and performance of sugar beet to sources of nitrogen and liquid manures were conducted at Agricultural Research Station (ARS), Madhurakhandi (Dist. Bagalkot), University of Agricultural Sciences, Dharwad during the year 2010-11 and 2011-12 with the following objectives:

1. To study the effect of row proportions and different cultivars of sugar beet on growth, yield and quality of sugarcane and sugar beet in an intercropping system,
2. To study the effect of different sources of nitrogen and liquid manures on growth, yield and quality of sugar beet and
3. To workout the economics.

REVIEW OF LITERATURE

Cultivation of two or more crops simultaneously in the same field for higher yield and increased economic returns is important in the present context of agricultural scenario as per capita availability of cultivable land is shrinking due to demographic pressures. Intercropping system offers increased cropping intensity as two or more crops occupy the land simultaneously. The literature pertaining to two experiments namely 1. Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2. Performance of sugar beet to sources of nitrogen and liquid manures are reviewed in this chapter. The literature on intercropping of sugar beet in sugarcane and its nitrogen management with integration of inorganic fertilizers, organic manures and liquid manures in particular is very meagre and hence the reviews on related crops have been included.

2.1 Intercropping systems and their importance

Intercropping is an age old practice of growing simultaneously two or more crops in the same piece of land. It is a technique of crop intensification in both time and space wherein, the competition between crops may occur during a part or whole of crop growth period. It has been a common practice followed by the farmers of India, Africa, Sri Lanka and West Indies (Andrews and Kassam, 1976).

The basic idea of intercropping is not only that two or more crop species grown together can exploit the resources better than either of them grown separately, but, also to cover the inherent risks in dryland agriculture and more so, under dry land conditions are buffered to some extent and is called as 'biological insurance' (Ayyar, 1963 and Singh and Katyal, 1966).

Aiyer (1949) reported that the resources with regard to plant nutrients present in the soil or added to it as manures were utilised to the fuller extent in mixed stand than when component crops were grown separately. The crops with varying root depth, tap different layers of soil for plant nutrients and moisture. The periodical return and distribution of labour requirement throughout the year is of great help to the resource poor cultivators.

Donald (1963) opined that species of contrasting habit, both morphologically and physiologically would together be able to exploit the total environment more effectively than monoculture. If two species grown together are mutually beneficial, then there is cooperation. On the contrary, competition results when they tend to be mutually harmful and this competition is mainly for water, nutrients and light. The relationships of cooperation and competition are density dependent. At low densities there is cooperation and at high densities the active competition comes into existence. Willey and Roberts (1976) reported light as a more important factor when better temporal use of resources was to be achieved due to better distribution of leaf area over time.

Oguntowara and Norman (1974) observed that crop mixtures provide insurance against risk and give stable returns even under unfavourable weather conditions. The major way the crop mixture can achieve greater stability is from the compensation of one component crop when other fail or grow poorly, because of drought, pest or diseases. But, when two species are grown separately as sole crops, there is no possibility of this compensation. Intercropping would ensure low yield fluctuations than sole cropping even under unfavourable conditions. Rao and Willey (1980) stated that the crop mixtures would also stabilize returns over seasons as they provide more than one commodity and can act as buffer against frequent price changes in any one of the component crops. Price fluctuations are quite common in countries like India, where 40 per cent of agricultural produce comes from rain fed agriculture.

Higher yield in terms of total biomass and grain production per unit area in a given season without the use of costly inputs under intercropping system is attributed to better use of growth resources namely, light, moisture and nutrients (Sivakumar and Virmani, 1980). Lomte and Dabhade (1990) reported that the competition between base and intercrops basically depends on the maturity period, rooting habit, pattern of canopy spread, plant habit *etc.* of component crops. It is proven fact that the utilization of natural resources *viz.*, space, light, soil moisture, air, nutrient *etc.* were more efficient with intercropping than under sole cropping.

Sarkar *et al.* (1995) reported that intercropping not only stabilizes crop production by reducing the impact of weather vagaries, but also increases cropping intensity considerably. The yield advantages in intercropping system are mainly because of differential use of above ground and below ground growth resources by the component crops. The complementarities will occur when the

component crops have a differential rooting pattern (shallow-deep root), growth habit and occurrence of grand growth stage at different times.

Efficiency of intercropping system is sometimes limited by possible allelopathic effects and/or due to pest hazard. The real problem however, is practical management of intercropping systems under high degree of mechanization where requirements of component crops differ. The difficulties of intercropping are typically associated with more developed agriculture. Whereas, the poor farmer in developing countries can handle intercropping with ease and also often has a strong inherent preference to it. Hence, a further research on intercropping is required for the small farmer of limited means who is most likely to benefit.

2.2 Biological basis for intercropping advantages

When two or more crops are grown together in close association in the intercropping system, the interaction may be complementary leading to the yield advantages or competitive resulting in stress and yield reduction. An understanding of inter species interaction in intercropping system is essential for increasing their productivity and advantages.

Usually a yield advantage occurs because component crops differ in their use of growth resources in such a way that when they are grown in combination, they are able to complement each other and make better overall use of resources than when grown separately. Probably the main way that complementarities can occur is when the growth pattern of the component crop differs in time so that the crops make their major demand on resources at different times. This type of complementarities is said to give better temporal use of resources (Willey, 1979). In sugarcane intercropping system, the greatest scope for complementarities effect lies with temporal system in which annual intercrops are added between cane rows to improve resource use in the early part of the growing period. Further temporal difference can be best exploited by using species or varieties of intercrops that are significantly early maturing to be harvested before they compete with the cane (Verma and Yadav, 1986).

Besides, the combined leaf canopy of sugarcane and intercrops make better spatial use of light or combined root system may better special use of nutrients and/or water ending in spatial complementarity. In practice, the temporal and spatial effects are often inseparable.

2.2.1 Above ground interaction-light use in intercropping

Considering sunshine quantitatively as the product of the area and duration of the incidence, the loss of sunshine may be negligible in short duration and thickly sown crops. But, where the crop in the growth phase is large and the plants have to be spaced at relatively wide at planting and where the duration of its development phase is relatively long, the loss of solar energy can be large enough to be worth trying to recover it. The best example of a long duration crop, where the recovery of unutilized sun light is worthwhile, is perhaps sugarcane (Yadav, 1993).

Trenbath (1981) opined that the overall light use efficiency could be improved either by interception of incident light or through a better efficiency of conversion of intercepted light.

It appears that intercropping advantages arises in sugarcane intercropping by better interception of incident light. Intercropping advantages could also be expected when a top canopy of high light requiring crop and a bottom canopy of low light requiring crop are grown together (Reddy and Willey, 1981). Such a situation exists when sugarcane and legumes such as green gram, black gram, cowpea, soybean and groundnut are grown in association.

2.2.2 Below ground interactions

Any consideration of below ground resources use inevitably involves a study of rooting pattern of component crops.

2.2.2.1 Rooting pattern of component crops

Trenbath (1974) considered the distribution of roots of component crops in different layers of soil as the cause of yield advantage in mixture of oats varieties. In sugarcane based intercropping system, as sugarcane is planted in the furrows and the intercrops on the ridges, it is quite possible that roots of sugarcane exploit deeper soil layer while that of the intercrops, the surface layer. The roots of the component crops may intermingle freely.

2.2.2.2 Nutrient uptake by component crops

The component crops in the mixture may differ in the time of peak demand for nutrient elements resulting in higher total uptake (Willey, 1979). The component crops may require different nutrients and they may be able to extract the same nutrient from different forms in the soil (Willey, 1979; Snaydon and Harris, 1981). The overall greater uptake and removal of nutrient is one of the causes for yield advantage in the intercropping system (Natarajan and Willey, 1980). The higher uptake of nutrients may be due to many reasons. Intercropping systems explore a layer soil mass or explore the same soil mass more completely compared to sole stands of the same species (Francis, 1989).

The mobility of soluble ions such as nitrates is very high and they may be attracted by roots from as much as 25 cm distance in soil solution (Francis, 1989). So intercropping may also reduce the leaching loss of nutrients by decreasing the amount of unutilized nutrients. The ability of a companion crop to make more efficient use than the sole crop of soluble and mobile and immobile nutrients will depend on the extent of root growth of the component species, soil water levels and how completely the companion crop mixture explore the entire soil mass in the rooting zone.

2.3 Effect of intercropping of root crops on performance of sugarcane

The literature on intercropping of sugar beet cultivars at different row proportions in sugarcane is very meagre. Hence, the reviews of related crops such onion, potato, radish, carrot, turmeric, garlic, beet root and sweet potato are included.

2.3.1 Effect on growth components of sugarcane

Many workers have reported the influence of intercropping on the initial growth of the base crop of sugarcane. Under intercropping situations, the intercrop intercepts the sunlight that would have otherwise reached the base of sugarcane mother shoots. Lack of light at the base of sugarcane clumps causes reduction in tillering and finally reduction in number of millable cane. On the contrary Verma *et al.* (1981) observed an increase in the tiller population of sugarcane intercropped with garlic.

Solanke *et al.* (1990) reported no significant difference between sugarcane intercropped with potato and sole sugarcane with regard to cane height and number of functional leaves per main shoot. Kanwar *et al.* (1992) opined that sugarcane intercropped with potatoes did not affect germination per cent of sugarcane. Similarly, Singh and Mehra (1995) reported highest germination percentage of sugarcane under sugarcane + potato, but suppression of cane height was observed when sugarcane intercropped with radish and potato. Singh and Rai (1996) showed that significantly higher numbers of tillers under cane + garlic and cane + onion as compared to cane + coriander but at par with sole crop of cane.

Mahadevaswamy (2002) reported that the sole sugarcane gave the maximum leaf area index (5.35) and dry matter production (45.32 t ha⁻¹) when compared to leaf area index (5.16) and dry matter production (44.17 t ha⁻¹) obtained from sugarcane + onion intercropped in 1:4 row proportion. However, sugarcane + onion in 1:1 row proportion remained on par with sole sugarcane.

2.3.2 Effect on yield components of sugarcane

The number of millable cane is one of the important yield components and its population at harvest depends on the initial tiller population and the proportion of tillers transforming into millable canes. If the initial tiller population is lower, a higher conversion may result in higher millable canes. Under intercropping situations, the initial tillering is affected because of the competition from the intercrop. But later when the intercrops are harvested, the competition is finally eliminated and thus better conversion of tillers into millable canes is facilitated. However, as the initial tiller population is lower, the better conversion of tillers into number of millable cane can partially compensate the loss. Kar *et al.* (1972) at Shahjahanpur observed that reduction in production of tillers and millable canes due to intercropping of sugarcane with onions.

Singh (1972) observed reduction in number of tillers and millable canes by intercropping of one row of sugar beet in between two rows of autumn planted sugarcane planted at 90 cm. The number of tillers in pure cane and cane + sugar beet was 232 and 144.8 thousand ha⁻¹, respectively. Similarly, Patil (1978) observed that the sole sugarcane recorded higher number of millable canes (101000 ha⁻¹) when compared to number of millable canes (79800 ha⁻¹) obtained from intercropped sugarcane.

Studies conducted by Verma *et al.* (1981), revealed intercropping of garlic with sugarcane increased the number of millable canes. Verma and Yadav (1988) also reported an improvement in the number of millable canes when intercropped with two rows of potato under subtropical situations. Similarly, Sinha *et al.* (1990) and Yadav and Prasad (1991) observed higher number of millable canes, cane girth and weight of cane when sugarcane was intercropped with potato compared to sole crop of cane.

Maximum number of millable canes (101.68 thousands ha⁻¹) and higher single cane weight (1.70 kg) were recorded in sugarcane + onion intercropping when compared to sole sugarcane (Patel *et al.*, 1991). Singh and Rai (1996) reported that intercropping cane with garlic and onion found higher number of millable canes compared to sole sugarcane. Singh *et al.* (1997) revealed that the number of millable canes were relatively higher under the intercropping of vegetables as compared to root vegetables. Improvement in number of millable canes when intercropped with garlic was reported by Singh *et al.* (1999).

Mahadevaswamy (2002) conducted experiment on intercropping of sugarcane and onion in different row proportions and observed that the sole sugarcane gave the maximum cane diameter (2.533 cm), number of internodes (21.08), number of millable canes (130400 ha⁻¹) when compared to cane diameter (2.524 cm), number of internodes (20.93), number of millable canes (128900 ha⁻¹) obtained from sugarcane+ onion intercropped in 1:4 row proportion. However, sugarcane + onion in 1:1 row proportion remained on par with sole sugarcane.

2.3.3 Effect on yield of sugarcane

In the sugarcane based cropping systems, the idea is to get normal yield of sugarcane as that of the sole crop in addition to the additional yield advantage from the intercrops. 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, varieties used and the cultivation practices followed.

Pichumani and Krishnamurthy (1971) tried 20 different crops as intercrops in sugarcane and opined that the intercrops should be of short duration and compact in habit so that they should not shade cane and they themselves are not affected as the cane grows by shading. On the contrary, Sharma and Shukla (1971) reported the reduction in cane yield (was 2.8 q ha⁻¹) with potato as intercrop.

Singh (1972) at Pantnagar reported that millable cane yield of sole sugarcane was 107.0 t ha⁻¹ compared with 86.4 t ha⁻¹ of cane yield obtained when intercropped with sugar beet. Similarly, in another experiment Singh (1972) observed reduction in cane yield by intercropping of sugar beet. The cane yield obtained in pure stand and intercrops were 145.8 and 109.8 t ha⁻¹, respectively.

The study conducted at Pantnagar (Anon., 1976) on sugarcane + sugar beet intercrop revealed highest yield of sugarcane (93.97 t ha⁻¹) in pure stand whereas, the cane yield in intercropped treatment was 80.87 t ha⁻¹ *i.e.* a reduction of 13.1 t ha⁻¹ due to sugar beet intercrop. While, trials conducted at Lucknow (Anon., 1977) revealed that the best yield of beets (47.37 t ha⁻¹) was recorded in pure beet treatment compared with beet intercropped in sugarcane as one row in between two rows of sugarcane planted at 90 cm. Highest cane yield was obtained (96.9 t ha⁻¹) in pure crop and in intercropping it was only 85.0 t ha⁻¹. Similar findings were also made by Patil (1978) in sugarcane + sugar beet intercropping system.

Potato can be a very good intercrop during the early stages of sugarcane especially in autumn planted sugarcane. Verma *et al.* (1985) indicated favorable influence of companion cropping of potato on cane yield. Similarly, Singh *et al.* (1986) noted that sugarcane intercropped with potato cultivars Kufri Chandramukhi increased the cane yield by 28.0 per cent compared to sole cane. On the contrary, there are reports indicating marginal reduction in the cane yield. Virendra Singh *et al.* (1986) and Verma and Yadav (1988) recorded a reduction in the yield of sugarcane intercropped with potato in the autumn planted cane to the tune of 5.2 and 7.0 per cent, respectively. Sharma and Dubey (1994) reported a reduction of 9.5 per cent cane yield under Madhya Pradesh conditions in cultivars Co 6304 by growing potato as intercrop.

Iman *et al.* (1990) obtained higher sugarcane yield with intercropping of potatoes and concluded that intercropping of potato with cane exploited temporal complementary effects between crops to benefit the farmer. Nankar (1990) opined that cane yields were not adversely affected by

rising of potatoes in the centre of the ridge. On the contrary, sugarcane yield was decreased by intercropping with *B. vulgaris* and radish (Patil *et al.*, 1991).

Yadav and Prasad (1991) observed increased cane yield grown in association with potato but wheat grown as an intercrop was found to affect cane yield. At Jalandhar (Punjab), Kanwar *et al.* (1992) opined that mean cane yield of autumn cane grown alone was 100.3 tonnes per hectare compared with 101.0 tonnes per hectare when intercropped with potato. The average reduction in cane yield due to single, double and triple rows of sugar beet intercropping was 4.9, 10.4 and 24.2 per cent, respectively (Godara *et al.*, 1994).

El-Gergawi and Abdalla (2000) studied intercropping of spring planted sugarcane with sweet potato and cowpea and reported that sugarcane intercropping caused significant reduction in yield of sweet potato and cowpea, whereas sugarcane yield was only slightly decreased by intercropping.

Khan *et al.* (2002) at Sugar Crops Research Institute, Mardan, reported that intercropping sugar beet in autumn planted sugarcane resulted in highest sugar beet root yield (71 t ha^{-1}) when two rows of sugar beet were planted in 120 cm spaced sugarcane.

Mahadevaswamy (2002) conducted experiment on intercropping of sugarcane and onion in different row proportions and observed that the pure stand of sugarcane gave the maximum cane yield (149.7 t ha^{-1}) when compared to cane yield (148.7 t ha^{-1}) obtained from sugarcane + onion intercropped in 1:4 row proportion. However, sugarcane + onion in 1:1 row proportion remained on par with sole sugarcane. Similarly, Singh and Vashist (2004) in an experiment on intercropping of sugarcane and onion in different row proportion reported that the pure stand of autumn sugarcane gave the maximum cane yield (593.2 q ha^{-1}) which was at par with cane yield (588.1 q ha^{-1}) obtained from sugarcane+ onion intercropped in 1:1 row proportion.

Roodagi *et al.* (2005) conducted experiment to study the influence of planting system and intercrops on sugarcane yield and reported that highest cane yield (111.09 t ha^{-1}) was recorded in sugarcane + sunnhemp and lowest cane yield (70.82 t ha^{-1}) was recorded in sugarcane + maize intercropping system.

Bahadar *et al.* (2007) studied sugar beet intercropping with sugarcane under various planting geometry system and found that highest cane yield of 104.0 t ha^{-1} was recorded when single row of sugar beet was sown in 90 cm spaced sugarcane, which was comparable to sole sugarcane (107.38 t ha^{-1}) in treatment with rows 90 cm apart. While, highest sugar beet yield (102.48 t ha^{-1}) was recorded under treatment where single row of sugar beet was sown in 90 cm spaced sugarcane.

2.3.4 Effect on quality parameters of sugarcane

At Lyallpur in West Pakistan, Fasihi *et al.* (1970) noticed higher sugar yields by intercropping sugarcane with sugar beet without suppressing the quality of sugarcane or beet. According to Venkataramana *et al.* (1977) intercrop onion did not influence the purity coefficient, sucrose content, reducing sugars and commercial cane sugar per cent of the associated sugarcane. Similarly, Verma and Yadav (1986) reported no differences in the pol per cent of sugarcane when intercropped with potato in autumn planted sugarcane.

Jayabal and Chockalingam (1990) recorded the highest sugar yield of 16.1 t ha^{-1} and lowest sugar yield of 12.8 t ha^{-1} when radish was intercropped with sugarcane.

Khan *et al.* (2002) at Sugar Crops Research Institute, Mardan, studied intercropping sugar beet in autumn planted sugarcane and reported that highest sugar yield was recorded in the treatment when two rows of sugar beet were planted in 120 cm spaced sugarcane when compared to 90 cm spaced sugarcane. Similarly, Mahadevaswamy (2002) in an experiment on intercropping of sugarcane and onion in different row proportions reported that the pure stand of sugarcane gave the maximum sugar yield (20.00 t ha^{-1}) when compared to sugar yield (19.83 t ha^{-1}) obtained from sugarcane+ onion intercropped in 1:4 row proportion. However, sugarcane + onion in 1:1 row proportion remained on par with sole sugarcane.

Bahadar *et al.* (2007) conducted research on sugar beet intercropping with sugarcane under various planting geometry system and found that highest sugar recovery 8.33 per cent and sugar yield of 8.87 t ha^{-1} were recorded in sugarcane when single row of sugar-beet was sown in 90 cm spaced sugarcane when compared to sole sugarcane with rows 90 cm apart which recorded sugar yield of 10.11 t ha^{-1} and sugar recovery of 9.36 per cent. Sugar beet recorded highest sugar recovery

of 15.85 per cent and sugar yield of 16.28 t ha⁻¹ when single row of sugar beet was sown in 90 cm spaced sugarcane.

2.4 Evaluation of intercropping system

Because of the involvement of two or more crops with large differences in their potential yields and diverse nature of their products, evaluation of intercropping systems poses several problems. Therefore some criteria other than the biological yield and net income may also have to be considered. Many indices have been suggested for evaluating the productivity and efficiency of the intercropping systems.

2.4.1 Economic evaluation

The criteria used in economic evaluation of intercropping system include gross returns, cost of cultivation and return per rupee invested (Palaniappan, 1985). Economics of intercropping once again depends upon factors such as amount of reduction in cane yield, the intercrop yield and its market price. Apart from these many indices have been suggested for evaluating the productivity and efficiency of the intercropping system and these include comparison of absolute yields and in economic term, the gross and net returns (Ofori and Stern, 1987).

Sadanandan and Mahapatra (1972) emphasized the importance of economic evaluation, as it will ultimately influence the farmer's choice regarding a particular cropping system. On the other hand, Beets (1982) considered evaluation in economic terms inappropriate due to seasonal price fluctuation of inputs and outputs and lack of cash economy in most areas where intercropping is practiced.

In most of the sugarcane based intercropping system, the net return has been considered to screen out the most beneficial intercropping system in comparison with sole sugarcane. In some cases, the benefit: cost ratio or the net returns per rupee invested has also been considered. Even though there was reduction in yield in many of the intercropping studies, the yield of inter crops could more than compensate the loss in cane yield. The economic value of the combined yield of sugarcane and the intercrop or cane equivalent yield (CEY) was generally higher compared to the yield of sole sugarcane.

The foregoing review clearly brings out the positive, neutral and negative effects of combining crops in sugarcane based intercropping system and how the agronomic techniques can influence the complementarities and competition between the component crops. Though there are overall biological and economical advantages in the intercropping systems, most of the studies have indicated depressing effect of intercrops on the base crop of sugarcane when grown at normal row spacing of 90 cm. The recent agro techniques like wide row planting in sugarcane would help to grow more of intercrop and manage them better without affecting the main crop of sugarcane, apart from use of machines for mechanical harvesting of sugarcane. Cultivation of short duration and short statured crop like sugar beet as intercrop in sugarcane will result in better spatial and temporal advantages with improved resources use efficiency and yield advantages in the system.

2.4.1.1 Economics of sugarcane based intercropping system

Higher returns following intercropping in sugarcane has been an important factor favoring intercropping. Intercropping aims at fairly high realization of net returns per unit time and space. Though the yield of main crop was reduced due to inclusion of component crops in intercropping system but higher monetary returns were obtained as a system.

Sharma and Shukla (1971) obtained highest net profit by intercropping sugarcane with potato compared with wheat, tomato, maize and sugar beet. Singh *et al.* (1974) observed higher economic feasibility of sugar beet intercrop in sugarcane over wheat and wheat followed by spring cane. Kar *et al.* (1975) got highest net returns from autumn cane + potato.

In Haryana, Randhawa (1975) reported maximum net returns from cane intercropped with onion compared to cane intercropped with egg plant and tomato. In cost benefit analysis all intercropped treatments gave higher net returns than pure cane. Mathur (1976) reported higher returns with autumn planted sugarcane inter planted with potato or wheat as compared to cane alone. Planting cane in spring after potato or wheat was less profitable. Similarly, Sinha *et al.* (1990) reported that intercropping sugarcane with potatoes gave a 54.3-76.2 per cent increase in net returns compared with pure stands of sugarcane. Patil *et al.* (1991) at Bidar studied the intercropping of sugarcane with different vegetables and reported that the highest B:C ratio was observed in intercropping sugarcane with radish or onion. Kanwar *et al.* (1992) observed that gross economic

returns were highest in sugarcane - potato intercrop. However, net returns were maximum in sugarcane - raya intercrop.

Godara *et al.* (1994) opined that intercropping of two rows of sugar beet in autumn planted sugarcane gave Rs. 9,727 ha⁻¹ more profit over sole crop of sugarcane whereas, single row of sugar beet intercropping with autumn cane also gave an additional net returns of Rs. 5,350 ha⁻¹. Net income per rupee investment indicated that, onion either in companionship with autumn cane (1.94) or in sequence with spring cane (1.61) was superior followed by garlic (1.47) and potato (1.33) with autumn cane (Porwal *et al.*, 1994).

Higher net profit of 46, 39 and 20 per cent was observed in cane + potato, cane + radish and cane + turnip intercropping system, respectively than the pure crop cane (Singh and Mehra, 1995). Singh and Vashist (2004) at Regional Research Station, Kheri, Sangrur studied the *rabi* onion-intercropping in autumn planted sugarcane and reported that sugarcane: onion (1:1) planting method recorded maximum net returns (Rs. 24986 ha⁻¹) which was at par with pure stand of autumn sugarcane (Rs. 24142 ha⁻¹). Sanjay Kumar *et al.* (2011) conducted field experiment to find out the most remunerative winter vegetables grown as intercrops with autumn planted sugarcane and concluded that onion intercropping was most remunerative in autumn cane with the highest net return (Rs. 192340 ha⁻¹) which was comparable with sugarcane + potato intercropping system (Rs. 188680 ha⁻¹) among all the intercropping systems.

2.4.2 Assessment of yield advantages

Intercrop advantage can result from the increased resources use efficiency from the prolonged exploitation of resources due to larger combined leaf area duration (Trenbath, 1986).

Land Equivalent Ratio (LER) is a useful index for measuring the efficiency of the intercropping system. The LER has been defined as the relative land area required as sole crops to produce the same yield as of intercropping. However, this index takes into account only the area but not the time factor and hence LER usually gives an over estimated value for the intercrop advantage.

Area Time Equivalent Ratio (ATER) which considered time factor along with the land area was proposed by Hiebsch and McCollum (1987). Again the ATER assumes that continuous crop production throughout the year is possible for all the components species, which is not true. Because of this limitation, ATER underestimates the intercrop yield advantages.

2.4.2.1 Yield advantages in sugarcane based intercropping systems

Kapur and Kanwar (1989) reported that the sugarcane + sugar beet gave the highest total cane equivalent yield, which was 38.0 and 11.1 per cent higher over cane + wheat and cane + raya, respectively. Intercropping of garlic with autumn cane increased the cane equivalent yield by 30.7 per cent, followed by onion (23.6 %) (Porwal *et al.*, 1994).

Field experiment conducted at Coimbatore (Tamil Nadu) to study the productivity and feasibility of intercropping sugarcane under normal (90 cm) and wide row (120 and 150 cm) spacing with onion revealed, higher LER and ATER under wide row spacing (120 cm) and an intercrop density of 1:4 (sugarcane: onion) (Mahadevaswamy and Martin, 2002).

Sanjay Kumar *et al.* (2011) reported among the various winter vegetables grown as intercrops with autumn planted sugarcane revealed that onion intercropping as most remunerative in autumn cane with the highest cane equivalent yield (147.9 t ha⁻¹) which was comparable with sugarcane + potato intercropping system (147.0 t ha⁻¹).

2.5 Performance of sugar beet genotypes

2.5.1 Growth, yield parameters and yield of sugar beet

Hassaneina and Hassouna (2000) showed that Maribo cultivars as the most appropriate cultivars to be cultivated under sandy clay loam soil of Nubaria region. Gala was next best cultivars whereas, Invermono was not promising.

Samarendra (2005) evaluated the performances of 5 sugar beet cultivars (Raspoly, Solid, Maribomonova, Virtus and Mariboultramono) in Calcutta and found that highest root yield of 51.45 t ha⁻¹ was recorded by Solid cultivar which was followed by Ramnoskaya 06 (46.29 t ha⁻¹).

Allam *et al.* (2007) evaluated sugar beet cultivars and observed that the cultivars FD 9993, FD 9992 and Del 938 exhibited a satisfactory root and sugar yield under Kafr El-Sheikh condition.

Whereas, Gloria, Panther, Toro, Del 938 and Demaploy cultivars were found to be better under El-Fayoum condition.

Camas *et al.* (2007) had undertaken a study to determine the performance of two sugar beet cultivars (Duetto and Leila) and reported that cultivar Leila was found superior over Duetto with its high fresh root yield.

Selvakumar *et al.* (2007) at Coimbatore reported that among the sugar beet hybrids, the highest sugar beet root yield (64.41 t ha^{-1}) was recorded for Indus, which was on a par with Cauvery (63.7 t ha^{-1}). Similarly, Budhar (2007) from Paiyur (Tamil Nadu) reported all the hybrids (Indus, Shubhra and Cauvery) performed better.

Rajashekaran (2007) at Coimbatore reported that the growth parameters *viz.*, plant height, leaf area index, crop growth rate, dry matter production and yield attributes such as root length, root girth and root weight of sugar beet were significantly higher in Indus and which was on par with Cauvery hybrid than the hybrid Shubra.

Balakrishnan and Selvakumar (2008b) reported that Cauvery performed better in terms of yield (76 and 94 t ha^{-1} during 2005 and 2006 respectively) as compared to Shubhra and Indus. In another study, Balakrishnan and Selvakumar (2009) reported that Cauvery genotype recorded significantly higher root length, root girth, root weight and root yield (76.04 and 92.54 t ha^{-1}) in 2007 and 2008, respectively which was on par with Indus (69.29 and 84.72 t ha^{-1} , respectively). According to Shewate *et al.* (2008a), HI 0064 superior in winter season when compared to other varieties. On the contrary, Bhullar *et al.* (2009) reported that cultivar Posada yielded 22.3 per cent higher mean root yield (84.61 t ha^{-1}) than HI 0064.

Shewate *et al.* (2009) at Vasantdada Sugar Institute, Pune evaluated the performance of newly introduced promising Tropicalized sugar beet varieties and concluded that HI 0064, a Monogerm cultivars recorded higher germination (75.44%), plant population ($85,000 \text{ ha}^{-1}$), higher single root weight (1378.18 g), root length (33.09 cm.), root girth (33.75 cm.), root yield (105.39 t ha^{-1}), as compared to other monogerm varieties like Dorotea and Posada.

Refaq (2010) concluded that sugar beet cultivar Samo-2 resulted in higher fresh (119.6 t ha^{-1}) and root dry weight (20.6 t ha^{-1}). Salimath and Lamani (2010) reported that, among the five tropical sugar beet varieties (PAC-6009, SR-125, PAC-60008, PAC-60006 and PAC-60002) evaluated, PAC-60002 performed better in zone-1, PAC-60006 in zone-2 and 3 and PAC-60008 in zone-8 of Karnataka with an average beet yield of 31.8, 35.97, 62.64 and 68.41 t ha^{-1} , respectively. Though the cultivars PAC-60006 reported highest yield across the zones, its brix reading was considerably low (13.98%). Hence, the cultivar PAC-60009 (16.9% brix) which recorded next highest average yield could be preferred followed by PAC-60008.

At Godavari Bio-refineries Pvt. Ltd. Sameerwadi (Mudhol) Yekkeli (2010) reported that in a sugarcane and sugar beet intercropping system, the sugar beet cultivars shubhra recorded higher root yield (47 t ha^{-1}) than cultivar Cauvery. While, Khogali *et al.* (2011) reported Voroshenger (46.5 and $47.5 \text{ g plant}^{-1}$) and Polyproductiva (57.1 and $61.6 \text{ g plant}^{-1}$) cultivars produced significantly higher shoot dry weight than Anisa (56.8 and $60.7 \text{ g plant}^{-1}$) in 2007-08 and 2008-09, respectively.

2.5.2 Quality parameters of sugar beet

The study conducted at Ugar Khurd region of Karnataka state (Anonymous, 2004) revealed that cultivar Pasoda, Dorotea and HI 0064 are well suited for to obtain higher yield and better quality of the crop. Dorotea cultivars recorded higher brix (16.70%). For Calcutta region, Samarendra (2005) reported highest sugar content of 21.67 per cent in Mariboultramono cultivar and closely followed by Virtus (21.17%).

Balakrishnan and Selvakumar (2008b) evaluated performance of sugar beet hybrids and found that, Shubhra recorded the highest brix reading of 21 per cent, followed by Indus (17%) and Cauvery (16%). In another study, Balakrishnan and Selvakumar (2009) found that Shubra recoded higher brix reading of 20 per cent and followed by Cauvery (18%) and Indus (16%). Bhullar *et al.* (2009) reported that Posada yielded higher sugar yield (12.21 t ha^{-1}) than HI 0064.

Shewate *et al.* (2009) evaluated the performance of Tropical sugar beet varieties and concluded that HI 0064, monogerm cultivars recorded significantly higher sucrose content (16.59%) and juice purity (85.37%) as compared to other monogerm varieties like Dorotea and Posada. While, Ahmad *et al.* (2010) found that cultivars Kawe Terma recorded significantly higher sugar (17.08%),

brix (20.0%), purity (85.4%) and sugar yield (20.5 t ha⁻¹) than cultivars KWS-1415 at Peshawar (Pakistan).

Fath Elah *et al.* (2010) reported that, maximum sugar content and white sugar yield were obtained in 7112, LP Laraj and RS003 genotypes and minimum values in 7221-II at Sugar beet Seed Institute (SBSI), Karaj, Iran. Refay (2010) found that quality parameters such as TSS (19.9%), purity percentage (90%), sucrose percentage (17.33%) and sugar yield (19.20 t ha⁻¹) as well as chemical composition of roots were greater for Samo-2 as compared to those of other two varieties *viz.* Unifers and Samo-1. Similarly, Yekkeli (2010) reported that sugar beet cultivars shubhra recorded higher sucrose content (15.5%) and sugar yield (4.43 t ha⁻¹) than cultivar Cauvery.

2.5.3 Economics of sugar beet

Budhar (2007) reported that Shubhra and Indus recorded higher yield, net income and B: C ratio than other cultivars studied. According to Rajashekar (2007) Indus recorded significantly higher net returns of ₹ 43,078 ha⁻¹ and B:C ratio of 2.16. Similarly, Yekkeli (2010) reported that the sugar beet cultivars Shubhra recorded higher benefit cost ratio (5.72) than cultivar Cauvery at Sammerwadi (Mudhol).

2.6 Effect of plant density and geometry on performance of sugar beet

2.6.1 Growth, yield parameters and yield of sugar beet

Habibi *et al.* (2004) at Karaj (Iran) indicated that a density of 8 plants m⁻² was optimum for sugar beet production. While, Usmanikhail *et al.* (2005) reported greater vertical diameter (25.63 cm), horizontal diameter (16.17 m) and single beetroot weight (4.20 kg) under lower plant population of 67000 plants ha⁻¹, mainly due to more space available for each plant to receive greater quantities of moisture and nutrients, as compared to higher plant population at 83000 plants ha⁻¹. Plant population at 83,000 plants ha⁻¹ was considered optimum, where the crop showed better beet root yield (84.357 t ha⁻¹), as compared to plant population at 67000 plants ha⁻¹.

El-Maghraby *et al.* (2008) at Egypt evaluated the effect of three plant densities 35 cm (20,000), 25 cm (28,000) and 15 cm (46 000 plants feddan⁻¹) on the growth of sugar beet cv. Farida and revealed that lower plant densities 20,000 plants feddan⁻¹ [1 feddan = 0.42 ha] resulted in significant increase in root length, root perimeter, crop growth rate (CGR) and relative growth rate (RGR) in comparison to other treatments

Ahmad *et al.* (2010) compared the conventional ridge planting method (ridges 50 cm apart) with flat planting techniques for sugar beet under different row geometries and reported that mean root diameter of beets reached a maximum of 12.7 cm on beds with two rows. Bhullar *et al.* (2010) studied the effects of planting density on sugar beet with three planting densities - 83,333 plants (rows spaced at 60 cm and plants at 20 cm), 1,00,000 plants (50 cm x 20 cm) and 1,11,111 plants (60 cm x 15 cm) ha⁻¹ and reported that planting density of 1, 00,000 plants ha⁻¹ produced the highest root and sugar yield.

2.7 Effect of sources of nitrogen on performance of sugar beet

The literature pertaining to nitrogen management practices with integration of inorganic fertilizers, organic manures and liquid manures on growth, yield and quality of sugar beet has been reviewed. Literature pertaining to nitrogen management in sugar beet is very meagre and hence reviews on related crops such as onion, radish and carrot are included.

2.7.1 Growth, yield parameters and yield of sugar beet

Abdel- Aal and Ibrahim (1990) in Egypt, observed that application of nitrogen fertilizer to sugar beet plants significantly increased root length and diameter, leaf area plant⁻¹, root, top and total weights plant⁻¹ and root and sugar yields as well as juice purity per cent compared to untreated plants (without nitrogen fertilizer). Emara (1990) in Egypt, stated that application of nitrogen fertilizer at 60 kg fad⁻¹ gave the higher LAI, root length, root diameter, tuber and sugar yields fad⁻¹. While, Khan *et al.* (1990) reported that application of 120 kg N ha⁻¹ was produced highest yields and good quality of sugar beet grown under saline-sodic soils.

Singhania and Sharma (1990) reported that fertilizing sugar beet plants with 120 kg N ha⁻¹ produced 24.15 t ha⁻¹ of root yield. Similarly, Vijaykumar and Zutshi (1991) also reported that application of 120 kg N ha⁻¹ increased the roots, tops and sugar yield. While, Mahmoud *et al.* (1990a)

in Egypt recorded that application of nitrogen fertilizer at 80 kg N fad^{-1} enhanced dry matter accumulation and leaf area index (LAI).

Ali (1993) in Egypt, found that supplying sugar beet plants with nitrogen fertilizer at the rate of 80 kg fad^{-1} increased root and foliage fresh weights, leaf area plant^{-1} , root and sugar yields fad^{-1} . While, Frese (1993) reported that maximum sugar yields of 124 t ha^{-1} was obtained with application of 120 kg ha^{-1} and was best suited for the production of ethanol.

Wojcik (1993) reported that root yield was increased from 53.0 t ha^{-1} without nitrogen fertilizer to 63.1 t ha^{-1} with 140 kg N ha^{-1} using urea as nitrogen source. Lopez *et al.* (1994) in Spain, studied the influence of N fertilization on sugar beet plants using urea as source of nitrogen. They determined that response of sugar yield to nitrogen fertilizer rates was greatly influenced by nitrogen available in the soil. Optimum yield was obtained with application of 160 kg N ha^{-1} .

Kopenzynski (1996) studied the effect of 30 t FYM ha^{-1} and 60 or 120 kg N ha^{-1} on loamy and sandy soils and reported that without N fertilizer or manure, root yields were 35.4 and 23.6 t ha^{-1} on both the soils, respectively. FYM increased yields from 36.3 to 39.7 t ha^{-1} on the loamy soils and from 26.7 to 31.3 t ha^{-1} on the sandy soil. While, 120 kg N increased root yield by 5.7 to 6.3 t ha^{-1} on the sandy soil.

Sharief *et al.* (1997) reported that application of nitrogen fertilizer rate at 80 kg N fad^{-1} to sugar beet recorded significantly higher LAI, fresh and dry weights of root and foliage plant^{-1} . Similarly, EL-Hennawy *et al.* (1998) reported that application of nitrogen at 120 kg N fad^{-1} resulted in highest values of root and top yields fad^{-1} . EL-Moursy *et al.* (1998) found that application of nitrogen fertilizer at 100 kg fad^{-1} significantly increased root length and diameter, root fresh weight, root, top and sugar yields fad^{-1} as well as TSS per cent.

Khan *et al.* (1998) revealed that root yields (83.5 t ha^{-1}) and sugar yield (10.3 t ha^{-1}) of sugar beet were highest with application of 200 kg N ha^{-1} . On the contrary, Laszlo and Matyasne (1998) reported that nitrogen fertilizer rates more than 120 kg ha^{-1} to sugar beet reduced sugar yield and continued to increase yield of tops.

Ostrowska and Kucinska (1999) from Central Poland observed that sugar beet reaction on organic fertilizer as such as farmyard manure or barley straw + Phacelia. Most effective and similar results of pure sugar yield were achieved by interaction between both forms of organic manure and mineral nitrogen in doses at 90 kg N ha^{-1} . Basha (1999) found that addition of 120 kg N fad^{-1} significantly raised root and foliage weights plant^{-1} , root and top yields fad^{-1} . Similarly, Soheir *et al.* (1999) also recorded highest values of root, top and sugar yields fad^{-1} at 120 kg N fad^{-1} .

Abdou (2000) found that fertilizing sugar beet plants with 100 kg N fad^{-1} produced highest values of root length and diameter, root, top and sugar yields fad^{-1} . While, Hassaneina and Hassouna (2000) reported that combined application of bio fertilizer (HALEX) and mineral nitrogen of 144 kg N ha^{-1} resulted in positive response across various varieties tested.

Ostrowska *et al.* (2001) concluded that application of nitrogen at the rate of 90 kg N ha^{-1} produced the highest root and gross sugar yields ha^{-1} . Singh *et al.* (2001) studied the response of onion (cv. N-53) to the integrated application of nitrogen and farmyard manure and reported that the average weight of bulb and bulb yield increased significantly with application of farmyard manure at 10 t ha^{-1} and N at 120 kg ha^{-1} .

Noruzi *et al.* (2003) conducted experiment at Hamedan province, Iran and concluded that application 120 kg ha^{-1} nitrogen fertilizer recorded tuber yield of 53.98 t ha^{-1} which was the best treatment for recommendation.

Kandil *et al.* (2004) reported that application of 180 kg N ha^{-1} recorded significantly higher root fresh weight and root dry weight plant^{-1} , LAI, CGR, RGR and NAR. While, Kucinska *et al.* (2004) reported that combination of cow dung and chemical fertilizer were the most effective in the enhancement of tuber yield of sugar beet.

Allam *et al.* (2005) at Kafr El-Sheikh Governorate (Egypt) studied the effect of nitrogen fertilizer on sugar beet and recorded highest root yield of 47.05 t fed^{-1} with application of 95 kg N fed^{-1} . Buriro *et al.* (2006) reported that application of 100 kg N ha^{-1} was the optimum level for getting maximum sugar beet tuber yield.

Mamatha (2006) observed significantly higher neck diameter in onion with the application of FYM and vermicompost @ 100 per cent RDN when compared to urea. Higher diameter of 1.38 cm

with FYM and 1.30 cm with vermicompost were observed whereas, urea recorded 0.70 cm neck diameter at harvest.

In radish, Dhananjaya (2007) at Dharwad reported that application of poultry manure @ 1.25 t ha⁻¹ (50% N equivalent) + vermicompost @ 1.75 t ha⁻¹ (50% N equivalent) recorded highest growth parameters such as number of leaves (3.83 and 3.52 plant⁻¹), highest leaf area (380.00 and 413.95 cm²), dry weight of leaves (13.33 and 11.80 g plant⁻¹) and yield attributes like root length (16.13 and 13.89 cm), root diameter (2.27 and 1.85 cm) and yield (33.02 and 30.54 t ha⁻¹) during *rabi* and summer season, respectively. Zimny *et al.* (2007) observed that every type of organic fertilizer (manure, vermicompost, stubble crop + straw) promoted increasing of mass of single root, its length and thickness in sugar beet. But significant increase of root length, mass and thickness was observed after applying of 100 kg N ha⁻¹.

Rajashekaran (2007) reported that the growth parameters, *viz.*, plant height, leaf area index, crop growth rate, dry matter production and highest yield attributes such as root length, root girth and root weight, root yield and top yield of the tropical sugar beet were significantly higher with 150 kg N along with 75 kg P₂O₅ and 75 kg K₂O along with FYM. Similarly, Balakrishnan and Selvakumar (2008a) at Tamil Nadu reported that yield of sugar beet were mainly influenced by integrated nutrient management. Application of 100 per cent RDF + biofertilizers along with FYM recorded significantly higher number of leaves, plant height root length, root girth and root yield ha⁻¹.

Shewate *et al.* (2008b) at Vasantdada Sugar Institute, Pune evaluated the dose of nitrogen for tropical sugar beet and reported that application of 180 kg N ha⁻¹ gave significantly maximum crown girth (36.47 cm), number of roots (84 000 ha⁻¹), root length (33.80 cm) and root yield of 102.13 t ha⁻¹.

Dhotre (2009) studied the influence of different nitrogen sources on growth of *kharif* onion and reported that application of urea resulted in higher morphological characters like plant height, number of leaves and neck thickness and highest number of rings per bulb and bulb yield. However application of N through agrigold and vermicompost were on par to its performance.

Nakatsu and Tamura (2009) reported that yield and nitrogen uptake of sugar beets were increased by application of organic matter. This was because sugar beets had a longer growth period and were able to utilize a greater amount of the nitrogen released from soil and applied organic matter.

Kale (2010) studied the effect of different sources of nitrogen on onion and observed that yield and yield attributing characters like bulb weight, equatorial diameter and polar diameter were superior due to application of ammonium sulphate when compared to urea, sheep manure and FYM as source of nitrogen for onion. Similarly, Praveen Kumar (2010) studied the influence of different sources of organic manures on yield of onion and reported that highest morphological characters like plant height, number of leaves, leaf length and neck thickness and yield and yield attributes like weight of the bulb (51.72 g) and yield (19.87 kg ha⁻¹) was recorded with FYM + recommended dose of NPK.

2.7.2 Quality parameters

Hassaneina and Hassouna (2000) showed that combination of biofertilizer (HALEX) and mineral nitrogen fertilization (144 kg N ha⁻¹) treatments, recorded highest sugar yields of 54.49 t ha⁻¹ with Gala; 56.33 t ha⁻¹ with Invermono, and 78.81 t ha⁻¹ with Maribo varieties, respectively. Allam *et al.* (2005) reported highest sugar yield of 7.98 t fed⁻¹ was obtained with application of 80 kg N fed⁻¹. Similarly, Samarendra (2005) reported that application of 140 kg N ha⁻¹ resulted in significantly higher sugar yield of 10.46 t ha⁻¹.

Balakrishnan *et al.* (2006) reported that the sugar related characters like brix reading and sucrose percentage were higher with application of 150:75:75 kg NPK ha⁻¹. While, Leilah *et al.* (2007) concluded that, application of N at 216 kg ha⁻¹ to sugar beet resulted in higher sugar yield (8.78 and 9.25 t ha⁻¹) respectively during 1995-96 and 1996-97. Similarly, Panhwar *et al.* (2007) observed that N @ 120 kg ha⁻¹ gave maximum sugar yield of 12.11 t ha⁻¹ as compared to control.

Slamka (2007) reported that application of the bio slurry at 50 t ha⁻¹ in conjunction with NPK fertilizer in autumn gave highest average root sugar content (15.5%). While, Barik and Fantozzi (2008) observed that higher sugar yield of 11.86 t ha⁻¹ and sugar concentration in root juice of 22.2 per cent was produced by 160:60:100 NPK kg ha⁻¹.

Kale (2010) studied the effect of different sources of nitrogen on onion and observed that total soluble solids (TSS) were superior due to application of ammonium sulphate over other nitrogen sources. While, Praveen Kumar (2010) revealed that highest total soluble solids (14.22 brix) was observed in the onion grown with FYM + Panchagavya.

2.7.3 Economics

Warade *et al.* (1995) conducted a field experiment to study effect of organic, inorganic and bio fertilizers on yield of onion and reported that application of FYM 40 t + 50 : 50 : 50 kg NPK ha⁻¹ obtained highest gross monetary returns (Rs. 52598 ha⁻¹) and B:C ratio (5.63). Similarly, Singh *et al.* (2001) recorded maximum net returns and B:C ratio in onion with the application of nitrogen @ 120 kg ha⁻¹ along with 10 t ha⁻¹ of FYM.

In radish, Dhananjaya (2007) reported that maximum net returns (Rs. 43,061 and 36,140) and B:C ratio (4.24 and 2.82) in treatments which received 100 per cent RDF and FYM (50% N equivalent) + poultry manure (50% N equivalent), respectively. Rajashekar (2007) observed that application of 150 kg N along with 75 kg P₂O₅ and 75 kg K₂O to sugar beet recorded the significantly higher net returns and B:C ratio.

Dhotre (2009) studied the influence of different nitrogen sources on economics of *kharif* onion and reported that highest B: C ratio recorded in treatment with sheep manure as source of nitrogen followed by urea. Whereas high yielding treatments of vermicompost, agrigold and bhoomilabh showed significantly lower B: C ratio on account of higher cost. Similarly, Kale (2010) reported that highest net returns was found in ammonium sulphate when compared to other nitrogen sources *i.e.*, urea, sheep manure and FYM. Whereas, highest B:C ratio was recorded with application of urea followed by sheep manure and ammonium sulphate. Praveen Kumar (2010) observed that application of recommended dose of NPK + FYM resulted in highest B: C ratio of 4.59 followed by treatment which received Beejamrut + Jeevamrut + Azospirillum + PSB (4.83).

2.7.4 Nutrient uptake

Patel *et al.* (1992) conducted a field experiment on onion at GAU, Junagadh during *rabi* season and reported that application of N @ 80 kg and P₂O₅ @ 40 kg ha⁻¹ produced higher total uptake of N (74 kg ha⁻¹) and P₂O₅ (10.1 kg ha⁻¹). Similarly, Shanmugasundaram and Savithri (2004) noticed that application of nitrogen at 120 kg ha⁻¹ with FYM (10 t ha⁻¹) recorded higher amount of nitrogen content and uptake of nitrogen in foliage as well as in carrot root. Rajashekar (2007) observed application of 150 kg N along with 75 kg P₂O₅ and 75 kg K₂O to sugar beet recorded the significantly highest N, P and K uptake.

2.8 Effect of liquid manures on performance of different crops

Various types of fermented organics prepared from plant and animal origin consisting of dung, urine, buttermilk, plant extracts, jaggery *etc.*, are known to impart beneficial effects. Among these panchagavya, jeevamrutha, beejamrutha, sasyamrutha, vermiwash, amritpani are most important. These products are effective in promotion of growth, development and fruiting of crops. Although, these manures may not provide enough nutrients in the area of application, but they help in the quick build up of soil fertility through enhanced activity of soil micro-flora and fauna (Yadav and Mowade, 2004). Similar views was shared by Somanasundaram and Singarum (2006) who reported beneficial effect of Panchagavya spray in many crops when compared to foliar spray of recommended nutrients and growth regulators.

Since the information on Jeevamrutha is not available in sugar beet, hence reviews on Panchagavya are included. Similarly research reviews on sugar beet is very meager, hence the review on crops such as rice, jasmine, chilli, turmeric, onion, ashwa gandha, green gram, coleus, bhendi, groundnut and paprika are reviewed and presented

2.8.1 Growth, yield parameters and yield

Two per cent spray of panchagavya was effective in enhancing the growth of rice (Vivekanandan, 1999b). Similarly, Beaulah (2001) reported that spraying two rounds of panchagavya @ 3.0 per cent, one before the flower initiation and another during bud setting phase in jasmine ensured continuous flowering. Panchagavya sprayed on chilli produced dark green leaves and new growth within 10 days (Subhashini *et al.*, 2001).

Natarajan (2002) reported that application panchagavya on turmeric and onion was found to

enhance growth, vigour of crops, owing to induce resistance to pest and disease. While, Cynthia (2003) observed that spraying four per cent panchagavya increased the growth parameters like plant height, plant spread, number of laterals, number of leaves per plant, fresh and dry weight of shoot, fresh and dry weight of tubers, leaf area, leaf area index, the highest dry matter production and yield components like number of tubers per plant, harvest index, and total alkaloid content in *Withania somnifera*.

Somasundaram *et al.* (2003) conducted field experiment at Coimbatore (Tamil Nadu) indicated that application of 3 per cent panchagavya was the ideal concentration for foliar spray on green gram cultivars CO-4. They also stated that foliar application of panchagavya at the rate of 3 per cent at 15, 25, 40 and 50 DAS with no inorganic was the effective low cost technology in terms of grain yield of green gram. While, Selvaraj (2003) showed that, panchagavya foliar application alone on 10th, 20th, 30th, 40th and 50th DAP gave 18 per cent higher yield of New Zealand spinach over the conventional method. Whereas, treatment combination of panchagavya + vermicompost on french bean cultivars Ooty - 2 registered 36 per cent higher pod yield than conventional methods.

Kanimozhi (2003) carried out an experiment to standardize organic production package for *Coleus forskohlii* Briq. Observed that spraying of four per cent panchagavya increased the plant height, plant spread, number of laterals, number of leaves per plant, fresh and dry weight of shoot, leaf area, leaf area index, relative water content, dry matter production, number of tubers per plant, fresh and dry weight of tubers and harvest index.

Similarly panchagavya 3 per cent spray 4 times for bhendi augmented the yield level in treatment receiving poultry manure (10.27 t ha⁻¹) which is comparable to inorganic supplementation with pesticide spray (10.39 t ha⁻¹) (Lourduraj *et al.*, 2005).

Yadav and Lourduraj (2006b) showed that foliar spray of panchagavya recorded significantly higher values of all the yield parameters of rice compared to without panchagavya spray. In another study, Yadav and Lourduraj (2006a) they reported that the application of 50 per cent N through poultry manure along with foliar spray of Panchagavya (3%) on 30th and 50th day after sowing was the viable organic approach for eco-friendly rice production.

De Britto and Girija (2006) revealed that use of panchagavya improved plant growth parameters in black gram and green gram. They also reported that cow dung in Panchagavya acts as a medium for the growth of beneficial microbes and cow urine provides nitrogen which is essential for crop growth. While, Panchagavya applied @ 3 per cent spray at 0, 30, 50 days after sowing in case of rice recorded significantly higher grain yield (5430 kg ha⁻¹) over no panchagavya spray (4990 kg/ha) with different organic manure treatments (Ramanathan, 2006).

Sankar *et al.* (2007) reported that treatment consisting of 100 per cent recommended dose of NPK + Panchagavya applied to onion had significantly increased the average weight of bulb (52.7g). Nekar *et al.* (2009) studied the effect of foliar application of liquid organic manures on growth and productivity of groundnut. Application of panchagavya and cow urine recorded significantly superior plant height, dry matter production, SPAD chlorophyll meter reading, test weight, pod yield and net returns compared to control.

Malarvizhi *et al.* (2009) observed that application of Panchagavya at 2 per cent recorded the highest plant height of 68.0 cm in paprika and increased the number of primary branches per plant. Sankar *et al.* (2009) reported that Panchagavya + 100 per cent recommended dose of NPK fertilizers and Panchagavya + 50 per cent FYM + 50 per cent poultry manure were significantly superior and on par in maintaining a higher plant height and number of leaves in onion throughout the cropping period. Similarly, Kumaravelu and Kadambian (2009) also observed that Panchagavya spray (3%) at 10 DAS significantly increased the growth of green gram plants. The lateral roots, number of nodules, fresh and dry mass of the plants increased significantly at 3 and 4% treatment.

2.8.2 Quality parameters

Beulah (2001) reported that, the quality parameters *viz.*, crude fibres, protein, ascorbic acid, carotene content and shelf life were higher under organic manure applied with panchagavya spray in rice. Similar improvement in keeping quality of turmeric and onion was noticed by Natarajan (2002) with application of panchagavya.

2.8.3 Economics

Panchagavya spray recorded significantly higher gross returns (Rs. 37608 ha⁻¹), net returns (Rs. 17822 ha⁻¹) and B:C ratio (1.92) as compared to without panchagavya spray (Rs. 34612 ha⁻¹, Rs. 15586 ha⁻¹ and 1.84, respectively). Application of 50 per cent N through composted poultry manure + 50 per cent N through green leaf manure along with panchagavya spray recorded higher net returns (Rs. 17822 ha⁻¹), followed by recommended NPK through panchagavya spray (Rs. 15586 ha⁻¹) in rice (Yadav and Lourduraj, 2006b).

2.9 Effect of combined application of sources of nitrogen and liquid manures performance of different crops

2.9.1 Growth, yield parameters and yield

Application of recommended NPK through fertilizers along with panchagavya spray resulted in significantly higher grain yield (5946 kg ha⁻¹) in maize, followed by application of 50 per cent N through composted poultry manure + 50 per cent N through green leaf manure along with panchagavya spray (5877 kg ha⁻¹) which did not differ significantly with each other (Yadav and Lourduraj, 2006a).

Rajendran *et al.* (2006) reported that, application of vermicompost @ 5 t ha⁻¹ as soil application combined with foliar spray of 3 per cent panchagavya 10 DAS enhanced the yield and quality of grains of amaranthus. Similarly, Sanwal *et al.* (2007) reported that application of compost significantly improved the size of ginger rhizomes and increased the yield by applying poultry manure + panchagavya followed by poultry manure + amritpani and cow manure + panchagavya. Shwetha (2007) observed that significantly higher total dry matter production of soybean at harvest recorded with RDF + FYM and organic manures in combination with foliar spray of beejamrut + jeevamrut + panchagavya.

Yadahalli (2008) at Dharwad revealed that application of mulches (glyricidia loppings or organic residues) + FYM with organic solutions amrutpani/jeevamrut) in chilli recorded higher leaf area, leaf area index and dry matter production and yield (860.70, 830.83 and 818 kg ha⁻¹) as that of check treatment FYM @ 10 t/ha + 100% RDF) (935.40 kg ha⁻¹).

The study conducted at Institute of Organic Farming, Dharwad (Anon., 2009) revealed that in maize-chickpea cropping system, integrated application of FYM + VC + Green leaf manure + panchagavya spray at flowering produced significantly higher maize yield and maize equivalent yield (5497 and 10189 kg ha⁻¹) as compared to other treatments. Similarly, Nekar *et al.* (2009) reported that application of organic manures at the time of sowing and foliar application of liquid manures mainly panchagavya, cow urine, biodigesters resulted in better growth and development and produced significantly higher yield of groundnut. Among the liquid manures, panchagavya in combination with cow urine superior and recorded yield of 2192 kg ha⁻¹.

Channagoudra (2012) conducted field experiments to study the impact of organic manures, crop residues, green manures and liquid organic manure on organic cotton and revealed that application of compost (50%) + vermicompost (50%) equivalent to RDF + GLM with surface application of jeevamrutha @ 500 l ha⁻¹ recorded significantly higher kapas yield (1640 kg ha⁻¹) over other organic combinations. Further same author in another experiment reported that combined application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF with foliar spray of panchagavya @ 5% recorded significantly higher kapas yield (1999 kg ha⁻¹) over other organic combinations.

2.9.2 Economics

Yadahalli, (2008) conducted field experiment at Main Agricultural Research Station, Dharwad during *kharif* 2006 on Vertisols to study the effect of mulches, organics and organic solutions on chilli. Results revealed that application of mulches (glyricidia loppings or organic residues) + organics (FYM) with organic solutions (Amrutpani/Jeevamrut) recorded an equivalent net returns (Rs. 26710, Rs. 25521 and Rs. 25040/ha) as that of (FYM @ 10 t/ha + 100% RDF) (Rs. 29914/ha).while, Anon. (2009) revealed that in maize-chickpea cropping system, net returns was higher with application of FYM + VC + Green leaf manure (3/8 + 3/8 + 1/4) + panchagavya (Rs. 65017/ha) followed by application of FYM + VC + Green leaf manure (3/8 + 3/8 + 1/4) (Rs. 56596/ha).

Channagoudra (2012) conducted field experiments to study the impact of organic manures, crop residues, green manures and liquid organic manure on organic cotton and revealed that crop

residue (50%) + vermicompost (50%) equivalent to RDF with lucerene green manure with jeevamrutha @ 500 l ha⁻¹ recorded significantly higher net returns and B:C ratio (Rs. 59531 ha⁻¹ and 2.86, respectively) over other combinations. Further same author in another experiment reported that combined application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF with foliar spray of panchagavya @ 5% was recorded significantly higher gross returns, net returns and B:C ratio (Rs. 113574, 80199 ha⁻¹ and 3.40, respectively) over RDF + FYM.

2.9.3 Nutrient uptake

Channagoudra (2012) conducted field experiments to study the impact of organic manures, crop residues, green manures and liquid organic manure on organic cotton and revealed that application of compost (50%) + vermicompost (50%) equivalent to RDF + GLM with surface application of jeevamrutha @ 500 l ha⁻¹ recorded significantly higher uptake of nitrogen, phosphorus and potassium (78.4, 16.7 and 80.3 kg ha⁻¹, respectively) over other organic combinations and RDF alone. Further same author in another experiment reported that application EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF with foliar spray of panchagavya @ 5% was recorded significantly higher uptake of nitrogen, phosphorus and potassium (73.80, 15.16 and 78.35 kg ha⁻¹, respectively) over other organic combinations.

MATERIAL AND METHODS

The two field experiments namely 1. Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2. Performance of sugar beet to sources of nitrogen and liquid manures were conducted at Agricultural Research Station (ARS), Madhurakhandi (Bagalkot district), University of Agricultural Sciences, Dharwad during the year 2010-11 and 2011-12. The details of the materials used and experimental techniques adopted during the course of investigation are described in this chapter.

3.1 Experimental site

The investigation was carried out at Agricultural Research Station (ARS), Madhurakhandi (Bagalkot district), University of Agricultural Sciences, Dharwad, during *kharif* seasons of 2010-11 and 2011-12 under irrigated conditions. Madhurakhandi is located at a latitude of 16° 20' N and longitude of 75° 20' E with an altitude of 715 m above mean sea level. The research station is located in Northern dry zone (Zone-3) of Karnataka.

3.2 Climatic Conditions

The data on climatic parameters such as rainfall, mean maximum and minimum temperature, relative humidity recorded at near by Bagalkot meteorological observatory, which is 70 km away from Agricultural Research Station, Madhurakhandi. During the experimental year 2010-11 and 2011-12 and the mean data of 10 years (2001-2010) is presented in Table 1 and depicted in Fig. 1. The total annual rainfall of 2010-11 and 2011-12 was 512.8 and 301.9 mm, respectively. Likewise, the monthly as well as weekly minimum and maximum temperatures and relative humidity did not deviate from the normal. During 2010-11 and 2011-12, the highest mean monthly maximum temperature in 2010-11 and 2011-12 was 36.9° C and 38.7° C in the month of May, respectively and the lowest mean monthly minimum temperature of 13.1° C and 14.6° C was observed in the month of January, respectively. Mean monthly relative humidity was 83.40 and 81.18 per cent, respectively during both years in the month of August.

3.3 Soil and its characteristics

The experiment was conducted in vertisols. Composite soil sample was collected from experimental site before sowing and was analyzed for physical and chemical properties, the results of which are presented in Table 2. According to USDA soil classification, the soil belongs to the order Vertisols. Soil was alkaline with a pH of 8.27. The soil was low in available nitrogen content (252 kg N ha⁻¹), medium in available phosphorous (36.8 kg P₂O₅ ha⁻¹) and high in available potassium (353 kg K₂O ha⁻¹).

3.4 Previous crop on the experimental site

The previous crops grown on the field during *kharif* / *rabi* 2009-10 were maize and wheat in sequence and the field was kept fallow during summer.

3.5 Experimental details

3.5.1 Experiment-I: Intercropping of sugar beet cultivars with different row proportions in sugarcane

3.5.1.1 Treatment details

- T₁: Sole sugarcane (150 cm row spacing)
- T₂: Sole sugar beet cultivars Cauvery (50 x 20 cm)
- T₃: Sole sugar beet cultivars Shubhra (50 x 20 cm)
- T₄: Sole sugar beet cultivars Magnolia (50 x 20 cm)
- T₅: Sole sugar beet cultivars Calixta (50 x 20 cm)
- T₆: Sugarcane + sugar beet cultivars Cauvery (1: 1 row proportion)
- T₇: Sugarcane + sugar beet cultivars Cauvery (1: 2 row proportion)
- T₈: Sugarcane + sugar beet cultivars Cauvery (1: 3 row proportion)

Table 1: Monthly meteorological data for the experimental years (2010 and 2011) and the mean of the past 10 years (2001-2010) as recorded at the meteorological observatory near ARS, Bagalkot, University of Agricultural Sciences, Dharwad

Month	Raninfall (mm)			Temperature (°C)						Relative humidity (%)		
				Maximum			Minimum			2010-11	2011-12	Mean *
	2010-11	2011-12	Mean *	2010-11	2011-12	Mean *	2010-11	2011-12	Mean *			
June	46.4	65.8	101.47	31.4	31.2	32.0	24.0	22.8	22.9	74.2	76.00	74.11
July	55.8	54.2	39.39	28.2	30.5	29.2	19.9	22.3	22.4	83.0	81.04	78.23
August	84.8	78.3	69.11	28.4	30.2	27.9	19.9	22.1	21.8	83.4	81.18	79.72
September	111.8	28.9	101.76	28.3	30.8	29.2	20.7	21.1	21.8	82.5	78.16	79.07
October	64.2	49.3	95.44	28.7	32.1	29.4	21.4	21.2	21.3	76.2	74.47	74.39
November	66.8	0	16.76	29.1	30.7	28.7	19.4	16.7	29.0	75.1	65.24	65.60
December	0	0	8.08	28.1	30.5	28.3	17.8	15.4	15.2	65.0	66.17	67.93
January	0	0	1.69	30.9	28.2	28.2	13.1	14.6	14.5	58.5	81.00	65.15
February	1.1	0	6.27	32.2	31.1	31.4	15.5	15.9	17.5	54.2	68.00	60.37
March	0	0	18.32	36.0	33.6	34.7	19.2	17.9	19.7	53.2	73.00	57.33
April	1	0	16.99	34.2	37.1	35.9	23.7	22.5	23.0	58.3	71.00	57.67
May	80.9	25.4	51.06	36.9	38.7	37.2	23.7	22.9	23.9	58.2	69.00	59.04
Total	512.8	301.9	526.34									

* Mean of 10 years (2001-2010)

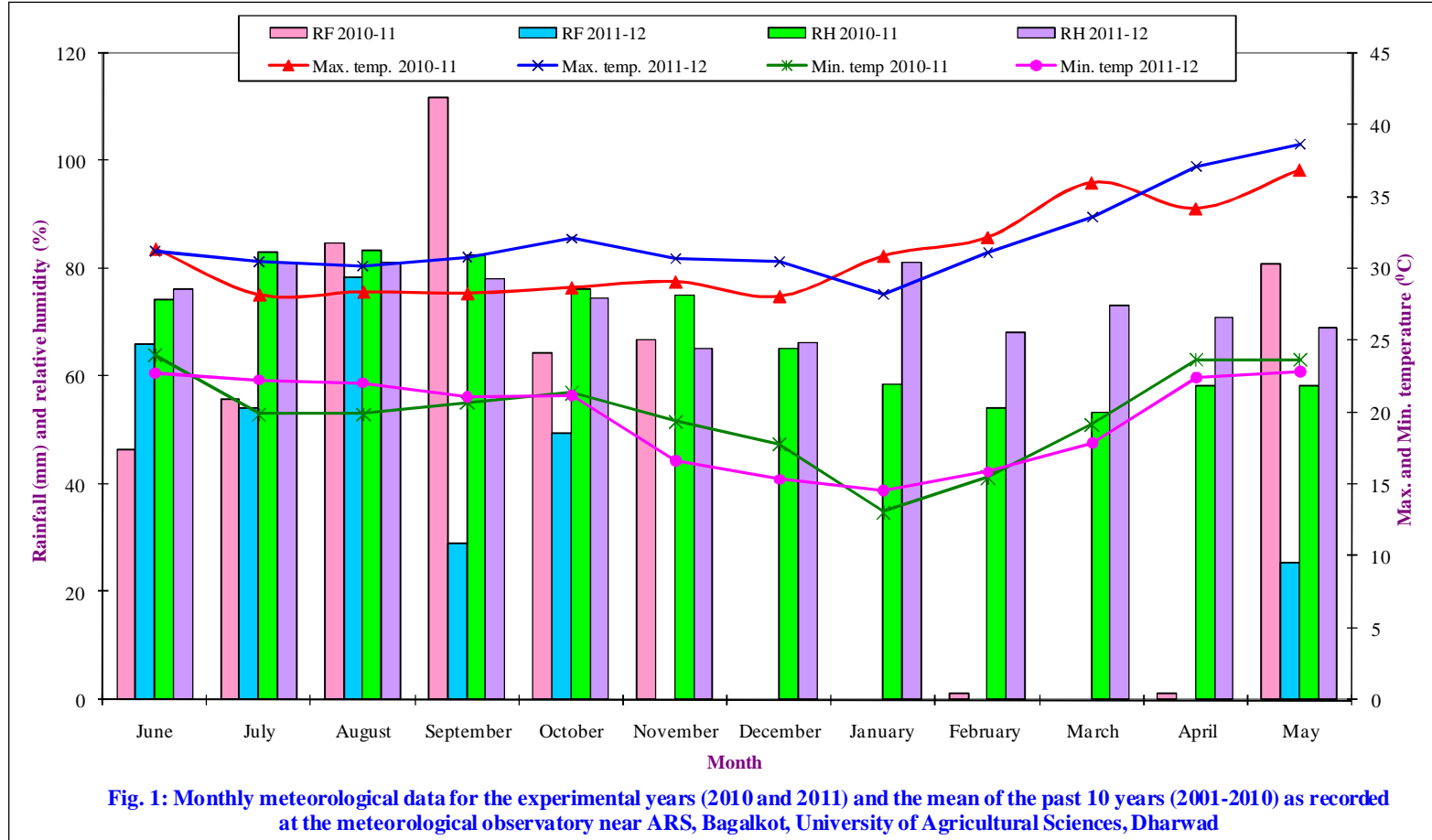


Fig 1 : Monthly meteorological data for the experimental years (2010 and 2011) and the mean of the past 10 years (2001-2010) as recorded at the meteorological observatory, ARS, Bagalkot, University of Agricultural Sciences, Dharwad

- T₉ : Sugarcane + sugar beet cultivars Shubhra (1: 1 row proportion)
 T₁₀ : Sugarcane + sugar beet cultivars Shubhra (1: 2 row proportion)
 T₁₁ : Sugarcane + sugar beet cultivars Shubhra (1: 3 row proportion)
 T₁₂ : Sugarcane + sugar beet cultivars Magnolia (1: 1 row proportion)
 T₁₃ : Sugarcane + sugar beet cultivars Magnolia (1: 2 row proportion)
 T₁₄ : Sugarcane + sugar beet cultivars Magnolia (1: 3 row proportion)
 T₁₅ : Sugarcane + sugar beet cultivars Calixta (1: 1 row proportion)
 T₁₆ : Sugarcane + sugar beet cultivars Calixta (1: 2 row proportion)
 T₁₇ : Sugarcane + sugar beet cultivars Calixta (1: 3 row proportion)

3.5.2 Design and layout

The experiment was laid out in a Randomized Complete Block design with three replications. The plan of layout of the experiment is given in Fig. 2.

3.5.3 Plot size

Gross plot: 15.0 m × 10.0 m = 150.0 m²

Net plot: Varies with row proportions. Details of the spacing adopted and net plot size followed for sugarcane and sugar beet are as follows:

Treatment	Spacing adopted (cm)		Net plot size (m ²)	
	Sugar cane	Sugar beet	Sugarcane	Sugar beet
Sole sugarcane	150	-	68.4 (9m x 7.6 m)	-
Sole sugar beet	-	50 × 20	-	109.2 (13m x 8.4 m)
Sugarcane + sugar beet (1:1)	150	75 × 20	68.4 (9m x 7.6 m)	100.8 (12m x 8.4m)
Sugarcane + sugar beet (1:2)	150	50 × 20	68.4 (9m x 7.6 m)	109.2 (13m x 8.4 m)
Sugarcane + sugar beet (1:3)	150	40 × 20	68.4 (9m x 7.6 m)	112.6 (13.4 m x 8.4m)

3.5.4 Genotypes

The following genotypes were used for the experiment.

Sugarcane: Sugarcane cultivar Co-94012 developed by the scientists of Sugarcane Breeding Institute, Coimbatore and released in the name of Phule Savitri for cultivation in Maharashtra. It is an early (11-12 months), high sugared and high yielding cultivar with high CCS yield. Co-94012 is a somaclonal variant of CoC-671, with better sucrose content and moderately resistant to red rot and smut diseases. This is the first sugarcane cultivars to be released in India through the use of somaclonal variation

Sugar beet : Cauvery, Shubhra, Magnolia and Calixta

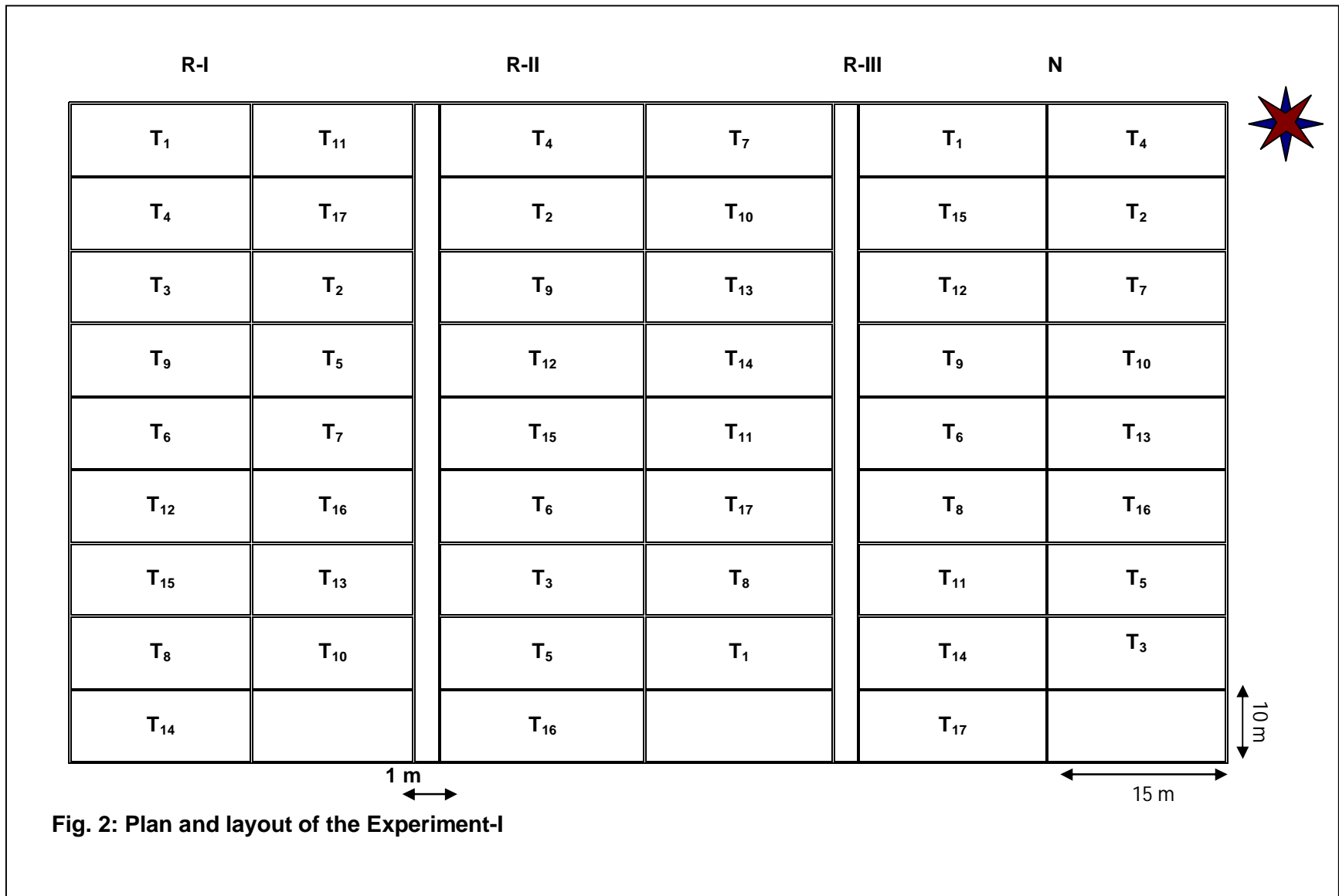
Table 2: Physical and chemical properties of soil of the experimental site

Sl. No.	Parameters	Value obtained	Method employed
I.	Physical properties		
a.	Particle size analysis		
	Coarse sand (%)	11.11	International pipette method (Piper, 1966)
	Fine sand (%)	26.45	
	Silt (%)	22.21	
	Clay (%)	37.15	
	Textural class	Clay	
II.	Chemical properties		
a.	Soil pH (1:2.5 soil: water)	8.27	Potentiometry (Piper, 1966)
b.	Electrical conductivity (1:2.5 soil: water) (dS m ⁻¹)	0.15	Conductivity bridge (Jackson, 1967)
c.	Organic carbon (g kg ⁻¹)	4.5	Walkley and Black's wet oxidation method (Jackson, 1967)
d.	Available nitrogen (kg ha ⁻¹)	252	Alkaline permanganate method (Subbaiah and Asija, 1956)
e.	Available P ₂ O ₅ (kg ha ⁻¹)	36.80	Olsen's method (Jackson, 1967)
f.	Available K ₂ O (kg ha ⁻¹)	353	Flame photometer (Jackson, 1967)

Legend

T ₁	Sole sugarcane
T ₂	Sole SB cv. Cauvery
T ₃	Sole SB cv. Shubhra
T ₄	Sole SB cv. Magnolia
T ₅	Sole SB cv. Calixta
T ₆	SC + SB cv. Cauvery (1:1 RP)
T ₇	SC + SB cv. Cauvery (1:2 RP)
T ₈	SC + SB cv. Cauvery (1:3 RP)
T ₉	SC + SB cv. Shubhra (1:1 RP)
T ₁₀	SC + SB cv. Shubhra (1:2 RP)
T ₁₁	SC + SB cv. Shubhra (1:3 RP)
T ₁₂	SC + SB cv. Magnolia (1:1 RP)
T ₁₃	SC + SB cv. Magnolia (1:2 RP)
T ₁₄	SC + SB cv. Magnolia (1:3 RP)
T ₁₅	SC + SB cv. Calixta (1:1 RP)
T ₁₆	SC + SB cv. Calixta (1:2 RP)
T ₁₇	SC + SB cv. Calixta (1:3 RP)

Note : SC: Sugarcane, SB: Sugar beet, RP: Row Proportion



Salient features of different sugarbeet cultivars

Particulars	Cauvery	Shubhra	Magnolia	Calixta
Plant height	High	High	Medium Bushy	Medium
Leaf thickness	Thin	Thin	Thick	Thin
Leaf attitude	Semi Prostrate	Semi Prostrate	Spready	Semi prostrate
Leaf blade length	Long	Long	Medium	Medium
Leaf blade width	Broad	Broad	Narrow	Medium
Leaf blade colour	Dark green	Dark green	Green	Dark green
Hypocotyls colour	Green	Green	80-100% Red	Green
Root position in soil	Deep	Deep	Deep	Deep
Root length	Long Conical	Short round	Long	Short round
Root width	High	High	Medium	Medium
Root yield	High	High	Medium	Medium to high
Sugar content	High (17-17.5 %)	High (17-17.5 %)	Medium (16.5-17 %)	High (17-17.5 %)
<i>Sclerotium</i> rot resistance	Less Tolerant	Less Tolerant	More Tolerant	Medium Tolerant
Duration in days	160-165	160-165	170-180	165-175

3.6 Details of cultivation

3.6.1 Land Preparation

The land was brought to a fine tilth by initial ploughing once with tractor drawn plough and twice with cultivator. Later the field was harrowed twice with bullock pairs, stubbles and weeds were removed from the field. Afterwards the raised beds (for sugarbeet sowing) were formed by opening ridges and furrows at 150 cm distance (for sugarcane planting) with tractor mounted ridger and furrow opener.

3.6.2 Fertilizer application

Recommended fertilizer levels in the form of diammonium phosphate, muriate of potash and urea, as per the plant density were applied for each of the crop. The details of plant population and fertilizer dose applied are furnished as under:

Treatment	Plant population (%)		N, P ₂ O ₅ and K ₂ O (kg ha ⁻¹)	
	Sugarcane	Sugar beet	Sugarcane	Sugar beet
Sole sugarcane	100	-	250 :75 :190	-
Sole sugar beet	-	100	-	120 :60 :90
Sugarcane + sugar beet (1:1row proportion)	100	33	250 :75 :190	39.60:19.80:29.70
Sugarcane + sugar beet (1:2 row proportion)	100	66	250 :75 :190	79.20:39.60:59.40
Sugarcane + sugar beet (1:3 row proportion)	100	100	250 :75 :190	120 :60 :90

For sugar beet, at the time of sowing 50 per cent of the recommended dose of N and entire quantity of P₂O₅ and K₂O were applied as basal dose. The remaining 50 per cent of nitrogen was top dressed at 45 days after sowing.

For sugarcane at the time of planting 10 per cent of the recommended dose of N and entire quantity of P₂O₅ and K₂O were applied as basal dose. The remaining 90 per cent of nitrogen was top dressed with 20, 30 and 40 per cent at 6th, 10th and 14th weeks after planting, respectively.

3.6.3 Sowing/planting

Sugar beet sowing

Sugar beet seeds were sown by hand dibbling in three different row proportions on raised bed which were formed by opening ridges and furrows at distance of 150 cm apart as per the plan of layout of the experiment (Fig.3).

Sugarcane planting

Planting material was selected from nine months old crop cultivar Co-94012. The harvested cane was de-trashed, cut into two-eye budded setts and only good healthy setts were selected for planting. The selected setts were treated with 0.1% Carbendizem (50%WP) [fungicide] and 0.1% Chlorpyrifos (20% EC) before planting to disinfect from stem borer, sett born diseases and to facilitate good germination.

After two months of sowing of sugar beet on the raised bed, furrows which were meant open during sugarbeet sowing were reopened by bullock drawn ridge former for planting of sugarcane without affecting standing sugarbeet crop (Fig. 3).

Date of sowing	Sowing date		Harvesting date	
	2010	2011	2010	2011
Sugar beet	26-06-2010	14-07-2011	14-12-2010	02-01-2012
Sugarcane	7-09-2010	23-09-2011	26-09-2011	19-10-2012

3.6.4 After care

Sugarcane: A heavy earthing up was done immediately after the harvest of sugar beet and subsequent earthing up operation was carried out (three times) at monthly interval. Irrigation was given immediately after planting and crop was irrigated at monthly interval. The crop was hand weeded thrice to keep field free from weeds

Sugar beet: Details of after care operations followed for sugar beet in experiments are discussed in Table 3.

3.6.5 Harvesting of sugarcane

The sugarcane crop was harvested at the age of 11 month. The canes from the net plot area were harvested separately. Canes were cut at ground level, detashed, tops were removed, bundled and weighed plot wise.

3.7 Experiment–II: Performance of sugar beet to sources of nitrogen and liquid manures

3.7.1 Treatment details

Sources of nitrogen (SN) (Main plot)

SN₁ -100 per cent RDN (120 kg ha⁻¹) through inorganic fertilizer

SN₂ -75 per cent RDN through inorganic fertilizer +25 per cent RDN through vermicompost and poultry manure in equal proportion

SN₃ -50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost and poultry manure in equal proportion

SN₄ -25 per cent RDN through inorganic fertilizer +75 per cent RDN through vermicompost and poultry manure in equal proportion

SN₅ -100 per cent RDN through vermicompost (33%), poultry manure (33%) and green manuring (33%)

Liquid manures (LM) (Subplot)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of vermiwash (20 %) at 30 and 60 DAS

LM₃- Foliar spray of cow urine (10 %) at 30 and 60 DAS

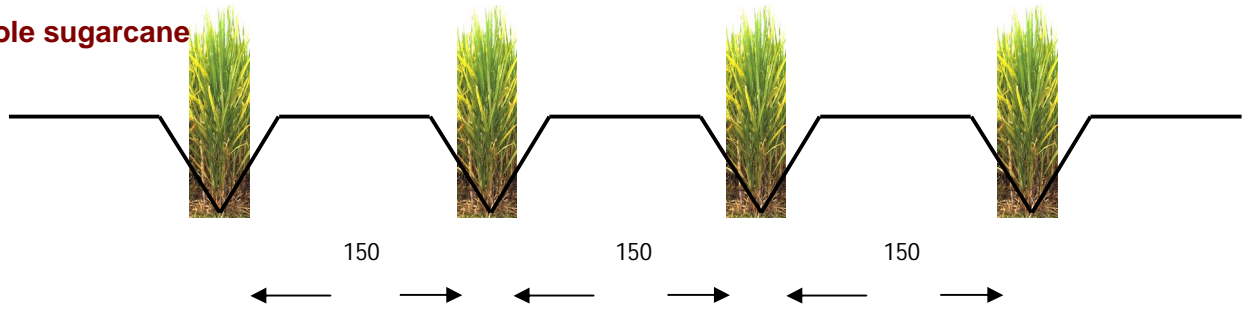
LM₄- Foliar spray of vermiwash (20 %) and cow urine (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

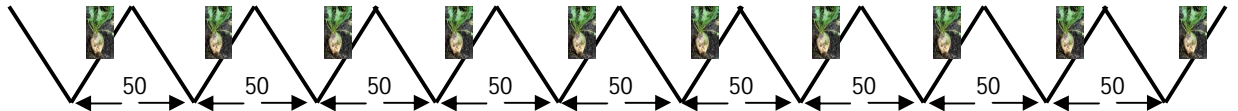
Table 3: Details of after care operations followed for sugar beet in both the experiments

Sl. No.	Operation	Methodology / procedure
1.	Gap filling and thinning	Gap filling was undertaken at 10 DAS in order to maintain optimum and uniform plant population in each plot. Thinning was done at 15 th day of sowing wherever excess seedling were present.
2.	Hand weeding and intercultivation	Intercultivation with bullock drawn harrow was attended at 40 DAS to manage weeds and pulvarise the soil. Hand weedings were given at 25 and 65 DAS in order to keep the plots clean and weed free to avoid the crop weed competition. The nature, time and frequency of inter cultivations were similar for all the treatments.
3.	Plant protection	
	Pest management	During both years, plant protection measures were undertaken to protect the sugar beet crop from sugar beet armyworm and leaf eating caterpillar. Two sprayings of Acephate 75 SP @ 0.05 per cent and Karate 5 EC @ 0.05 per cent were taken alternately at 25 days intervals.
	Disease management	Soil application of <i>Trichoderma viride</i> at 2.5 kg/ha, mixed with 50 kg of FYM for controlling <i>Sclerotium</i> root rot at 80DAS.
4.	Irrigation	First irrigation was given immediately after sowing and there after irrigation was given at weekly interval depending upon the soil moisture and weather conditions during monsoon for both crops.
5.	Harvesting	<p>The sugar beet crop matured in 165 days. The drying and yellowing of lower leaf whorls of matured plant indicate the maturity of sugar beet for harvest. The irrigation was stopped two weeks before harvest. Beets in the border and sampling rows were harvested first by hand (uprooting) and removed from the field. Then beets in each net plot area were harvested and tops were removed and weighed and with it the weight of the sample beet harvested for quantitative character was also added to arrive at the beet yield in the net plot.</p> <p>The harvested beet tuber was handled as gently as possible to remove soil and trash to minimize the beet breakage and bruising to get quality beet tuber.</p>

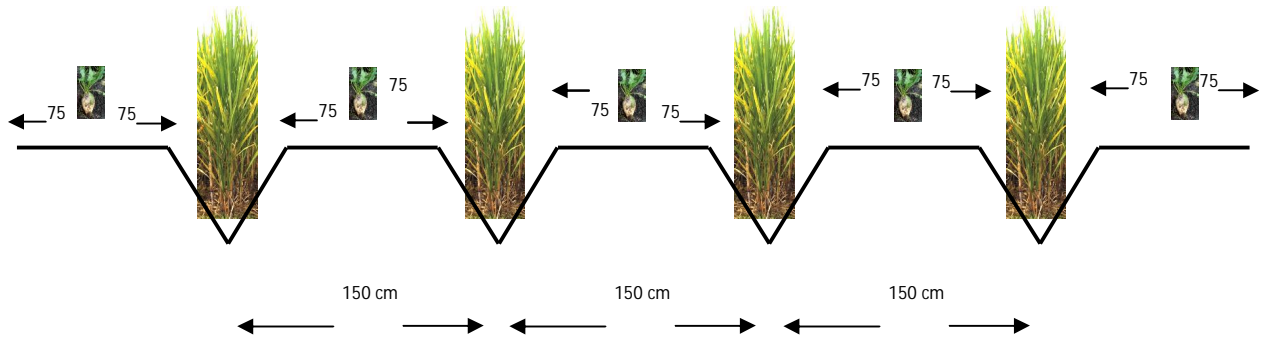
Sole sugarcane



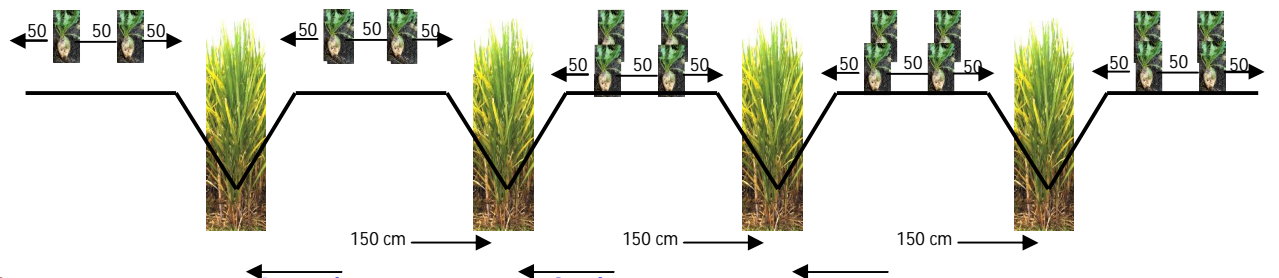
Sole sugar beet



Sugarcane + sugar beet (1:1 row proportion)



Sugarcane + sugar beet (1:2 row proportion)



Sugarcane + sugar beet (1:3 row proportion)

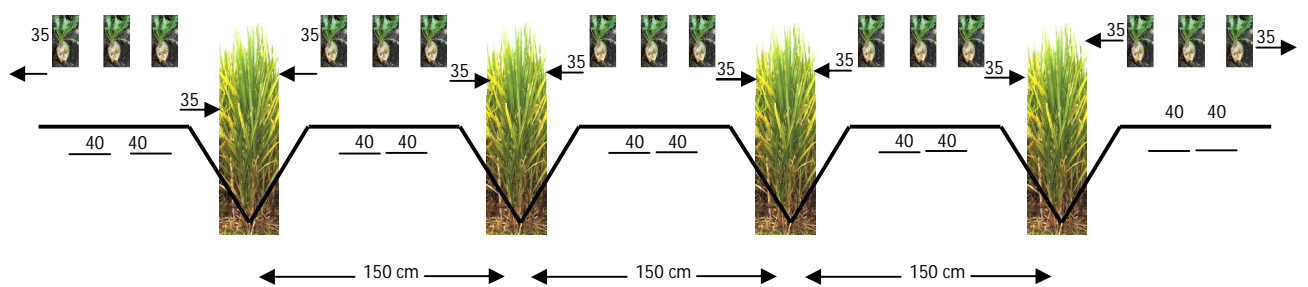


Fig. 3: Schematic diagram showing planting pattern of sugarcane and sugar beet in intercropping system



Reopening of furrows



Furrows kept ready for sugar cane planting



Sugarcane sets treatment for planting



Planting of sugarcane

Plate 1 : Sugar cane planting in standing sugar beet crop (Experiment-I)



Sugar beet before planting of sugarcane



Sugarcane + Sugar beet intercropping



Sugarcane after harvesting of sugar beet

Plate 2 : General view of experimental plot (Experiment-I)

Note :

1. Recommended dose of N (RDN): 120 kg ha⁻¹
2. Common dose of FYM of 10 t ha⁻¹ and recommended dose of phosphorous (60 kg ha⁻¹) through diammonium phosphate and potassium (90 kg ha⁻¹) through muriate of potash were applied uniformly to all the plots.

3.7.2 Design and layout

The experiment-2 was laid out in a split plot design having 25 treatment combinations and replicated thrice. The plan of layout of the experiment is depicted in Fig. 4.

3.7.3 Plot size

Gross plot size : 4 m x 3.6 m

Net plot size : 2.5 m x 2.4 m

3.7.4 Genotype/cultivars : Calixta

3.7.5 Spacing : 50 cm x 20 cm

3.7.6 Sowing time : June 1st week

3.8 Cultural practices

3.8.1 Land preparation

The land was brought to a fine tilth by initial ploughing once with tractor drawn plough and twice with cultivator. Later field was harrowed twice with bullock pairs, stubbles and weeds were removed from the field. At the time of sowing, the land was prepared in to ridges and furrows and the plots were laid out as per the plan of layout of the experiment.

3.8.2 Manures and fertilizers

A common dose of FYM of 10 t ha⁻¹ and recommended dose of phosphorous (60 kg ha⁻¹) through diammonium phosphate and potassium (90 kg ha⁻¹) through muriate of potash were applied uniformly to all the plots. Recommended dose of nitrogen 120 kg ha⁻¹ was applied in the form of urea in split application (50 % N as basal, remaining 50 % N as top dress at 45 DAS). Organic manures viz, vermicompost, poultry manure, green manuring and liquid manures (Jeevamrutha, vermiwash and cow urine) were applied as per the treatment schedule to the respective plots is furnished as under.

Details of sources of nitrogen and liquid manures applied for the experiment

Mainplot	Quantity of N, P ₂ O ₅ , K ₂ O applied (kg ha ⁻¹) in the form of			Quantity applied (kg ha ⁻¹)			Subplot	Quantity applied (lit ha ⁻¹)		
	UREA	DAP	MOP	VC	PM	GM		Liquid manures	Jeeva mrutha	Vermi wash
SN ₁	261	130	150	0	0	0	LM ₁	500	0	0
SN ₂	196	130	150	165	109	0	LM ₂	0	120	0
SN ₃	130	130	150	331	220	0	LM ₃	0	0	60
SN ₄	65	130	150	497	329	0	LM ₄	0	120	60
SN ₅	0	130	150	437	290	791	LM ₅	0	0	0
Total	652	650	750	1430	948	791	Total	500	240	120

Note: VC: Vermicompost PM: Poultry manure GM: Green manuring

3.8.3 Sowing

Healthy seeds of sugar beet genotype Calixta used for sowing. The seeds were dibbled on the top of the ridges at 2 to 2.5 cm depth with one seed hole⁻¹ on 28th June, 2010 in the first year and 8th July, 2011 for 2nd year.

Legend

Sources of nitrogen (SN)

SN₁-100 per cent RDN (120 kg ha⁻¹) through inorganic fertilizer

SN₂-75 per cent RDN through inorganic fertilizer +25 per cent RDN
through vermicompost and poultry manure in equal proportion

SN₃-50 per cent RDN through inorganic fertilizer + 50 per cent RDN
through vermicompost and poultry manure in equal proportion

SN₄-25 per cent RDN through inorganic fertilizer +75 per cent RDN
through vermicompost and poultry manure in equal proportion

SN₅-100 per cent RDN through vermicompost (33%) ,poultry manure
(33%) and green manuring (33%)

Liquid manures (LM):

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of vermiwash (20 %) at 30 and 60 DAS

LM₃- Foliar spray of cow urine (10 %) at 30 and 60 DAS

LM₄- Foliar spray of vermiwash (20 %) and cow urine (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

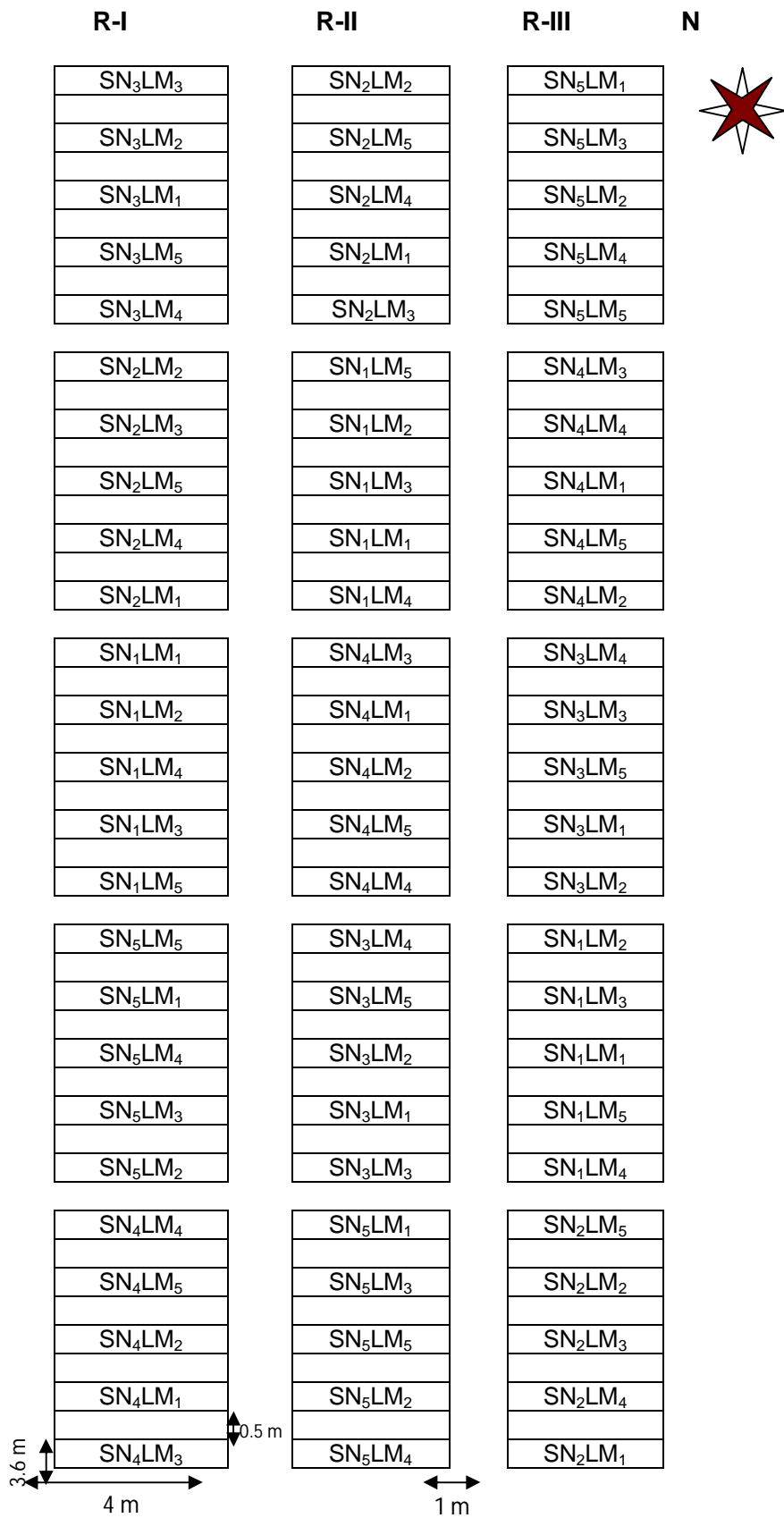


Fig. 4: Plan of lay out of the Experiment-II



Opening of ridges and furrows



Sowing of sugar beet by hand dibbling

Plate 3 : Sowing of sugar beet by hand dibbling (Experiment-II)

3.8.4 Foliar nutrition

The following liquid manures were applied individually as per the treatments in the following concentrations.

Jeevamrutha @ 100 per cent at sowing, 30 and 60 DAS

Cow urine @ 10 per cent at 30 and 60 DAS

Vermiwash @ 20 per cent at 30 and 60 DAS

Detailed procedure for preparation of liquid manures

Jeevamrutha

Jeevamruth liquid organic manure was used as a nutrient source. Jeevamruth was prepared by using 10 kg dung, 10 litre cow urine, jaggery 2 kg, 2 kg pulse flour and 1 kg of soil mixed thoroughly in 200 litre of water taken in a drum. The mixture was thoroughly stirred for a week twice daily and used. This was applied @ 500 litre ha⁻¹ to a soil during sowing.

Vermiwash

A liquid nutrient/plant growth promoting substance obtained by the vermiculture / vermicomposting which contains major, minor elements, PGRs, antibiotics, microflora and others was extracted at advanced stage of vermicomposting by sprinkling water in vermitanks.

Cowurine

It was directly collected from local cow one day before spraying for the crop.

3.8.5 After care

Details of after care operations followed for sugar beet in experiments are presented in Table 3.

3.9 Observations recorded

Detailed methods of recording observations on growth yield and quality of sugarcane and sugar beet is presented in Table 4.

3.10 Production efficiency indices of intercropping systems

3.10.1 Land equivalent ratio (LER)

It is defined as the relative land area under sole crops that is required to produce the yields obtained in intercropping at the same level of management. LER was worked out by using the following formula given by Willey (1979).

$$LER = La + Lb = Ya/Sa + Yb/Sb$$

Where,

La and Lb = LER for the crop 'a' and 'b'

Ya and Yb = Individual crop yields under intercropping

Sa and Sb = Individual crop yields under sole cropping

3.10.2 Area time equivalent ratio (ATER)

The limitation in the use of LER is the emphasis on the land area without consideration of time the field is dedicated to production. To correct this deficiency, the LER was modified by Hiebsch and Maccollum (1980) to include the duration of time the crop was on the land from planting to harvest. This method is known as the area time equivalent ratio (ATER).



Jeevamrutha



Vermiwash



Cow urine



Vermicompost

Poultry manure

Green manuring

Plate 4 : Detailed view of preparation and application of organic manures to sugar beet



Plate 5 : General view Experiment-II

Table 4: Methods of recording observations on different parameters

SI. No.	Parameter	Procedure followed
I	Sugarcane	
A.	Growth parameters of sugarcane	
1.	Germination (%) at 45 DAP	The germination was recorded from the gross plot on 45 th days after planting (DAP) and expressed as percentage of the buds planted.
2.	Plant height (cm)	Plant height was recorded from ground level to the base of the last fully opened leaf from randomly selected five plants at 90, 150, 210, and 270 DAP and at harvest. The mean height of five plants was recorded as plant height in centimetre
3.	Number of green leaves per plant	The total number of green leaves per plant present on randomly selected plants in each net plot were counted and expressed as the average number of green leaves per plant at 90, 150, 210, and 270 DAP and at harvest.
4.	Leaf area (LA) [dm ² plant ⁻¹]	Length and breadth of third, fourth, fifth and sixth leaves from the top were determined in the five selected plants. The leaf area of individual leaves of the plant was calculated by multiplying with a factor 0.75 [Romero, 1978]. The mean leaf area of selected leaves was multiplied by number of leaves per plant to arrive at the leaf area per plant and expressed in decimetres square per plant at 90, 150, 210, and 270 DAP and at harvest. $LA = \frac{(L \times B) \times 0.75}{100}$ Where, LA= Leaf area in dm ² plant ⁻¹ , L= Length of leaf in cm, B= Breadth of leaf in cm.
5.	Leaf area index (LAI)	$LAI = \frac{A}{P}$ Where, A= Leaf area per plant (dm ²), P= Land area occupied by the plant (dm ²) (Sestak <i>et al.</i> , 1971)

Contd.....

SI. No.	Parameter	Procedure followed
6.	Leaf area duration (LAD)	<p>The leaf area duration is the integral part of leaf area index (LAI) over a growth period (Watson, 1952). LAD for various growth period was worked out from the formula of Power <i>et al.</i> (1967) and expressed in days.</p> $\text{LAD} = \frac{Li_1 + (Li + 1)}{2} \times (t_2 - t_1)$ <p>Where, Li :LAI at i^{th} stage , $Li + 1$:LAI $(i+1)^{\text{th}}$ stage, (t_2-t_1) :Time interval between i^{th} and $(i+1)^{\text{th}}$ stage in days</p>
7.	Number of internodes per plant	Number of internodes present on sugarcane was recorded from base of cane stalk to fully opened leaf base. The average number of internodes of five randomly selected plants was recorded at 90, 150, 210, and 270 DAP and at harvest.
8.	Dry matter production per plant and its distribution into stem and leaves (g plant^{-1})	The dry matter production was determined only from the above ground portion of the plant. Five plants were selected from border rows randomly by cutting at the base from sample rows and they were separated into stem and leaves, chaffed separately and kept for drying in sun. The semi dried material was kept into hot air oven at 70° C till a constant weight and the weight were recorded. After weighing the material, total dry matter production was calculated and was expressed in grams per plant. The mean dry matter of five randomly selected plants from sampling rows was recorded at 90, 150, 210, and 270 DAP and at harvest.
B.	Yield components and yield of sugarcane	
1.	Length of internode (cm)	The length of the internodes present at top, middle and bottom portion of each cane was recorded at harvest and average of these was recorded as mean intermodal length and was expressed in centimetre.
2.	Girth of cane (cm)	The girth of millable canes was recorded at maturity exactly in the centre of sixth internode from the top using a vernier callipers and expressed in centimetres.
3.	Number of millable canes	All the canes from each net plot were cut at the ground level, de-trashed, de-topped, counted and recorded as number of millable canes per plot. These were expressed as millable canes per hectare.
4.	Cane weight (g plant^{-1})	The weights of ten randomly selected millable canes were recorded at harvest and the average of those was worked out and expressed as single cane weight in grams per plant.

Contd.....

Sl. No.	Parameter	Procedure followed
5.	Cane yield (t ha ⁻¹)	All the millable canes in the net plot were cut close to the ground level. The green tops and trash were removed and cane yield per net plot was recorded. The cane yield was calculated and expressed in tonnes per hectare.
C.	Quality parameters of sugarcane	
1.	Brix and sucrose per cent	From the juice sample, the total solids (Brix %) were estimated by Brix hand reflector meter and sucrose (pol) per cent was estimated by Harne's dry lead sub-acetate clarification method (Meade and Chen, 1977).
2.	Commercial cane sugar (CCS %)	CCS % = [Sucrose % - [Brix %-Sucrose%] X 0.40] X 0.73 (Parthasarathy <i>et al</i> ,1979)
3.	Sugar yield (t ha ⁻¹)	$\text{Sugar yield [t ha}^{-1}\text{]} = \frac{\text{C.C.S [\%]} \times \text{Cane yield [t ha}^{-1}\text{]}}{100}$ <p>Where, CCS = Commercial cane sugar (%) (Sastry and Venkatachari ,1960)</p>
II.	Sugar beet	
A.	Growth observations on sugar beet	
1.	Plant height (cm)	The plant height was measured at 30, 60, 90 and 120 days after sowing and at harvest from ground level to the apex of the crop and the mean height was expressed in centimeter.
2.	Number of leaves per plant	The number of leaves per plant was counted from the selected five plants and averaged out.
3.	Leaf area (dm ² plant ⁻¹)	<p>The length and breadth of the five fully opened green leaves per plant were measured. The length was measured from the base to the tip of the lamina and breadth was taken at the widest point of the lamina. From this, the average length and breadth was worked out. The leaf area was calculated as per the formula,</p> $\text{LA} = \frac{\text{L} \times \text{B}}{100} \times 0.75$ <p>Where, LA= Leaf area in dm² plant⁻¹, L= Length of leaf in cm, B= Breadth of leaf in cm The leaf area of the plant was calculated by multiplying this leaf area with the total number of leaves per plant (Ghodke, 2007).</p>

Contd.....

Sl. No.	Parameter	Procedure followed
4.	Leaf area index (LAI)	Furnished in Table No.4 Serial number: I/A/5 (LAI of sugarcane)
5.	Leaf area duration (LAD)	Furnished in Table No.4 Serial number: I/A/6 (LAD of sugarcane)
6.	Total dry matter production (g plant ⁻¹)	The weight of dry matter is an index of productive capacity of the plant. Five plants from sampling rows were uprooted for recording dry matter production (g). After removal the plant was washed thoroughly to remove the adhering soil and separated in to leaves and root. After recording their fresh weights, these plant parts were collected in separate brown paper bags, properly labelled, initially sundried and then dried in hot air oven at 70 ⁰ C for recording their oven dry weights until constant weights were recorded .
B.	Yield components and yield of sugar beet	
1.	Tuber length (cm)	The length of the tuber was measured from the collar to the tip of well grown roots and expressed in centimetre.
2.	Tuber girth (cm)	Five tubers were randomly selected and girth of the individual tuber was taken and the mean was expressed in centimetre.
3.	Tuber weight (g plant ⁻¹)	Five tubers were taken in each plot randomly and weighed. The mean weight was expressed in g tuber ⁻¹ .
4.	Tuber yield (t ha ⁻¹)	Tuber yield per hectare was calculated based on the net plot yield and expressed in t ha ⁻¹ .
5.	Green foliage yield (t ha ⁻¹)	Green foliage yield per hectare was calculated based on the net plot yield and expressed in t ha ⁻¹ .
6.	Harvest index (HI)	$\text{Harvest index} = \frac{\text{Economic yield (t/ha)}}{\text{Biological yield (t/ha)}}$ <p style="text-align: right;">(Donald, 1962)</p>

Contd.....

SI. No.	Parameter	Procedure followed
C.	Quality parameters of sugar beet	
1.	Brix and sucrose per cent	From the juice sample, the total solids (Brix per cent) were estimated by Brix hand reflector meter and sucrose (pol) per cent was estimated by Hare's dry lead sub-acetate clarification method (Meade and Chen, 1977).
2.	Commercial beet sugar (CBS %)	$\text{CBS \%} = [\text{Sucrose \%} - [\text{Brix \%} - \text{Sucrose \%}] \times 0.40] \times 0.73$ (Parthasarathy <i>et al</i> ,1979)
3.	Sugar yield (t ha ⁻¹)	$\text{Sugar yield [t ha}^{-1}\text{]} = \frac{\text{C.B.S [\%]} \times \text{Tuber yield [t ha}^{-1}\text{]}}{100}$ <p>Where, CBS = Commercial beet sugar (%) (Sastry and Venkatachari ,1960)</p>

ATER was calculated by the formula evolved by Hiebsch and Maccollum (1980).

$$\text{ATER} = \frac{(\text{RY}_a \times t_a) + (\text{RY}_b \times t_b)}{T}$$

Where,

RY = Relative yield of species 'a' and 'b'

$$\text{RY} = \frac{\text{Yield of intercrop per hectare}}{\text{Yield of monocrop per hectare}}$$

t = Duration (days) for species 'a' and 'b'

T = Total duration (days) of the intercropped system

3.10.3 Sugarcane equivalent yield (SEY, t ha⁻¹)

The sugarcane equivalent yield of intercropping system was calculated by taking into account the yield of component crops (sugarcane and sugar beet) and the prevailing market price of both the crops. The sugarcane equivalent yield was calculated as

$$\text{SEY (kg ha}^{-1}\text{)} = \text{Sugarcane yield (t ha}^{-1}\text{)} + \frac{\text{Sugar beet yield (t ha}^{-1}\text{)} \times \text{price of sugar beet (Rs. /tonne)}}{\text{Sugarcane price (Rs. /tonne)}}$$

3.10.4 System productivity index (SPI)

System productivity index (SPI) proposed by Odo (1991), standardizes the economic yield of intercrops (secondary crop) in terms of the main (primary) crop yield. The SPI assists to identify the combination utilizing the growth resources most effectively and maintains a stable yield performance. It was calculated as

$$\text{SPI} = \frac{\text{SA}}{\text{LB}} \times \text{Lb} + \text{Sa}$$

Where,

SA and LB are mean yields of sole crops and Sa and Lb are their yields in intercropping system.

3.11 Plant analysis

3.11.1 NPK uptake by plants at harvest

The plant samples of sugarcane and sugar beet collected for dry matter production studies at harvest were analyzed for nitrogen, phosphorus and potash contents after drying in hot air oven at 70°C and powdered in Willey mill to pass 40 mesh sieves and the powdered material was collected in a butter paper bag and later used for estimation of major nutrients. Nitrogen estimation was done by Kjeldahl's method (Jackson, 1967), phosphorus by Vanado Molybdate Phosphoric Acid Yellow Colour method and potassium by Flame Photometric method.

Based on nutrient content of plants and dry matter production, uptake of nitrogen, phosphorus and potassium were worked out by using following formula:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Per cent nutrient concentration}}{100} \times \text{Biomass (kg/ha)}$$

3.12 Soil analysis

3.12.1 N, P₂O₅ and K₂O analysis

Composite soil sample was collected from 0-30 cm depth just before lay out of the experiment and analyzed for available N, P₂O₅ and K₂O contents using alkaline permanganate method (Subbaiah and Asija, 1956), Olsen's method (Jackson, 1967) and flame photometer method (Jackson, 1967), respectively.

3.13 Economics of the system

3.13.1 Cost of cultivation

It was worked out on the basis of cost of labour, inputs and other costs for both sugarcane and sugar beet seperately. The detailed cost of cultivation treatment wise is furnished in Appendix II (a & b).

3.13.2 Gross returns (Rs. ha⁻¹)

It was worked out on the basis of market rates prevailing at the time of harvest of the produce.

3.13.3 Net returns (Rs. ha⁻¹)

Net returns were calculated by subtracting the cost of cultivation (Rs. ha⁻¹) from the gross return.

3.13.4 Benefit cost ratio

The ratio of gross returns to cost of cultivation was worked out for each treatment and was used as benefit cost ratio (B: C) to compare the performance of different treatments.

$$\text{B: C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.14 Statistical analysis and the interpretation of data

Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 'T' tests was p=0.05. Critical differences were calculated wherever 'F' test was significant. Means were compared by Duncan Multiple Range Test (DMRT). The data were analysed statistically following computer package MSTAT-C and DMRT was used to determine the significant differences among the treatment means.

EXPERIMENTAL RESULTS

The two field experiments namely 1. Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2. Performance of sugar beet to sources of nitrogen and liquid manures were carried out during 2010-11 and 2011-12. Results obtained from both field experiments on different aspects are presented in this chapter. For the sake of convenience, the results are presented under following heads.

Experiment–I: Intercropping of sugar beet cultivars at different row proportions in sugarcane

4.1 Performance of sugarcane

4.1.1 Growth components of sugarcane

4.1.1.1 Germination (%) at 45 DAP

The data on germination percentage of sugarcane recorded at 45 DAP during 2010-11, 2011-12 and on pooled basis presented in Table 5.

Germination percentage of sugarcane did not differ significantly between sole and intercropped sugarcane.

4.1.1.2 Plant height

The data on plant height of sugarcane differed significantly due to intercropping with sugar beet cultivars in different row proportions at all stages of crop growth during 2010-11, 2011-12 and on pooled basis (Table 6).

Sole sugarcane recorded significantly higher plant height at 90 DAP in 2010-11, 2011-12 and on pooled basis (53.85, 49.97 and 51.91 cm, respectively) compared to other treatments. However, growing of sugarcane (SC) + sugar beet (SB) in 1:1 row proportion (RP) remained on par with sole sugarcane, irrespective of sugar beet cultivars tested.

In general, increase in the row ratios of sugar beet resulted in gradual reduction of sugarcane plant height. Growing of sugar beet in 1:2 row ratio recorded significantly higher plant height than 1:3 row ratio. Irrespective of sugar beet cultivars lower sugarcane plant height was recorded under 1:3 row ratio. Similar trend was observed at 150, 210 and at 270 DAP.

At harvest, significantly higher plant height was recorded by sole sugarcane in 2010-11, 2011-12 and on pooled basis (167.82, 163.03 and 165.42 cm, respectively) compared to other treatments. However, growing of SC + SB under 1:1 RP recorded on par plant height as that of sole sugarcane, across various cultivars tested. On the contrary, lower sugarcane plant height was recorded under 1:3 row ratio.

4.1.1.3 Number of leaves per plant

Number of leaves per plant of sugarcane differed significantly due to intercropping of sugar beet cultivars at different row proportions at all stages of crop growth during both years of experimentation and on pooled basis (Table 7).

Sole sugarcane recorded significantly higher number of leaves per plant at 90 DAP in 2010-11, 2011-12 and on pooled basis (11.35, 10.86 and 11.11, respectively) compared to other treatments. However, sugarcane grown with sugar beet in 1:1 row ratio remained on par with sole sugarcane, irrespective of the various varieties tested.

In general, increase in the row ratios of sugar beet there was a gradual reduction in number of leaves per plant. Growing of sugar beet in 1:1 row ratio recorded significantly higher number of leaves per plant than 1:2 and 1:3 row ratios. While, irrespective of sugar beet cultivars lower number of leaves per plant was observed under 1:3 row ratio. Similar trend was observed at 150, 210 and at 270 DAP.

At harvest, sole sugarcane recorded significantly higher number of leaves per plant (16.34, 14.77 and 15.55, respectively) in 2010-11, 2011-12 and on pooled basis compared to other treatments. However, growing of SC + SB in 1:1 RP recorded on par number of leaves per plant as

Table 5: Germination (%) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Germination (%) at 45 DAP		
	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	86.75a	85.51a	86.13a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	85.51a	84.26a	84.89a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	84.76a	83.52a	84.14a
T ₄ - SC + SB cv. Cauvery (1:3 RP)	84.60a	83.36a	83.98a
T ₅ - SC + SB cv. Shubhra (1:1 RP)	84.77a	83.53a	84.15a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	84.03a	82.78a	83.41a
T ₇ - SC + SB cv. Shubhra (1:3 RP)	83.82a	82.58a	83.20a
T ₈ - SC + SB cv. Magnolia (1:1 RP)	85.84a	84.60a	85.22a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	85.11a	83.86a	84.48a
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	84.96a	83.71a	84.33a
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	85.11a	83.87a	84.49a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	84.40a	83.15a	83.78a
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	83.89a	82.64a	83.26a
S.Em±	3.51	3.45	3.48
CV (%)	7.15	7.26	7.35

Means followed by common letter do not differ significantly by DMRT @ p=0.05
 Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 6: Plant height (cm) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Plant height (cm)								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	53.85a	49.97a	51.91a	102.45a	99.79a	101.12a	143.59a	139.86a	141.72a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	50.38ab	47.02ab	48.70a-c	98.18ab	94.46a-c	96.32a-c	136.68ab	134.38ab	135.53ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	47.78bc	43.41b-d	45.59b-e	90.12c-f	87.78b-e	88.95c-e	127.44bc	123.39cd	125.41bc
T ₄ - SC + SB cv. Cauvery (1:3 RP)	46.87bc	42.55cd	44.71c-e	86.58ef	84.08de	85.33de	119.78c	117.99d	118.89c
T ₅ - SC + SB cv. Shubhra (1:1 RP)	50.95ab	47.28ab	49.12ab	97.55a-c	94.26a-c	95.91a-c	135.84ab	134.22a-c	135.03ab
T ₆ - SC + SB cv. Shubhra (1:2 RP)	48.18bc	44.71b-d	46.45b-e	89.57d-f	87.02c-e	88.30de	127.56bc	123.68b-d	125.62bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	45.23c	42.66cd	43.95de	83.45f	81.28e	82.37e	121.54c	118.38d	119.96c
T ₈ - SC + SB cv. Magnolia (1:1 RP)	49.51a-c	46.38a-c	47.95a-d	97.90ab	94.98ab	96.44ab	135.08ab	133.50a-c	134.29ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	47.34bc	43.51b-d	45.42b-e	91.65b-e	89.27b-d	90.46b-d	127.19bc	124.56b-d	125.88bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	44.78c	41.87d	43.33e	88.68ef	85.97de	87.33de	122.42c	119.84d	121.13c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	50.21ab	46.84ab	48.52a-c	97.15a-d	95.08ab	96.11a-c	135.68ab	134.06a-c	134.87ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	47.93bc	44.21b-d	46.07b-e	91.19b-e	88.82b-d	90.00b-d	124.65bc	121.41d	123.03c
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	45.10c	42.08d	43.59de	88.00ef	86.05de	87.03de	121.13c	117.06d	119.09c
S.Em±	1.64	1.40	1.50	2.62	2.57	2.55	4.15	3.75	3.74
CV (%)	6.78	6.99	6.35	7.13	7.25	7.21	7.45	7.57	7.32

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

Contd....

Table 6 contd.....

Treatment	Plant height (cm)					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	162.14a	159.00a	160.57a	167.82a	163.03a	165.42a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	155.72ab	152.83ab	154.28ab	161.41ab	158.48ab	159.95ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	145.99b-d	142.53bc	144.26bc	153.16bc	147.77b-d	150.47b-d
T ₄ - SC + SB cv. Cauvery (1:3 RP)	138.33d	137.14c	137.73c	144.87c	142.79d	143.83d
T ₅ - SC + SB cv. Shubhra (1:1 RP)	154.61a-c	152.36ab	153.49ab	161.16ab	157.01a-c	159.08a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	146.11b-d	142.83bc	144.47bc	152.65bc	148.47b-d	150.56b-d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	139.74d	137.53c	138.64c	146.63c	143.17d	144.90d
T ₈ - SC + SB cv. Magnolia (1:1 RP)	153.90a-c	151.78ab	152.84ab	160.44ab	157.42ab	158.93a-c
T ₉ - SC + SB cv. Magnolia (1:2 RP)	145.73b-d	143.71bc	144.72bc	152.87bc	149.36b-d	151.12b-d
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	140.96d	138.99c	139.98c	147.51c	144.63d	146.07d
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	154.23a-c	152.53ab	153.38ab	160.77ab	158.17ab	159.47ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	143.20cd	140.56c	141.88c	149.74bc	146.20cd	147.97cd
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	139.68d	136.20c	137.94c	147.32c	142.35d	144.83d
S.Em±	4.06	3.65	3.65	4.25	3.84	3.82
CV (%)	7.76	7.36	7.31	7.89	7.77	7.38

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 7: Number of leaves per plant of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Number of leaves per plant								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	11.35a	10.86a	11.11a	18.89a	18.02a	18.46a	26.78a	25.41a	26.10a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	10.82a	10.30ab	10.56a	17.64ab	17.26ab	17.45a	25.81a	24.55ab	25.18a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	8.69cd	8.34cd	8.52c	15.17c-e	14.72bc	14.95bc	23.25d	22.56b-e	22.91cd
T ₄ - SC + SB cv. Cauvery (1:3 RP)	8.46cd	8.07d	8.26c	13.68e	13.05c	13.37cd	21.34ef	21.20ef	21.27de
T ₅ - SC + SB cv. Shubhra (1:1 RP)	10.25a-c	10.11a-c	10.18ab	17.55ab	17.07ab	17.31a	25.11a-c	24.07a-d	24.59a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	8.58cd	8.19cd	8.38c	14.89de	14.25c	14.57b-d	23.65b-d	22.44b-e	23.05b-d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	8.25d	7.82d	8.04c	13.89e	13.28c	13.58b-d	23.03de	21.83d-f	22.43de
T ₈ - SC + SB cv. Magnolia (1:1 RP)	10.60ab	10.45a	10.53a	17.04a-d	16.91ab	16.97a	25.33ab	24.27a-c	24.80a-c
T ₉ - SC + SB cv. Magnolia (1:2 RP)	8.86b-d	8.43b-d	8.64bc	15.48b-e	14.83bc	15.16b	22.65d-f	22.14c-f	22.40de
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	8.58cd	8.21cd	8.40c	13.74e	13.08c	13.41b-d	21.01f	19.94f	20.48e
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	10.08a-d	10.62a	10.35a	17.32a-c	17.20ab	17.26a	25.41ab	24.44a-c	24.92ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	8.63cd	8.50b-d	8.57c	15.51b-e	14.75bc	15.13b	23.52cd	22.32b-f	22.92cd
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	8.49cd	8.13d	8.31c	13.29e	12.83c	13.06d	22.23d-f	22.38b-e	22.30de
S.Em±	0.64	0.66	0.55	0.76	0.90	0.60	0.62	0.82	0.69
CV (%)	11.80	12.60	10.35	8.43	10.29	6.74	7.51	8.75	7.32

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd.....

Table 7 contd.....

Treatment	Number of leaves per plant					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	20.55a	19.09a	19.82a	16.34a	14.77a	15.55a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	19.57a	18.23ab	18.90a	15.36a	13.91ab	14.64a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	17.02d	16.24b-e	16.63cd	12.81d	11.92b-e	12.36cd
T ₄ - SC + SB cv. Cauvery (1:3 RP)	15.11ef	14.88ef	15.00de	10.90ef	10.56ef	10.73de
T ₅ - SC + SB cv. Shubhra (1:1 RP)	18.87a-c	17.75a-d	18.31a-c	14.66a-c	13.43a-d	14.05a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	17.42b-d	16.12b-e	16.77b-d	13.21b-d	11.80b-e	12.50b-d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	16.80de	15.51d-f	16.16de	12.59de	11.19d-f	11.89de
T ₈ - SC + SB cv. Magnolia (1:1 RP)	19.10ab	17.95a-c	18.52a-c	14.89ab	13.62a-c	14.26a-c
T ₉ - SC + SB cv. Magnolia (1:2 RP)	16.42d-f	15.82c-f	16.12de	12.21d-f	11.50c-f	11.85de
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	14.78f	13.62f	14.20e	10.56f	9.30f	9.93e
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	19.18ab	18.12a-c	18.65ab	14.96ab	13.80a-c	14.38ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	17.29cd	16.00b-f	16.64cd	13.08cd	11.68b-f	12.38cd
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	16.00d-f	16.05b-e	16.03de	11.78d-f	11.73b-e	11.76de
S.Em±	0.62	0.82	0.69	0.62	0.82	0.68
CV (%)	6.11	8.57	6.96	8.04	11.59	9.27

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

that of sole sugarcane, irrespective of varieties tested. While, 1:3 row ratio (irrespective of sugar beet cultivars) recorded lower number of leaves per plant as compared to sole sugarcane.

4.1.1.4 Leaf area ($\text{dm}^2 \text{ plant}^{-1}$)

Leaf area of sugarcane was significantly influenced by the different row proportions and cultivars of sugar beet intercropped with sugarcane during 2010-11, 2011-12 and on pooled basis (Table 8).

Sole sugarcane recorded significantly higher leaf area at 90 DAP in 2010-11, 2011-12 and on pooled basis (16.13, 13.89 and 15.01 $\text{dm}^2 \text{ plant}^{-1}$, respectively) compared to intercropped treatments. Among the intercropped treatments, SC+ SB (1:1 RP) however found on par with sole sugarcane, irrespective of sugar beet cultivars tested. While, sugarcane grown with sugar beet in row ratio of 1:2 (irrespective of sugar beet cultivars) accounted significantly higher leaf area than 1:3 row ratio. Similar trend was observed at 150 DAP.

At 210 DAP, significantly higher leaf area recorded by sole sugarcane in 2010-11, 2011-12 and on pooled basis (79.01, 70.13 and 74.57 $\text{dm}^2 \text{ plant}^{-1}$, respectively) compared to intercropped treatments. Among the intercropped treatments, SC + SB (1:1 RP) however found on par with former treatment irrespective of sugar beet cultivars tested. While, sugarcane grown with sugar beet in row ratio of 1:2 (irrespective of sugar beet cultivars) accounted significantly higher leaf area than 1:3 row ratio. Similar trend was observed at 270 DAP.

At harvest, sole sugarcane accounted significantly higher leaf area in 2010-11, 2011-12 and on pooled basis (77.41, 66.79 and 72.10 $\text{dm}^2 \text{ plant}^{-1}$, respectively) compared to intercropped treatments. Irrespective of sugar beet cultivars, SC + SB (1:1 RP) recorded similar leaf area as that of sole sugarcane. While, sugarcane grown with sugar beet at row ratio of 1:2 (irrespective of sugar beet cultivars) recorded significantly higher leaf area than 1:3 row ratio.

4.1.1.5 Leaf area index (LAI)

Leaf area index (LAI) differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 9).

Sole sugarcane recorded significantly higher LAI at 90 DAP in 2010-11, 2011-12 and on pooled basis (0.36, 0.31 and 0.33, respectively) compared to intercropped treatments. Among the intercropped treatments, SC + SB (1:1 RP) however found on par with sole sugarcane (irrespective of sugar beet cultivars tested). While, 1:2 RP accounted significantly next higher LAI than 1:3 RP. Similar trend was observed at 150 DAP.

At 210 DAP, significantly higher LAI was noticed in sole sugarcane during 2010-11, 2011-12 and on pooled basis (1.76, 1.56 and 1.66, respectively) compared to intercropped treatments. Among the intercropped treatments, SC + SB (1:1 RP) however found on par with sole sugarcane irrespective of sugar beet cultivars tested. Sugarcane grown with sugar beet in row ratio of 1:2 (irrespective of sugar beet cultivars) recorded next higher LAI than 1:3 row ratio. Similar trend was observed at 270 DAP.

At harvest, sole sugarcane recorded significantly higher LAI in 2010-11, 2011-12 and on pooled basis (1.72, 1.48 and 1.60, respectively) compared intercropped treatments. Among the intercropped treatments, SC+ SB (1:1 RP) recorded comparable LAI as that of sole sugarcane irrespective of sugar beet cultivars tested. Sugarcane grown with sugar beet in row ratio of 1:2 (irrespective of sugar beet cultivars) resulted in significantly higher leaf area index than 1:3 row ratio. Lower LAI was recorded under 1:3 row ratio.

4.1.1.6 Leaf area duration (Days)

The data on leaf area duration (LAD) differed significantly due to intercropping of sugarcane with sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 10).

Significantly higher LAD was observed with sole sugarcane between 90-150 DAP during both years of experimentation and on pooled basis (39.71, 34.77 and 37.24 days, respectively) compared to intercropped treatments.

Among the intercropped treatments, growing of sugarcane with sugar beet in 1:1 row ratio remained on par with former treatment (across various cultivars tested) followed by growing of sugarcane and sugar beet in 1:2 and 1:3 row ratios. Similar trend was observed between 151 and 210 DAP.

Table 8: Leaf area (dm² plant⁻¹) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Leaf area (dm ² plant ⁻¹)								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	16.13a	13.89a	15.01a	43.43a	38.26a	40.85a	79.01a	70.13a	74.57a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	15.05a	12.92a	13.98a	39.91a	35.42a	37.66a	74.44a	66.02ab	70.23a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	11.63bc	10.07b	10.85bc	32.38c	28.94b	30.66b	65.42bc	59.18b-d	62.30b-e
T ₄ - SC + SB cv. Cauvery (1:3 RP)	10.49bc	9.02bc	9.75bc	28.38c-e	24.95de	26.66cd	58.78cd	54.44de	56.61ef
T ₅ - SC + SB cv. Shubhra (1:1 RP)	14.70a	12.60a	13.65a	39.78a	35.35a	37.56a	71.97ab	64.33a-c	68.15a-d
T ₆ - SC + SB cv. Shubhra (1:2 RP)	11.38bc	9.79bc	10.59bc	31.65b-d	27.91b-d	29.78bc	65.37b-d	57.83c-e	61.60c-f
T ₇ - SC + SB cv. Shubhra (1:3 RP)	10.14c	8.67c	9.41c	28.64c-e	25.22c-e	26.93b-d	62.39cd	55.13de	58.76ef
T ₈ - SC + SB cv. Magnolia (1:1 RP)	14.79a	13.15a	13.97a	39.88a	35.28a	37.58a	73.39ab	65.53ab	69.46ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	11.72b	10.06b	10.89b	32.68b	28.85bc	30.76b	63.08cd	57.48c-e	60.28ef
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	10.76bc	9.29bc	10.02bc	27.68de	24.29de	25.99cd	57.26d	50.67e	53.96f
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	14.72a	12.84a	13.78a	39.41a	35.70a	37.55a	73.06ab	65.51ab	69.29a-c
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	11.18bc	9.93bc	10.56bc	31.73bc	27.80b-d	29.76bc	65.27b-d	57.74c-e	61.50d-f
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	10.30bc	8.89bc	9.60bc	26.28e	23.37e	24.82d	60.48cd	56.75de	58.62ef
S.Em±	0.53	0.46	0.50	1.38	1.27	1.32	2.79	2.50	2.64
CV (%)	7.34	7.86	7.49	7.02	7.33	7.14	7.22	7.71	7.32

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd.....

Table 8 contd.....

Treatment	Leaf area (dm ² plant ⁻¹)					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	82.10a	72.39a	77.24a	77.41a	66.79a	72.10a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	76.72a	67.43a	72.07a	72.17a	62.31a	67.24a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	65.62c	59.10bc	62.36bc	59.78bc	53.06b	56.42b
T ₄ - SC + SB cv. Cauvery (1:3 RP)	57.02d	52.99cd	55.01cd	50.15de	46.34cd	48.25cd
T ₅ - SC + SB cv. Shubhra (1:1 RP)	74.20ab	66.51a	70.36a	70.09a	60.71a	65.40a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	66.48bc	58.07bc	62.28bc	61.33b	52.26bc	56.79b
T ₇ - SC + SB cv. Shubhra (1:3 RP)	63.03cd	54.91cd	58.97cd	58.20bc	49.33bc	53.76bc
T ₈ - SC + SB cv. Magnolia (1:1 RP)	74.78a	65.26ab	70.02ab	70.61a	61.15a	65.88a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	62.57cd	56.89c	59.73c	56.17b-d	50.45bc	53.31bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	55.26d	48.07d	51.67d	48.23e	40.48d	44.36d
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	74.75a	66.65a	70.70a	69.99a	60.91a	65.45a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	66.27bc	57.88c	62.07c	60.00bc	51.09bc	55.54b
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	60.72cd	57.50c	59.11cd	53.70c-e	50.97bc	52.33bc
S.Em±	2.83	2.51	2.67	2.61	2.27	2.44
CV (%)	7.45	7.68	7.23	7.75	7.29	7.26

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 9: Leaf area index of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Leaf area index														
	90 DAS			150 DAS			210 DAS			270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	0.36a	0.31a	0.33a	0.97a	0.85a	0.91a	1.76a	1.56a	1.66a	1.82a	1.61a	1.72a	1.72a	1.48a	1.60a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	0.33a	0.29a	0.31a	0.89ab	0.79a	0.84a	1.65a	1.47ab	1.56ab	1.70a	1.50a	1.60a	1.60ab	1.38a	1.49a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	0.26bc	0.22b	0.24b	0.72c	0.64b	0.68b	1.45bc	1.32b-d	1.38b-e	1.46d	1.31bc	1.39bc	1.33cd	1.18b	1.25b
T ₄ - SC + SB cv. Cauvery (1:3 RP)	0.23bc	0.20b	0.22b	0.63de	0.55b-d	0.59cd	1.31c	1.21de	1.26ef	1.27e	1.18cd	1.22cd	1.11ef	1.03cd	1.07cd
T ₅ - SC + SB cv. Shubhra (1:1 RP)	0.33a	0.28a	0.30a	0.88ab	0.79a	0.83a	1.60ab	1.43a-c	1.51a-d	1.65a-c	1.48a	1.56a	1.56ab	1.35a	1.45a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	0.25bc	0.22b	0.24b	0.70cd	0.62bc	0.66bc	1.45bc	1.29cd	1.37c-f	1.48b-d	1.29bc	1.38bc	1.36c	1.16bc	1.26b
T ₇ - SC + SB cv. Shubhra (1:3 RP)	0.23c	0.19b	0.21b	0.64c-e	0.56b-d	0.60cd	1.39c	1.23de	1.31ef	1.40de	1.22cd	1.31cd	1.29cd	1.10bc	1.19bc
T ₈ - SC + SB cv. Magnolia (1:1 RP)	0.33a	0.29a	0.31a	0.89ab	0.78a	0.84a	1.63ab	1.46ab	1.54a-c	1.66ab	1.45ab	1.56ab	1.57ab	1.36a	1.46a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	0.26b	0.22b	0.24b	0.73c	0.64b	0.68b	1.40c	1.28c-e	1.34d-f	1.39de	1.26c	1.33c	1.25c-e	1.12bc	1.18bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	0.24bc	0.21b	0.22b	0.62e	0.54cd	0.58d	1.27c	1.13e	1.20f	1.23e	1.07d	1.15d	1.07d	0.90d	0.99d
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	0.33a	0.29a	0.31a	0.88a	0.79a	0.83a	1.62ab	1.46ab	1.54a-c	1.66ab	1.48a	1.57a	1.56ab	1.35a	1.45a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	0.25bc	0.22b	0.23b	0.71cd	0.62bc	0.66bc	1.45bc	1.28cd	1.37c-f	1.47cd	1.29bc	1.38c	1.33cd	1.14bc	1.23
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	0.23bc	0.20b	0.21b	0.58e	0.52d	0.55d	1.34c	1.26de	1.30ef	1.35de	1.28c	1.31cd	1.19d-f	1.13bc	1.16bc
S.Em±	0.01	0.01	0.01	0.03	0.03	0.03	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
CV (%)	7.34	7.35	7.39	7.02	7.33	7.14	7.22	7.17	7.29	7.23	7.19	7.26	7.31	7.25	7.29

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 10: Leaf area duration (Days) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Leaf area duration (Days)											
	90 – 150 DAS			151 – 210 DAS			211 - 270 DAS			271 DAS – At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	39.71a	34.77a	37.24a	81.63a	72.26a	76.94a	107.41a	95.01a	101.21a	106.34a	92.78a	99.56a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	36.64a	32.22a	34.43a	76.23a	67.63a	71.93a	100.77a	88.97a	94.87a	99.26a	86.49a	92.87a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	29.34bc	26.01b	27.68bc	65.20b	58.75b	61.98b	87.36de	78.85bc	83.11b-d	83.60b	74.77b	79.18b
T ₄ - SC + SB cv. Cauvery (1:3 RP)	25.91b-e	22.64ab-e	24.28b-e	58.11bc	52.93bc	55.52bc	77.20ef	71.62cd	74.41de	71.44cd	66.22bc	68.83cd
T ₅ - SC + SB cv. Shubhra (1:1 RP)	36.32a	31.96a	34.14a	74.50a	66.45a	70.48a	97.45a-d	87.23ab	92.34a-c	96.19a	84.81a	90.50a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	28.68b-d	25.13b-d	26.91b-d	64.68bc	57.16bc	60.92bc	87.90b-e	77.27c	82.59cd	85.21b	73.55b	79.38b
T ₇ - SC + SB cv. Shubhra (1:3 RP)	25.86c-e	22.59c-e	24.22c-e	60.69bc	53.56bc	57.13bc	83.61ef	73.36cd	78.49de	80.82bc	69.49b	75.16bc
T ₈ - SC + SB cv. Magnolia (1:1 RP)	36.45a	32.29a	34.37a	75.52a	67.21a	71.36a	98.78ab	87.19ab	92.99aab	96.93a	84.27a	90.60a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	29.60b	25.94bc	27.77b	63.84bc	57.55b	60.69bc	83.76ef	76.24c	80.00de	79.16b-d	71.56b	75.36bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	25.63de	22.39de	24.01de	56.63c	49.97c	53.30c	75.02f	65.82d	70.42e	69.00d	59.03c	64.02d
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	36.08a	32.36a	34.22a	74.98a	67.48a	71.23a	98.54a-c	88.11ab	93.32ab	96.49a	85.04a	90.76a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	28.61b-d	25.15b-d	26.88b-d	64.67bc	57.02bc	60.85bc	87.70c-e	77.08c	82.39cd	84.18b	72.64b	78.41bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	24.38e	21.51e	22.95e	57.84bc	53.41bc	55.63bc	80.80ef	76.17c	78.48de	76.28b-d	72.31b	74.30bc
S.Em±	1.27	1.16	1.21	2.77	2.51	2.64	3.74	3.34	3.54	3.62	3.19	3.40
CV (%)	7.09	7.34	7.19	7.13	7.25	7.18	7.23	7.21	7.18	7.25	7.23	7.16

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

During 211- 270 DAP, significantly higher LAD was recorded by sole sugarcane in 2010-11, 2011-12 and on pooled basis (107.41, 95.01 and 101.21 days, respectively) compared to intercropped treatments. Among the intercropped treatments, SC + SB (1:1 RP) however found on par with sole sugarcane, irrespective of sugar beet cultivars tested. While, sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars accounted significantly higher LAD than 1:3 row ratio.

Between 271 to harvest, sole sugarcane recorded significantly higher LAD in 2010-11, 2011-12 and on pooled basis (106.34, 92.78 and 99.56 days, respectively) compared to intercropped treatments. Among the intercropped treatments, SC + SB (1:1 RP) accounted comparable LAD as that of sole sugarcane irrespective of sugar beet cultivars tested. Sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars accounted significantly higher leaf area duration than 1:3 row ratio. Lower LAD was recorded under 1:3 row ratio as compared to other row proportions.

4.1.1.7 Dry matter accumulation in leaves (g plant^{-1})

Dry matter accumulation (DMA) in leaves of sugarcane was significantly influenced by the intercropping of sugarcane with different row proportions of sugar beet cultivars during 2010-11, 2011-12 and on pooled basis (Table 11).

Sole sugarcane recorded significantly higher DMA in leaves at 90 DAP (43.15, 39.87 and 41.51 g plant^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis compared to other treatments. Among the intercropped treatments, growing of SC + SB under 1:1 RP however found on par with former treatment, irrespective of sugar beet cultivars tested. Sugarcane grown with sugar beet at row ratio of 1:2 (irrespective of sugar beet cultivars) showed significantly higher DMA in leaves than 1:3 row ratio. Similar trend was observed at 150DAP.

At 210 DAP, significantly higher DMA in leaves recorded by sole sugarcane (105.54, 100.16 and 102.85 g plant^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis compared to intercropped treatments. Among the intercropped treatments, growing of SC + SB in 1:1 RP however found on par with sole sugarcane irrespective of sugar beet cultivars tested. While, growing of sugarcane with sugar beet at row ratio of 1:3 irrespective of sugar beet varieties recorded significantly lower DMA in leaves than 1:2 row ratio. Similar trend was observed at 270 DAP.

At harvest, sole sugarcane accounted significantly higher DMA in leaves (106.71, 103.19 and 104.95 g plant^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis compared to intercropped treatments. Among the intercropped treatments, growing of SC + SB under 1:1 RP remained on par with sole sugarcane, irrespective of sugar beet cultivars examined. While, sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars shown significantly higher DMA in leaves than 1:3 row ratio.

4.1.1.8 Dry matter accumulation in stem (g plant^{-1})

The data on dry matter accumulation (DMA) in stem differed significantly due to intercropping of sugar beet cultivars in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 12).

At 90 DAS, significantly higher DMA in stem was recorded by sole sugarcane in 2010-11, 2011-12 and on pooled basis (34.86, 32.49 and 33.67 g plant^{-1} , respectively). However, growing of SC + SB under 1:1 RP however found on par with former treatment, irrespective of sugar beet cultivars tested. Sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars showed significantly higher DMA in stem than 1:3 row ratio.

Gradual reduction in dry matter accumulation in stem was observed with increase in row ratios of sugar beet. SC + SB in 1:2 row ratio showed higher DMA in stem than 1:3 row ratio. While, irrespective of sugar beet cultivars tested lower DMA in stem was recorded under 1:3 row ratio as compared to other row proportions. Similar trend was observed at 150 DAP.

At 210 DAP, sole sugarcane recorded significantly higher DMA in stem in 2010-11, 2011-12 and on pooled basis (202.06, 194.87 and 198.47 g plant^{-1} , respectively) compared to other treatments. However, growing of SC + SB in 1:1 RP found on par with sole sugarcane treatment. While, irrespective of sugar beet cultivars tested lower DMA in stem was recorded under 1:3 row ratio. Similar trend was observed at 270 DAP.

Table 11: Dry matter accumulation in leaves (g plant⁻¹) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Dry matter accumulation in leaves (g plant ⁻¹)								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	43.15a	39.87a	41.51a	62.48a	59.79a	61.14a	105.54a	100.16a	102.85a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	40.25ab	37.62ab	38.94ab	58.95ab	56.42a-d	57.68ab	99.76a-c	94.45a-d	97.10a-c
T ₃ - SC + SB cv. Cauvery (1:2 RP)	38.01bc	34.82b-d	36.41bc	56.45b-d	53.72b-e	55.08b-d	95.90b-d	89.57b-d	92.73bc
T ₄ - SC + SB cv. Cauvery (1:3 RP)	35.89c	33.89cd	34.89c	53.48cd	51.18de	52.33cd	90.81d	86.79d	88.80c
T ₅ - SC + SB cv. Shubhra (1:1 RP)	40.38ab	37.54ab	38.96ab	58.28a-c	55.77a-e	57.03a-c	99.02a-d	95.20a-c	97.11a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	38.19bc	35.29b-d	36.74bc	56.39b-d	53.47b-e	54.93b-d	94.68b-d	89.85b-d	92.27bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	36.40c	33.73d	35.07c	54.44b-d	51.46c-e	52.95b-d	91.85cd	87.17cd	89.51c
T ₈ - SC + SB cv. Magnolia (1:1 RP)	40.45ab	37.03a-c	38.74ab	59.10ab	56.56a-c	57.83ab	100.70ab	96.43ab	98.57ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	38.23bc	35.32b-d	36.78bc	57.09b-d	53.43b-e	55.26b-d	94.68b-d	89.85b-d	92.27bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	36.65c	33.39d	35.02c	52.57d	50.83e	51.70d	92.45b-d	87.26cd	89.86c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	40.31ab	37.25ab	38.78ab	58.63ab	57.01ab	57.82ab	100.77ab	96.39ab	98.58ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	37.45bc	35.23b-d	36.34bc	56.45b-d	54.02b-e	55.24b-d	95.11b-d	90.83b-d	92.97bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	36.31c	33.39d	34.85c	54.08b-d	50.75e	52.41cd	91.10d	87.72cd	89.41c
S.Em±	1.19	1.13	1.13	1.73	1.80	1.75	2.91	2.88	2.86
CV (%)	6.88	6.47	6.25	6.36	6.75	6.46	6.23	6.45	6.28

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd.....

Table 11 contd.....

Treatment	Dry matter accumulation in leaves (g plant ⁻¹)					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	117.69a	113.18a	115.44a	106.71a	103.19a	104.95a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	111.51a-c	106.88a-c	109.20a-c	100.53a-c	96.89a-c	98.71a-c
T ₃ - SC + SB cv. Cauvery (1:2 RP)	108.05b-d	102.59bc	105.32bc	97.07b-d	92.60bc	94.84bc
T ₄ - SC + SB cv. Cauvery (1:3 RP)	102.96d	99.81c	101.39c	91.98d	89.82c	90.90c
T ₅ - SC + SB cv. Shubhra (1:1 RP)	111.18a-d	108.23a-c	109.70a-c	100.20a-d	98.24a-c	99.22a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	106.83b-d	102.88bc	104.85bc	95.85b-d	92.89bc	94.37bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	104.00cd	100.19c	102.10c	93.02cd	90.20c	91.61c
T ₈ - SC + SB cv. Magnolia (1:1 RP)	112.86ab	109.46ab	111.16ab	101.87ab	99.47ab	100.67ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	106.83b-d	102.88bc	104.85bc	95.85b-d	92.89bc	94.37bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	104.60b-d	100.29c	102.44c	93.62b-d	90.30c	91.96c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	112.92ab	109.41ab	111.17ab	101.94ab	99.43ab	100.68ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	107.26b-d	103.85bc	105.56bc	96.28b-d	93.87bc	95.07bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	103.25cd	100.74c	102.00c	92.27cd	90.75c	91.51c
S.Em±	2.90	2.90	2.87	2.90	2.90	2.87
CV (%)	6.64	6.80	6.67	6.16	6.30	6.18

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 12: Dry matter accumulation in stem (g plant⁻¹) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Dry matter accumulation in stem (g plant ⁻¹)								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	34.86a	32.49a	33.67a	109.61a	103.73a	106.67a	202.06a	194.87a	198.47a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	32.13ab	29.97ab	31.05ab	106.88ab	101.21ab	104.05ab	199.33ab	192.35ab	195.84ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	30.34bc	28.28b-d	29.31bc	105.09bc	99.52b-d	102.30bc	197.54bc	190.66b-d	194.10bc
T ₄ - SC + SB cv. Cauvery (1:3 RP)	28.79bc	27.41b-d	28.10bc	103.54bc	98.65b-d	101.09bc	195.99bc	189.79b-d	192.89bc
T ₅ - SC + SB cv. Shubhra (1:1 RP)	31.83a-c	29.83ab	30.83ab	106.58a-c	101.07ab	103.83ab	199.03a-c	192.21ab	195.62ab
T ₆ - SC + SB cv. Shubhra (1:2 RP)	30.83bc	28.57bc	29.70bc	105.58bc	99.81bc	102.69bc	198.04bc	190.95bc	194.49bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	28.68bc	27.48b-d	28.08bc	103.43bc	98.72b-d	101.07bc	195.88bc	189.86b-d	192.87bc
T ₈ - SC + SB cv. Magnolia (1:1 RP)	31.90a-c	29.70ab	30.80ab	106.65a-c	100.94ab	103.79ab	199.10a-c	192.08ab	195.59ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	30.35bc	28.84bc	29.60bc	105.10bc	100.08bc	102.59bc	197.56bc	191.22bc	194.39bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	28.64c	26.15cd	27.40c	103.39c	97.39cd	100.39c	195.85c	188.53cd	192.19c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	31.70a-c	29.72ab	30.71ab	106.45a-c	100.96ab	103.70ab	198.90a-c	192.10ab	195.50ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	30.52bc	28.27b-d	29.40bc	105.27bc	99.51b-d	102.39bc	197.73bc	190.65b-d	194.19bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	28.78bc	25.40d	27.09c	103.53bc	96.64d	100.09c	195.98bc	187.78d	191.88c
S.Em±	1.19	1.02	1.05	1.19	1.02	1.05	1.19	1.02	1.05
CV (%)	6.69	6.16	6.11	5.89	6.01	5.97	6.04	5.92	5.87

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd.....

Table 12 contd.....

Treatment	Dry matter accumulation in stem (g plant ⁻¹)					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	290.93a	281.19a	286.06a	339.51a	328.07a	333.79a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	288.20ab	278.68ab	283.44ab	336.78ab	325.56ab	331.17ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	286.41bc	276.98b-d	281.70bc	334.99bc	323.86b-d	329.42bc
T ₄ - SC + SB cv. Cauvery (1:3 RP)	284.86bc	276.12b-d	280.49bc	333.44bc	323.00b-d	328.22bc
T ₅ - SC + SB cv. Shubhra (1:1 RP)	287.90a-c	278.54ab	283.22ab	336.48a-c	325.42ab	330.95ab
T ₆ - SC + SB cv. Shubhra (1:2 RP)	286.90bc	277.27bc	282.09bc	335.48bc	324.15bc	329.81bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	284.75bc	276.18b-d	280.47bc	333.33bc	323.06b-d	328.20bc
T ₈ - SC + SB cv. Magnolia (1:1 RP)	287.97a-c	278.40ab	283.19ab	336.55a-c	325.28ab	330.91ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	286.42bc	277.54bc	281.98b	335.00bc	324.42bc	329.71bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	284.72c	274.86cd	279.79c	333.29c	321.73cd	327.51c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	287.77a-c	278.42ab	283.09ab	336.34a-c	325.30ab	330.82ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	286.59bc	276.97b-d	281.78bc	335.17bc	323.85b-d	329.51bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	284.85bc	274.10d	279.48c	333.43bc	320.98d	327.21c
S.Em±	1.19	1.02	1.05	1.19	1.02	1.05
CV (%)	5.72	5.64	5.88	5.61	5.54	5.58

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

At harvest, sole sugarcane accounted significantly higher DMA in stem (339.51, 328.07 and 333.79 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis compared to intercropped treatments. Among the intercropped treatments, growing of SC + SB in 1:1 RP remained on par with sole sugarcane, irrespective of sugar beet cultivars examined. While, sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars shown relatively higher DMA in stem than 1:3 row ratio.

4.1.1.9 Total dry matter production (g plant⁻¹)

Intercropping of sugar beet cultivars in different row proportions significantly influenced the total dry matter production (TDMP) of sugarcane during 2010-11, 2011-12 and on pooled basis (Table 13).

At 90 DAP, sole sugarcane recorded significantly higher TDMP in 2010-11, 2011-12 and on pooled basis (78.01, 72.36 and 75.19 g plant⁻¹, respectively) compared to other treatments. However, SC + SB in 1:1 RP (irrespective of sugar beet varieties) remained on par with sole sugarcane. Growing of SC + SB in 1:2 RP accounted higher TDMP in sugarcane than 1:3 row ratio. While, irrespective of sugar beet varieties lower TDMP was shown under 1:3 row ratio. Similar trend was observed at 150 DAP.

At 210 DAP, sole sugarcane shown significantly higher TDMP at in 2010-11, 2011-12 and on pooled basis (307.60, 295.03 and 301.32 g plant⁻¹, respectively) compared to other treatments. Among the intercropped treatments, sugarcane grown with sugar beet in 1:1 row ratio recorded significantly higher TDMP than other treatments but it was found on par with former treatment, across various cultivars tested. Growing of sugar beet in 1:2 row ratio accounted higher TDMP in sugarcane than 1:3 row ratio. Similar trend was observed at 270 DAP.

At harvest, significantly higher TDMP was recorded with sole sugarcane in 2010-11, 2011-12 and on pooled basis (446.22, 431.27 and 438.74 g plant⁻¹, respectively) compared to other treatments. Among the intercropped treatments, sugarcane grown with sugar beet in 1:1 row ratio recorded significantly higher TDMP than other treatments but it was found on par with sole sugarcane.

Gradual reduction in TDMP of sugarcane was observed with increase in row ratio from 1:1 to 1:3 (sugarcane: sugar beet). Growing of SC + SB in 1:2 row ratio accounted higher TDMP in sugarcane than 1:3 row ratio. While, irrespective of sugar beet varieties lower TDMP was observed under 1:3 row ratio.

4.1.2 Yield components and yield of sugarcane

4.1.2.1 Number of internodes per plant

Number of internodes per plant of sugarcane was significantly influenced by the intercropping of sugar beet cultivars with sugarcane in different row proportions during both years of experimentation and on pooled basis (Table 14).

Sole sugarcane recorded significantly higher number of internodes per plant at 90 DAP (3.85, 3.57 and 3.71, respectively) during both years of experimentation and on pooled basis compared to other treatments. However, growing of SC + SB under 1:1 RP found on par with sole sugarcane. Significantly lower number of internodes per plant was recorded in 1:3 row ratio of sugarcane intercropped with sugar beet cultivars as compared to sole sugarcane. Similar trend was observed at 150 DAP.

At 210 DAP, significantly higher number of internodes per plant was recorded by sole sugarcane (12.67, 12.05 and 12.36, respectively) during 2010-11, 2011-12 and pooled basis compared to intercropped treatments. Among the intercropped treatments, growing of SC + SB in 1:1 RP remained on par with sole sugarcane irrespective of sugar beet cultivars tested. Significantly lower number of internodes per plant was recorded in 1:3 row ratio of sugarcane intercropped with sugar beet cultivars as compared to sole sugarcane. Similar trend was observed at 270 DAP.

At harvest, sole sugarcane accounted significantly higher number of internodes per plant (22.94, 21.88 and 22.41, respectively) during 2010-11, 2011-12 and on pooled basis compared to intercropped treatments. Among the intercropped treatments, growing of SC + SB in 1:1 RP recorded on par number of internodes per plant as that of sole sugarcane irrespective of sugar beet cultivars examined. While, sugarcane grown with sugar beet at row ratio of 1:3 irrespective of sugar beet cultivars shown significantly lower number of internodes per plant as compared to other row ratios.

Table 13: Total dry matter production (g plant⁻¹) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Total dry matter production (g plant ⁻¹)								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	78.01a	72.36a	75.19a	172.09a	163.52a	167.81a	307.60a	295.03a	301.32a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	72.37ab	67.60ab	69.99ab	165.83ab	157.63a-c	161.73ab	299.09a-c	286.80a-c	292.95a-c
T ₃ - SC + SB cv. Cauvery (1:2 RP)	68.35bc	63.10b-d	65.72bc	161.54b-d	153.23b-e	157.39b-d	293.44b-d	280.22b-d	286.83b-e
T ₄ - SC + SB cv. Cauvery (1:3 RP)	64.68c	61.30cd	62.99c	157.02cd	149.83de	153.42cd	286.80d	276.58cd	281.69de
T ₅ - SC + SB cv. Shubhra (1:1 RP)	72.21ab	67.38ab	69.79ab	164.86a-c	156.85a-d	160.85a-c	298.06a-d	287.42a-c	292.74a-d
T ₆ - SC + SB cv. Shubhra (1:2 RP)	69.02bc	63.85b-d	66.44bc	161.97b-d	153.28b-e	157.62b-d	292.72b-d	280.80b-d	286.76b-e
T ₇ - SC + SB cv. Shubhra (1:3 RP)	65.08c	61.21cd	63.15c	157.87b-d	150.18c-e	154.03b-d	287.73cd	277.02cd	282.38c-e
T ₈ - SC + SB cv. Magnolia (1:1 RP)	72.34ab	66.73a-c	69.54ab	165.75ab	157.50a-d	161.62ab	299.80ab	288.52ab	294.16ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	68.58bc	64.16b-d	66.37bc	162.19b-d	153.51b-e	157.85b-d	292.24b-d	281.07b-d	286.65b-e
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	65.29c	59.54d	62.42c	155.97d	148.22e	152.09d	288.30b-d	275.79d	282.05c-e
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	72.01ab	66.96a-c	69.49ab	165.08a-c	157.97ab	161.52ab	299.67ab	288.49ab	294.08ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	67.97bc	63.50b-d	65.74bc	161.72b-d	153.53b-e	157.63b-d	292.83b-d	281.48b-d	287.16b-e
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	65.09c	58.79d	61.94c	157.61cd	147.39e	152.50d	287.08d	275.50d	281.29e
S.Em±	2.29	2.02	2.11	2.79	2.67	2.71	3.96	3.76	3.82
CV (%)	5.73	5.44	5.48	5.98	6.00	5.82	6.32	6.18	5.98

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion
Means followed by common letter do not differ significantly by DMRT @ p=0.05

Contd.....

Table 13 contd.....

Treatment	Total dry matter production (g plant ⁻¹)					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	408.63a	394.37a	401.50a	446.22a	431.27a	438.74a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	399.71a-c	385.56a-d	392.63a-d	437.30a-c	422.45a-d	429.88a-d
T ₃ - SC + SB cv. Cauvery (1:2 RP)	394.46b-d	379.57b-d	387.02b-d	432.06b-d	416.46b-d	424.26b-d
T ₄ - SC + SB cv. Cauvery (1:3 RP)	387.82d	375.93cd	381.87cd	425.41d	412.82cd	419.12cd
T ₅ - SC + SB cv. Shubhra (1:1 RP)	399.08a-d	386.76a-c	392.92a-c	436.67a-d	423.66a-c	430.16a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	393.74b-d	380.15b-d	386.94b-d	431.33b-d	417.04b-d	424.18b-d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	388.76cd	376.37cd	382.56cd	426.35cd	413.26cd	419.81cd
T ₈ - SC + SB cv. Magnolia (1:1 RP)	400.82ab	387.86ab	394.34ab	438.42ab	424.76ab	431.59ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	393.26b-d	380.42b-d	386.84b-d	430.85b-d	417.31b-d	424.08b-d
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	389.32b-d	375.14d	382.23cd	426.91b-d	412.03d	419.47cd
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	400.69ab	387.84ab	394.26ab	438.28ab	424.73a-d	431.51ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	393.85b-d	380.83b-d	387.34b-d	431.45b-d	417.72b-d	424.58b-d
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	388.10d	374.84d	381.47d	425.70d	411.74d	418.72d
S.Em±	3.95	3.76	3.83	3.95	3.76	3.83
CV (%)	5.73	5.89	5.65	5.58	5.69	5.42

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 14: Number of internodes per plant of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Number of internodes per plant								
	90 DAS			150 DAS			210 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	3.85a	3.57a	3.71a	8.16a	7.78a	7.97a	12.67a	12.05a	12.36a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	3.41a-c	3.19ab	3.30a	7.75ab	7.44ab	7.60ab	12.23ab	11.62ab	11.93ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	2.54b-e	2.37b-d	2.46b	7.14b-e	6.81b-d	6.97b-d	11.06b-e	10.54b-d	10.80cd
T ₄ - SC + SB cv. Cauvery (1:3 RP)	2.33e	2.17d	2.25b	6.87e	6.58d	6.73d	10.67de	10.13cd	10.40d
T ₅ - SC + SB cv. Shubhra (1:1 RP)	3.43ab	3.13a-d	3.28a	7.66ab	7.38ab	7.52a-c	12.13a-c	11.35a-c	11.74a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	2.45b-e	2.27b-d	2.36b	6.93c-e	6.61cd	6.77d	10.86b-e	10.36b-d	10.61d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	2.37de	2.20cd	2.28b	6.80e	6.49d	6.65d	10.36e	9.95d	10.15d
T ₈ - SC + SB cv. Magnolia (1:1 RP)	3.38a-d	3.07a-d	3.22a	7.60a-d	7.35a-c	7.48a-c	12.03a-d	11.55ab	11.79a-c
T ₉ - SC + SB cv. Magnolia (1:2 RP)	2.50b-e	2.32b-d	2.41b	7.10b-e	6.77b-d	6.93cd	11.35b-e	10.80b-d	11.07b-d
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	2.40c-e	2.23b-d	2.31b	6.91de	6.72b-d	6.82d	11.13b-e	10.60b-d	10.87cd
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	3.38a-d	3.18a-c	3.28a	7.64a-c	7.39ab	7.51a-c	11.91a-d	11.45a-c	11.68a-c
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	2.40c-e	2.24b-d	2.32b	7.28b-e	6.95b-d	7.12b-d	10.79c-e	10.25b-d	10.52d
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	2.34e	2.18d	2.26b	7.17b-e	6.80b-d	6.99b-d	10.26e	9.81d	10.03d
S.Em±	0.35	0.34	0.25	0.25	0.25	0.22	0.48	0.47	0.36
CV (%)	9.25	10.02	8.87	7.89	6.29	6.44	7.28	7.58	5.62

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd.....

Table 14 contd.....

Treatment	Number of internodes per plant					
	270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	15.81a	14.87a	15.34a	22.94a	21.88a	22.41a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	15.37ab	14.45ab	14.91ab	22.50ab	21.46ab	21.98ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	14.20b-e	13.37b-d	13.78cd	21.33b-e	20.38b-d	20.85cd
T ₄ - SC + SB cv. Cauvery (1:3 RP)	13.81de	12.95cd	13.38d	20.94de	19.96cd	20.45d
T ₅ - SC + SB cv. Shubhra (1:1 RP)	15.27a-c	14.17a-c	14.72a-c	22.39a-c	21.19a-c	21.79a-c
T ₆ - SC + SB cv. Shubhra (1:2 RP)	14.00b-e	13.18b-d	13.59d	21.13b-e	20.19b-d	20.66d
T ₇ - SC + SB cv. Shubhra (1:3 RP)	13.50e	12.77d	13.13d	20.62e	19.78d	20.20d
T ₈ - SC + SB cv. Magnolia (1:1 RP)	15.17a-d	14.37ab	14.77a-c	22.30a-d	21.38ab	21.84a-c
T ₉ - SC + SB cv. Magnolia (1:2 RP)	14.49b-e	13.62b-d	14.06b-d	21.61b-e	20.63b-d	21.12b-d
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	14.27b-e	13.43b-d	13.85cd	21.39b-e	20.44b-d	20.92cd
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	15.05a-d	14.27a-c	14.66a-c	22.17a-d	21.29a-c	21.73a-c
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	13.93c-e	13.08b-d	13.50d	21.05c-e	20.09b-d	20.57d
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	13.40e	12.64d	13.02d	20.52e	19.65d	20.09d
S.Em±	0.48	0.47	0.36	0.48	0.47	0.36
CV (%)	7.70	6.01	7.43	6.82	5.97	6.32

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

4.1.2.2 Diameter of cane (cm)

The data on diameter of cane differed significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 15).

Significantly higher cane diameter was recorded by sole sugarcane at 90 DAP in 2010-11, 2011-12 and on pooled basis (0.87, 0.84 and 0.85 cm, respectively) compared other treatments. However, growing of SC + SB in 1:1 RP remained on par with sole sugarcane across various cultivars tested. Irrespective of sugar beet cultivars tested lower diameter of cane was recorded under 1:3 row ratio.

At 210 DAP, sole sugarcane accounted significantly higher cane diameter during both years of experimentation and on pooled basis (1.76, 1.69 and 1.73 cm, respectively) compared to other treatments. Among the intercropped treatments, sugarcane grown with sugar beet in 1:1 row ratio recorded significantly higher diameter of cane than other treatments but it was found on par with former treatment across various cultivars tested. While, growing of sugar beet in 1:2 row ratio accounted higher diameter of cane than 1:3 row ratio. Similar trend was observed at 270 DAP.

At harvest, sole sugarcane resulted in significantly higher diameter of cane during 2010-11, 2011-12 and on pooled basis (2.63, 2.55 and 2.59 cm, respectively) compared other treatments. However, growing of SC + SB in 1:1 row ratio accounted on par cane diameter as that of sole sugarcane, across various cultivars tested. In general, increase in the row ratios of sugar beet there was a gradual reduction in diameter of cane. Growing of sugarcane and sugar beet in 1:2 row ratio recorded higher diameter of cane than 1:3 row ratio. The lowest diameter of cane was recorded under 1:3 row ratio.

4.1.2.3 Cane weight (g plant⁻¹)

The data on single cane weight of sugarcane varied significantly due to different row proportions and cultivars of sugar beet intercropped with sugarcane during 2010-11, 2011-12 and on pooled basis (Table 16).

Sole sugarcane recorded significantly higher single cane weight (1450, 1380 and 1420 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis compared to other treatments. However, growing of SC + SB in 1:1 RP remained on par with sole sugarcane, irrespective of sugar beet cultivars tested. While, irrespective of sugar beet cultivars significantly lower single cane weight was accounted under 1:3 row ratio as compared to rest of the treatments.

4.1.2.4 Length of internode (cm)

The data on length of internode of sugarcane differed significantly due to different row proportions of sugar beet cultivars intercropped with sugarcane during 2010-11, 2011-12 and on pooled basis (Table 16).

Sole sugarcane recorded significantly higher length of internodes during 2010-11, 2011-12 and on pooled basis (10.85, 10.38 and 10.62 cm, respectively) compared to other treatments. Sugarcane grown with sugar beet in 1:1 row proportion however, found on par with sole sugarcane, irrespective of sugar beet cultivars tested. While, sugarcane grown with sugar beet at row ratio of 1:2 irrespective of sugar beet cultivars accounted for relatively higher length of internode than 1:3 row ratio.

4.1.2.5 Number of millable canes ('000 ha⁻¹)

The number of millable canes differed significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 16).

Sole sugarcane recorded significantly higher number of millable canes during 2010-11, 2011-12 and on pooled basis (85.28, 81.10 and 83.19 '000 ha⁻¹, respectively) when compared to intercropped treatments. However, irrespective of sugar beet cultivars, growing of SC + SB in 1:1 RP found on par with sole sugarcane during both years and on pooled basis. Increase in the row ratios of sugar beet, resulted in gradual reduction in number of millable canes across different cultivars tested. Growing of sugar beet in 1:2 row ratio recorded higher number of millable canes than 1:3 row ratio. While, sugar beet grown along with sugarcane in 1:3 row ratio resulted in significantly lower number of millable canes as compared to sole sugarcane.

Table 15: Diameter of cane (cm) of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Diameter of cane (cm)														
	90 DAS			150 DAS			210 DAS			270 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	0.87a	0.84a	0.85a	1.08a	1.04a	1.06a	1.76a	1.69a	1.73a	2.26a	2.18a	2.22a	2.63a	2.55a	2.59a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	0.82a-c	0.79a	0.80a	1.03a-d	0.97a-d	1.00a-c	1.71a-c	1.64a	1.68a	2.21a-c	2.13a	2.17a	2.58a-c	2.50a	2.54a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	0.73d	0.71bc	0.72b	0.98b-e	0.94b-d	0.96b-d	1.62d	1.56b	1.59b	2.11d	2.05bc	2.08b	2.49d	2.42b	2.45b
T ₄ - SC + SB cv. Cauvery (1:3 RP)	0.71d	0.69c	0.70b	0.93e	0.89d	0.91d	1.61d	1.54b	1.57b	2.10d	2.03c	2.06b	2.47d	2.40b	2.44b
T ₅ - SC + SB cv. Shubhra (1:1 RP)	0.83ab	0.80a	0.81a	1.04ab	0.97a-d	1.01ab	1.72ab	1.65a	1.69a	2.21ab	2.14a	2.18a	2.59ab	2.51a	2.55a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	0.75b-d	0.70c	0.72b	0.98b-e	0.92b-d	0.95b-d	1.64b-d	1.55b	1.60b	2.13b-d	2.04c	2.09b	2.51b-d	2.41b	2.46b
T ₇ - SC + SB cv. Shubhra (1:3 RP)	0.73d	0.68c	0.70b	0.95c-e	0.91b-d	0.93b-d	1.62cd	1.53b	1.58b	2.12d	2.01c	2.07b	2.49d	2.39b	2.44b
T ₈ - SC + SB cv. Magnolia (1:1 RP)	0.82a-c	0.79a	0.80a	1.03a-d	0.99ab	1.01ab	1.71a-c	1.64a	1.68a	2.21a-c	2.13a	2.17a	2.58a-c	2.50a	2.54a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	0.74cd	0.70c	0.72b	0.96b-e	0.92b-d	0.94b-d	1.63b-d	1.56b	1.60b	2.13b-d	2.04bc	2.09b	2.50cd	2.41b	2.46b
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	0.72d	0.67c	0.69b	0.95de	0.89cd	0.92cd	1.61d	1.53b	1.57b	2.10d	2.01c	2.06b	2.48d	2.38b	2.43b
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	0.82a-c	0.78ab	0.80a	1.03a-c	0.98a-c	1.01ab	1.71a-c	1.63a	1.67a	2.20a-c	2.12ab	2.16a	2.58a-c	2.49a	2.53a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	0.74cd	0.71bc	0.72b	0.97b-e	0.94b-d	0.96b-d	1.63cd	1.56b	1.60b	2.13cd	2.04bc	2.09b	2.50cd	2.42b	2.46b
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	0.71d	0.68c	0.69b	0.94e	0.92b-d	0.93b-d	1.60d	1.53b	1.57b	2.09d	2.02c	2.06b	2.47d	2.39b	2.43b
S.Em±	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02
CV (%)	6.23	6.18	5.15	5.23	5.31	5.68	6.88	5.85	6.38	6.22	6.43	6.81	6.89	5.79	6.32

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

Table 16: Yield parameters of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Yield parameters								
	Cane weight (g plant ⁻¹)			Number of millable canes (000 ha ⁻¹)			Length of internode (cm)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	1450a	1380a	1420a	85.28a	81.10a	83.19a	10.85a	10.38a	10.62a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	1390ab	1320ab	1360ab	81.42ab	77.30ab	79.36ab	10.31ab	9.76ab	10.03ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	1280b-d	1210b-d	1250c-e	76.31b-d	72.83b-d	74.57b-d	9.23c-e	8.84cd	9.03c
T ₄ - SC + SB cv. Cauvery (1:3 RP)	1260b-d	1190cd	1220de	71.65d	68.14d	69.89d	9.10f	8.46d	8.78c
T ₅ - SC + SB cv. Shubhra (1:1 RP)	1380ab	1310a-c	1350a-c	79.20a-c	75.03a-c	77.11a-c	10.24a-c	9.72a-c	9.98ab
T ₆ - SC + SB cv. Shubhra (1:2 RP)	1260b-d	1190b-d	1230de	76.48b-d	73.06b-d	74.77b-d	9.39b-f	9.05b-d	9.22bc
T ₇ - SC + SB cv. Shubhra (1:3 RP)	1240cd	1180d	1210e	72.49cd	68.94cd	70.71cd	9.15ef	8.71d	8.93c
T ₈ - SC + SB cv. Magnolia (1:1 RP)	1360a-c	1300a-d	1330a-d	83.47ab	78.68ab	81.07ab	10.14a-e	9.68a-c	9.91ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	1270b-d	1220b-d	1250b-e	76.59b-d	72.98b-d	74.78b-d	9.67b-f	9.25b-d	9.46bc
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	1220d	1200b-d	1210e	71.84cd	68.40d	70.12d	9.20d-f	8.94b-d	9.07c
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	1370a-c	1310a-c	1340a-c	81.12ab	76.06ab	78.59ab	10.20a-d	9.70a-c	9.95ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	1270b-d	1210b-d	1240c-e	76.84b-d	73.23b-d	75.04b-d	9.30b-f	9.21b-d	9.26bc
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	1250cd	1170d	1210e	70.37d	68.06d	69.22d	9.22d-f	8.84cd	9.03c
S.Em±	0.05	0.05	0.04	2.57	2.25	2.32	0.35	0.31	0.28
CV (%)	6.18	6.48	5.41	6.76	7.32	5.89	6.24	5.77	5.18

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

4.1.2.6 Sugarcane yield (t ha^{-1})

Sugarcane yield differed significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 17).

Sole sugarcane recorded significantly higher cane yield during 2010-11, 2011-12 and on pooled basis (103.56 , 99.21 and 101.39 t ha^{-1} , respectively) when compared to intercropped treatments. Among the intercropped treatments, irrespective of sugar beet cultivars tested, growing of SC + SB in 1:1 RP remained on par with sole sugarcane during both years and on pooled basis.

In general, increase in the row ratios of sugar beet there was a gradual reduction in sugarcane yield. Growing of sugar beet in 1:2 row ratio recorded higher yield than 1:3 row ratio. Significantly lower sugarcane yield was recorded under 1:3 row ratio as compared to sole sugarcane.

4.1.3 Quality parameters of sugarcane

4.1.3.1 Brix (%)

Brix value of sugarcane did not differ significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 17).

4.1.3.2 Sucrose (%)

Sucrose content of sugarcane did not differ significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 17).

4.1.3.3 Commercial cane sugar (%)

The data on commercial cane sugar (%) recorded during 2010-11, 2011-12 and on pooled basis did not differ significantly among the treatments tested (Table 18).

4.1.3.4 Sugar yield (t ha^{-1})

Sugar yield differed significantly due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 18).

Sole sugarcane recorded significantly higher sugar yield during 2010-11, 2011-12 and on pooled basis (11.40 , 10.73 and 11.07 t ha^{-1} , respectively) as compared to intercropped treatments. However, growing of SC + SB in 1:1 and 1:2 RP irrespective of sugar beet cultivars tested found on par with sole sugarcane. While, lowest sugar yield recorded with 1:3 row proportion.

4.1.4 Nutrient uptake by sugarcane

4.1.4.1 Nitrogen uptake (kg ha^{-1})

The nitrogen uptake by sugarcane varied significantly due to intercropping of sugar beet cultivars in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 19).

Sole sugarcane recorded significantly higher nitrogen uptake (174.00 , 168.17 and $171.09 \text{ kg ha}^{-1}$, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. Among the intercropping system, increase in the row ratios of sugar beet there was a gradual reduction in nitrogen uptake by sugarcane. Growing of sugar beet in 1:1 and 1:2 row ratio recorded higher nitrogen uptake than 1:3 row ratio. Irrespective of sugar beet cultivars lower nitrogen uptake by sugarcane was recorded under 1:3 row ratio as compared to other treatments.

4.1.4.2 Phosphorus uptake (kg ha^{-1})

Significant differences in phosphorus uptake by sugarcane was observed due to intercropping of sugar beet cultivars at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 19).

Significantly higher phosphorus uptake by sugarcane was recorded in sole sugarcane and SC + SB in 1:1RP (irrespective of sugar beet cultivars) followed by sugarcane + sugar beet in 1:2 RP (irrespective of sugar beet cultivars) during 2010-11, 2011-12 and on pooled basis. Significantly lowest phosphorus uptake by sugarcane was noticed in sugarcane + sugar beet in 1:3 RP (irrespective of sugar beet cultivars)

Table 17: Yield and quality parameters of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Sugarcane yield (t ha ⁻¹)			Brix (%)			Sucrose (%)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	103.56a	99.21a	101.39a	19.58a	19.33a	19.45a	16.39a	16.13a	16.26a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	98.85ab	93.98a-d	96.42a-c	19.56a	19.31a	19.43a	16.29a	16.10a	16.19a
T ₃ - SC + SB cv. Cauvery (1:2 RP)	93.43b-d	89.19b-e	91.31b-e	19.55a	19.30a	19.42a	16.38a	16.12a	16.25a
T ₄ - SC + SB cv. Cauvery (1:3 RP)	87.71d	84.66de	86.18de	19.53a	19.30a	19.41a	16.37a	16.10a	16.24a
T ₅ - SC + SB cv. Shubhra (1:1 RP)	97.89a-c	93.78a-d	95.83a-d	19.56a	19.31a	19.43a	16.38a	16.12a	16.25a
T ₆ - SC + SB cv. Shubhra (1:2 RP)	93.25b-d	89.15b-e	91.20b-e	19.55a	19.30a	19.42a	16.36a	16.09a	16.22a
T ₇ - SC + SB cv. Shubhra (1:3 RP)	88.45cd	85.89c-e	87.17c-e	19.53a	19.29a	19.41a	16.37a	16.12a	16.24a
T ₈ - SC + SB cv. Magnolia (1:1 RP)	99.38ab	95.92ab	97.65ab	19.53a	19.27a	19.40a	16.35a	16.09a	16.22a
T ₉ - SC + SB cv. Magnolia (1:2 RP)	93.66b-d	89.27b-e	91.47b-e	19.53a	19.28a	19.40a	16.38a	16.10a	16.24a
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	87.85d	84.64de	86.25de	19.50a	19.25a	19.37a	16.31a	16.05a	16.18a
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	98.21a-c	95.30a-c	96.75a-c	19.55a	19.30a	19.42a	16.35a	16.09a	16.22a
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	93.12b-d	89.34b-e	91.23b-e	19.54a	19.29a	19.41a	16.38a	16.12a	16.25a
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	86.95d	83.35e	85.15e	19.51a	19.26a	19.38a	16.35a	16.08a	16.21a
S.Em±	3.38	3.30	3.32	0.61	0.61	0.61	0.51	0.50	0.51
CV (%)	7.23	7.87	6.35	5.45	5.21	5.33	5.37	5.43	5.40

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 18: Quality parameters of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment	Commercial cane sugar (%)			Sugar yield (t ha ⁻¹)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	11.03a	10.84a	10.94a	11.40a	10.73a	11.07a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	10.93a	10.82a	10.87a	10.83ab	10.18ab	10.50ab
T ₃ - SC + SB cv. Cauvery (1:2 RP)	11.03a	10.84a	10.93a	10.29ab	9.65ab	9.97ab
T ₄ - SC + SB cv. Cauvery (1:3 RP)	11.03a	10.82a	10.92a	9.66b	9.14ab	9.40b
T ₅ - SC + SB cv. Shubhra (1:1 RP)	11.03a	10.84a	10.93a	10.77ab	10.14ab	10.46ab
T ₆ - SC + SB cv. Shubhra (1:2 RP)	11.01a	10.81a	10.91a	10.29ab	9.66ab	9.97ab
T ₇ - SC + SB cv. Shubhra (1:3 RP)	11.02a	10.84a	10.93a	9.74ab	9.31ab	9.53ab
T ₈ - SC + SB cv. Magnolia (1:1 RP)	11.01a	10.82a	10.91a	10.96ab	10.40ab	10.68ab
T ₉ - SC + SB cv. Magnolia (1:2 RP)	11.04a	10.83a	10.93a	10.36ab	9.69ab	10.02ab
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	10.97a	10.78a	10.88a	9.63b	9.12ab	9.37b
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	11.00a	10.81a	10.90a	10.82ab	10.32ab	10.57ab
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	11.03a	10.84a	10.94a	10.27ab	9.67ab	9.97ab
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	11.01a	10.81a	10.91a	9.57b	9.01b	9.29b
S.Em±	0.34	0.34	0.34	0.49	0.48	0.48
CV (%)	5.33	5.42	5.37	8.24	8.44	8.31

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 19: Nutrient uptake (kg ha⁻¹) by sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

Treatment									
	Nitrogen			Phosphorous			Potassium		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	174.00a	168.17a	171.09a	10.71a	10.35a	10.53a	176.68a	170.76a	173.72a
T ₂ - SC + SB cv. Cauvery (1:1 RP)	168.78b-d	163.05b-d	165.91bc	10.49a	10.14a	10.32a	171.40bc	165.58b-d	168.49bc
T ₃ - SC + SB cv. Cauvery (1:2 RP)	165.02b-d	159.07d-g	162.05cd	9.50b	9.16b	9.33b	167.61bc	161.57d	164.59c
T ₄ - SC + SB cv. Cauvery (1:3 RP)	159.92g	155.19f-h	157.56e	8.51c	8.25c	8.38c	161.62d	156.84e	159.23d
T ₅ - SC + SB cv. Shubhra (1:1 RP)	168.52b-d	163.51bc	166.02bc	10.48a	10.17a	10.32a	171.14bc	166.05bc	168.60bc
T ₆ - SC + SB cv. Shubhra (1:2 RP)	164.74d-f	159.29d-f	162.02cd	9.49b	9.17b	9.33b	167.33c	161.79cd	164.56c
T ₇ - SC + SB cv. Shubhra (1:3 RP)	160.35fg	155.44e-h	157.89de	8.53c	8.27c	8.40c	162.06d	157.09e	159.57d
T ₈ - SC + SB cv. Magnolia (1:1 RP)	169.28b	164.01ab	166.64b	10.52a	10.20a	10.36a	171.91b	166.56ab	169.23b
T ₉ - SC + SB cv. Magnolia (1:2 RP)	164.62d-f	159.45c-e	162.04cd	9.48b	9.18b	9.33b	167.21c	161.96cd	164.58c
T ₁₀ - SC + SB cv. Magnolia (1:3 RP)	160.50e-g	154.91gh	157.70e	8.54c	8.24c	8.39c	162.20d	156.56e	159.38d
T ₁₁ - SC + SB cv. Calixta (1:1 RP)	169.24bc	163.98ab	166.61b	10.52a	10.20a	10.36a	171.87b	166.53ab	169.20b
T ₁₂ - SC + SB cv. Calixta (1:2 RP)	164.83c-e	159.62c-e	162.22c	9.49b	9.19b	9.34b	167.42bc	162.12cd	164.77c
T ₁₃ - SC + SB cv. Calixta (1:3 RP)	160.04g	154.79h	157.42e	8.51c	8.23c	8.37c	161.74d	156.44e	159.09d
S.Em±	1.52	1.44	1.47	0.09	0.09	0.09	1.54	1.47	1.49
CV (%)	6.59	5.82	6.32	6.64	7.01	7.22	6.59	7.32	7.08

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

4.1.4.3 Potassium uptake (kg ha^{-1})

The data regarding the potassium uptake of sugarcane was significantly influenced by intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 19).

Sole sugarcane recorded significantly higher potassium uptake (176.68, 170.76 and 173.72 kg ha^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. Among the intercropping system, increase in the row ratios of sugar beet there was a gradual reduction in potassium uptake by sugarcane. Growing of sugar beet in 1:1 and 1:2 row ratio recorded higher potassium uptake than 1:3 row ratio. Irrespective of sugar beet cultivars significantly lower potassium uptake by sugarcane was recorded under 1:3 row ratio, as compared to sole sugarcane.

4.1.5 Correlation studies (Table 20)

Cane yield showed significant and positive correlation with yield components such as number of millable canes ($r = 0.99$), single cane weight ($r = 0.95$), length of internode ($r = 0.94$), diameter of cane ($r = 0.96$) and number of internodes ($r = 0.94$). Similarly, growth parameters like LAI ($r = 0.93$), LAD ($r = 0.94$), total dry matter production ($r = 0.99$) and its accumulation in stem ($r = 0.97$) and leaves ($r = 0.97$) were positively and significantly correlated with cane yield.

4.2 Performance of sugar beet

4.2.1 Growth components of sugar beet

4.2.1.1 Plant height (cm)

Plant height of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions (RP) at different stages except at 30 DAS during 2010-11, 2011-12 and on pooled basis (Table 21).

At 60 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher plant height in 2010-11, 2011-12 and on pooled basis (49.86, 46.37 and 48.11 cm, respectively) when compared to sugar beet (cv. Magnolia) in 1:3 RP which recorded significantly lower plant height (39.24, 36.49 and 37.87 cm, respectively). However, all other treatments except sugar beet in 1:3 RP with cultivars (Calixta and Shubhra) recorded on par plant height with sugar beet grown in 1:1 RP with cultivar Cauvery.

At 90 DAS, the sole cultivars Cauvery (54.79, 50.95 and 52.87 cm, respectively) and Shubhra (54.21, 50.42 and 52.31 cm, respectively) recorded significantly higher plant height during 2010-11, 2011-12 and on pooled basis when compared to cultivars Magnolia and Calixta grown in 1:3 RP and Magnolia in 1:2 RP. However, rest of the treatments found on par with sole cultivar Cauvery.

At 120 DAS, significantly higher plant height of 57.77 cm and 57.16 cm were recorded in sole sugar beet cultivars Cauvery and Shubhra, respectively on pooled basis when compared to sugar beet in 1:3 RP with cultivar Magnolia which recorded significantly lower plant height (50.45, 46.46 and 48.46 cm, respectively). Rest of the treatments remained on par plant height with sole cultivar Cauvery (except Calixta and Shubhra grown in 1:3 RP and Magnolia grown in 1:2 RP).

Sole sugar beet cultivar Cauvery recorded significantly higher plant height at harvest, during both years and on pooled basis (42.38, 38.57 and 40.47 cm, respectively) when compared to cultivars Calixta and Shubhra grown in 1:3 RP and Magnolia grown in 1:2 RP. However, rest of the treatments remained on par with sole cultivar Cauvery. Significantly lowest plant height recorded in cultivar Magnolia in 1:3 RP (35.85, 32.51 and 34.18 cm, respectively)

4.2.1.2 Number of leaves per plant

Significant differences were observed in number of leaves per plant of sugar beet due to intercropping of sugar beet cultivars with sugarcane in different row proportions at different stages during 2010-11, 2011-12 and on pooled basis (Table 22).

At 30 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher number of leaves per plant in 2010-11, 2011-12 and on pooled basis (8.72, 8.46 and 8.59, respectively). Whereas, cultivar Magnolia grown in 1:3 RP with sugarcane recorded significantly lower number of leaves per plant (7.35, 7.13 and 7.24, respectively). Rest of the treatments remained on par with Cauvery in 1:1 RP.

Table 20: Correlation of cane yield ($t\ ha^{-1}$) with yield and growth parameters of sugarcane

SI. No	Parameters	'r' value*
I	Yield characters	
1.	Number of millable canes	$r = 0.99$
2.	Single cane weight	$r = 0.95$
3.	Length of internode	$r = 0.94$
4.	Diameter of cane	$r = 0.96$
5.	Number of internodes	$r = 0.94$
II	Growth characters	
1.	LAI	$r = 0.93$
2.	LAD	$r = 0.94$
3.	Total dry matter production	$r = 0.99$
4.	Dry matter accumulation in stem	$r = 0.97$
5.	Dry matter accumulation in leaves	$r = 0.97$

Note: * Indicates significance level at 5 %

Table 21: Plant height (cm) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Plant height (cm)								
	30 DAS			60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	25.79a	23.73a	24.76a	48.96ab	45.53ab	47.25ab	54.79a	50.95a	52.87a
T ₃ - Sole sugar beet cv. Shubhra	25.26a	23.24a	24.25a	48.41ab	45.02ab	46.72ab	54.21a	50.42a	52.31a
T ₄ - Sole sugar beet cv. Magnolia	24.63a	22.66a	23.65a	47.76ab	44.42ab	46.09ab	53.55a	49.80ab	51.68ab
T ₅ - Sole sugar beet cv. Calixta	24.89a	22.90a	23.90a	48.06ab	44.70ab	46.38ab	53.83a	50.06ab	51.95ab
T ₆ - SC + SB cv. Cauvery (1:1 RP)	25.83a	24.11a	24.97a	49.86a	46.37a	48.11a	53.42a	49.68ab	51.55ab
T ₇ - SC + SB cv. Cauvery (1:2 RP)	25.61a	23.65a	24.63a	49.12ab	45.68ab	47.40ab	52.74ab	49.05ab	50.89ab
T ₈ - SC + SB cv. Cauvery (1:3 RP)	25.74a	22.85a	24.30a	45.23a-c	42.06a-c	43.65a-c	51.33a-c	47.74a-c	49.53a-c
T ₉ - SC + SB cv. Shubhra (1:1 RP)	25.29a	23.89a	24.59a	49.21ab	45.77ab	47.49ab	53.08a	49.36ab	51.22ab
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	25.23a	23.25a	24.24a	48.66ab	45.25ab	46.96ab	51.87ab	48.24a-c	50.05a-c
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	25.21a	22.74a	23.98a	43.98b-d	40.90b-d	42.44b-d	50.76a-c	47.21a-d	48.98a-d
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	24.65a	22.93a	23.79a	48.95ab	45.52ab	47.24ab	51.45a-c	47.85a-c	49.65a-c
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	24.61a	22.54a	23.58a	47.92ab	44.57ab	46.24ab	47.33bc	44.02cd	45.67cd
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	24.60a	22.13a	23.37a	39.24d	36.49d	37.87d	46.15c	42.91d	44.53d
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	24.91a	23.12a	24.02a	49.26ab	45.81ab	47.54ab	52.05ab	48.41ab	50.23ab
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	24.90a	22.76a	23.83a	48.19ab	44.82ab	46.50ab	51.06a-c	47.49a-c	49.27a-c
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	24.81a	22.48a	23.65a	41.58cd	38.67cd	40.12cd	49.45b-c	45.99b-d	47.72b-d
S.Em±	0.79	0.98	0.66	2.00	1.86	1.93	1.69	1.52	1.58
CV (%)	5.45	7.35	6.01	7.36	7.21	6.87	5.67	5.46	5.58

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 21 contd.....

Treatment	Plant height (cm)					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	59.87a	55.68a	57.77a	42.38a	38.57a	40.47a
T ₃ - Sole sugar beet cv. Shubhra	59.23ab	55.08ab	57.16a	41.69ab	37.94ab	39.81ab
T ₄ - Sole sugar beet cv. Magnolia	58.45a-c	54.36a-c	56.40ab	40.96a-e	37.27 ab	39.12a-e
T ₅ - Sole sugar beet cv. Calixta	58.81a-c	54.69a-c	56.75ab	41.25a-c	37.54 ab	39.39a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	58.16a-c	54.09a-c	56.12ab	41.18a-d	37.47 ab	39.33a-d
T ₇ - SC + SB cv. Cauvery (1:2 RP)	56.89a-c	52.91a-c	54.90ab	39.98a-e	36.38 ab	38.18a-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	54.97a-d	51.12a-d	53.05a-c	38.87a-f	35.37 a-c	37.12a-f
T ₉ - SC + SB cv. Shubhra (1:1 RP)	57.33a-c	53.32a-c	55.32ab	40.12a-e	36.51 ab	38.31a-e
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	56.11a-c	52.18a-c	54.15ab	39.24a-f	35.71 a-c	37.47a-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	54.23b-d	50.43b-d	52.33bc	37.88c-f	34.47bc	36.18c-f
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	55.44a-d	51.56a-c	53.50ab	39.13a-f	35.61a-c	37.37a-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	53.87cd	50.10cd	51.98bc	37.52ef	34.14bc	35.83ef
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	50.45d	46.46d	48.46c	35.85f	32.51c	34.18f
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	56.23a-c	52.29a-c	54.26ab	39.87a-e	36.28a-c	38.08a-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	55.14a-d	51.28a-c	53.21a-c	38.79a-c	35.30a-c	37.04a-d
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	53.88cd	50.11cd	51.99bc	37.66d-f	34.27bc	35.97d-f
S.Em±	1.73	1.67	1.67	1.23	1.14	1.18
CV (%)	6.54	6.27	5.97	6.01	5.47	5.43

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

Table 22: Number of leaves per plant of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Number of leaves per plant								
	30 DAS			60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	8.42 ab	8.17 ab	8.29 ab	16.29ab	15.48ab	15.88ab	21.75a	20.01a	20.88a
T ₃ - Sole sugar beet cv. Shubhra	8.11 ab	7.87 ab	7.99 ab	15.68ab	14.90ab	15.29ab	21.41ab	19.70ab	20.55ab
T ₄ - Sole sugar beet cv. Magnolia	7.63 ab	7.40 ab	7.52 ab	14.82b-d	14.08bc	14.45bc	20.86a-c	19.19a-c	20.03a-c
T ₅ - Sole sugar beet cv. Calixta	7.86 ab	7.62 ab	7.74 ab	15.08b-d	14.33bc	14.70bc	21.13a-c	19.44a-c	20.28ab
T ₆ - SC + SB cv. Cauvery (1:1 RP)	8.72 a	8.46a	8.59a	17.11a	16.25a	16.68a	21.06a-c	19.38a-c	20.22a-c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	8.51 ab	8.25 ab	8.38 ab	16.36ab	15.54ab	15.95ab	19.65a-e	18.08a-e	18.86a-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	8.28 ab	8.03 ab	8.16 ab	14.54b-d	13.81bc	14.18bc	18.89c-f	17.38c-f	18.13d-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	8.35 ab	8.10 ab	8.22 ab	16.21ab	15.40ab	15.80ab	20.44a-d	18.80a-d	19.62a-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	8.15 ab	7.91 ab	8.03 ab	15.75ab	14.96ab	15.36ab	19.24b-f	17.70b-f	18.47c-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	7.87 ab	7.63 ab	7.75 ab	13.67c-e	12.99cd	13.33cd	18.24d-f	16.78d-f	17.51e-g
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	7.98 ab	7.74 ab	7.86 ab	15.64ab	14.86ab	15.25ab	19.65a-e	18.08a-e	18.86a-e
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	7.56 ab	7.33 ab	7.45 ab	14.68b-d	13.95bc	14.31bc	18.25d-f	16.79d-f	17.52e-g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	7.35 b	7.13b	7.24b	12.21e	11.60d	11.90d	17.11f	15.74f	16.43g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	7.95 ab	7.71 ab	7.83 ab	15.89ab	15.10ab	15.49ab	20.02a-e	18.42a-e	19.22a-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	7.81 ab	7.58 ab	7.69 ab	15.11bc	14.35bc	14.73bc	18.96c-f	17.44c-f	18.20d-f
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	7.64 ab	7.41 ab	7.53 ab	13.26d	12.60cd	12.93cd	17.68ef	16.27ef	16.97fg
S.Em±	0.34	0.33	0.33	0.64	0.61	0.63	0.82	0.77	0.61
CV (%)	7.35	7.11	7.48	7.37	6.97	7.15	7.20	7.36	5.63

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 22 contd.....

Treatment	Number of leaves per plant					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	24.87a	22.88a	23.88a	13.86a	12.89a	13.37a
T ₃ - Sole sugar beet cv. Shubhra	24.48ab	22.52ab	23.50ab	13.54ab	12.59ab	13.07ab
T ₄ - Sole sugar beet cv. Magnolia	23.86ab	21.95a-d	22.91a-c	13.02a-d	12.11a-d	12.56a-d
T ₅ - Sole sugar beet cv. Calixta	24.19ab	22.25ab	23.22ab	13.27a-c	12.34a-c	12.81a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	24.06ab	22.14a-c	23.10a-c	13.21a-d	12.29a-d	12.75a-d
T ₇ - SC + SB cv. Cauvery (1:2 RP)	23.11a-c	21.26a-e	22.19a-d	12.61a-f	11.73a-f	12.17a-f
T ₈ - SC + SB cv. Cauvery (1:3 RP)	22.74b-f	20.92b-e	21.83b-e	12.02b-f	11.18b-f	11.60b-f
T ₉ - SC + SB cv. Shubhra (1:1 RP)	23.55a-c	21.67a-d	22.61a-c	12.91a-e	12.01a-e	12.46a-e
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	22.02b-f	20.26c-f	21.14b-e	12.31b-f	11.45b-f	11.88b-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	20.35d-f	18.72fg	19.54ef	11.72d-f	10.90d-f	11.31d-f
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	22.89a-d	21.06a-e	21.97a-d	12.38a-f	11.51a-f	11.95a-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	21.13c-f	19.44e-g	20.28d-f	11.78c-f	10.96c-f	11.37c-f
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	19.68f	18.11g	18.89f	11.16f	10.38f	10.77f
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	23.15a-c	21.30a-e	22.22a-d	12.62a-f	11.74a-f	12.18a-f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	21.88b-f	20.13b-f	21.00c-f	12.04b-f	11.20b-f	11.62b-f
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	20.14ef	18.53fg	19.33e-f	11.43ef	10.63ef	11.03ef
S.Em±	0.94	0.66	0.77	0.53	0.49	0.51
CV (%)	7.23	5.47	6.14	7.36	7.13	7.29

Means followed by common letter do not differ significantly by DMRT @ p=0.05
 Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

At 60 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher number of leaves per plant in 2010-11, 2011-12 and on pooled basis (17.11, 16.25 and 16.68, respectively) compared to sugar beet in 1:3 RP with cultivar Magnolia which recorded significantly lower number of leaves per plant (12.21, 11.60 and 11.90, respectively). However, sole cultivars Cauvery and Shubhra; cultivars Shubhra, Magnolia and Calixta in 1:1 RP and sugarcane + sugar beet (Cauvery and Shubhra) in 1:2 RP remained on par with Cauvery in 1:1 RP.

At 90 DAS, the sole cultivar Cauvery recorded significantly higher number of leaves per plant (21.75, 20.01 and 20.88, respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, the sole cultivars Shubhra, Magnolia and Calixta, all cultivars in 1:1 RP and Cauvery in 1:2 RP recorded comparable number of leaves as that of sole cultivar Cauvery. Significantly lower number of leaves per plant was observed with cultivar Magnolia in 1:3 RP (17.11, 15.74 and 16.43, respectively). Similar trend was noticed at 120 DAS and at harvest.

4.2.1.3 Leaf area ($\text{dm}^2 \text{ plant}^{-1}$)

Leaf area of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions at different stages during 2010-11, 2011-12 and on pooled basis (Table 23).

At 30 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher leaf area in 2010-11, 2011-12 and on pooled basis ($7.04, 5.66$ and $6.35 \text{ dm}^2 \text{ plant}^{-1}$, respectively) when compared to other treatments. However, growing of cultivar Cauvery in sole and intercropping with sugarcane in 1:2 and 1:3 RP and cultivar Shubhra in 1:1 RP recorded on par leaf area as that of former treatment. The lower leaf area noticed in cultivar Magnolia under 1:3 RP ($4.75, 3.73$ and $4.24 \text{ dm}^2 \text{ plant}^{-1}$, respectively). The leaf area in the rest of treatments was intermediate.

At 60 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher leaf area in 2010-11, 2011-12 and on pooled basis ($46.37, 37.29$ and $41.83 \text{ dm}^2 \text{ plant}^{-1}$, respectively) when compared to other treatments. Growing of cultivar Cauvery in sole and in 1:2 RP found on par with former treatment. The lower leaf area was recorded in cultivar Magnolia in 1:3 RP ($26.57, 20.93$ and $23.75 \text{ dm}^2 \text{ plant}^{-1}$, respectively). The leaf area in rest of the treatments was intermediate.

At 90 DAS, sole cultivar Cauvery recorded significantly higher leaf area ($67.09, 59.96$ and $63.53 \text{ dm}^2 \text{ plant}^{-1}$, respectively) when compared to other treatments. However, sole cultivar Shubhra recorded comparable leaf area ($62.36, 55.23$ and $58.79 \text{ dm}^2 \text{ plant}^{-1}$, respectively) as that of former treatment. The lowest leaf area was recorded in cultivar Magnolia in 1:3 RP ($50.06, 42.93$ and $46.49 \text{ dm}^2 \text{ plant}^{-1}$, respectively). The leaf area in the rest of treatments was intermediate.

At 120 DAS, significantly higher leaf area recorded sole cultivar Cauvery ($79.78, 72.79$ and $76.29 \text{ dm}^2 \text{ plant}^{-1}$, respectively) when compared to other treatments. However, sole cultivars Shubhra and Cauvery in 1:1 RP remained on par with sole cultivar Cauvery. The lowest leaf area was recorded in cultivar Magnolia in 1:3 RP ($62.74, 55.76$ and $59.25 \text{ dm}^2 \text{ plant}^{-1}$, respectively). The leaf area in the rest of treatments was intermediate.

At harvest, sole cultivar Cauvery resulted in significantly higher leaf area ($50.83, 40.90$ and $45.87 \text{ dm}^2 \text{ plant}^{-1}$, respectively) when compared to other treatments. However, sole cultivar Shubhra recorded comparable leaf area ($47.48, 38.07$ and $42.78 \text{ dm}^2 \text{ plant}^{-1}$, respectively) as that of former treatment. The lowest leaf area was recorded in cultivar Magnolia in 1:3 RP ($29.55, 23.16$ and $26.35 \text{ dm}^2 \text{ plant}^{-1}$, respectively). The leaf area in rest of the treatments was intermediate.

4.2.1.4 Leaf area index (LAI)

Leaf area index of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 24).

At 30 DAS significantly higher LAI was recorded in cultivar Cauvery in 1:3 RP ($0.81, 0.65$ and 0.73 , respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. The lowest LAI was recorded in cultivar Magnolia in 1:1 RP ($0.37, 0.29$ and 0.33 , respectively). The LAI in the rest of treatments was intermediate.

At 60 DAS, cultivar Cauvery in 1:3 RP recorded significantly higher LAI in 2010-11, 2011-12 and on pooled basis ($4.63, 3.70$ and 4.17 , respectively) when compared to other treatments. However, cultivar Cauvery in its sole cropping and in 1:2 RP under intercropping found on par with former treatment. Significantly the lowest LAI was recorded in cultivar Magnolia under 1:1 RP ($2.39, 1.89$ and 2.14 , respectively). Rest of treatments recorded intermediate LAI.

Table 23: Leaf area (dm² plant⁻¹) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Leaf area (dm ² plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	6.86ab	5.51ab	6.18ab	43.76ab	35.15ab	39.46ab	67.09a	59.96a	63.53a
T ₃ - Sole sugar beet cv. Shubhra	6.19b-e	4.94b-f	5.56b-e	38.88cd	31.02cd	34.95cd	62.36ab	55.23ab	58.79ab
T ₄ - Sole sugar beet cv. Magnolia	5.30fg	4.20h-j	4.75f-h	33.68e-g	26.65e-g	30.16e-g	61.74b-d	54.61b-e	58.17b-d
T ₅ - Sole sugar beet cv. Calixta	5.74d-f	4.56e-i	5.15d-g	36.03c-f	28.64d-f	32.33d-f	61.94bc	54.81bc	58.38bc
T ₆ - SC + SB cv. Cauvery (1:1 RP)	7.04a	5.66a	6.35a	46.37a	37.29a	41.83a	62.77bc	55.65bc	59.21bc
T ₇ - SC + SB cv. Cauvery (1:2 RP)	6.84ab	5.49a-c	6.16ab	43.65ab	35.05ab	39.35ab	59.45b-e	52.33c-e	55.89c-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	6.50a-c	5.21a-d	5.86a-c	37.05c-e	29.63c-e	33.34c-e	58.89de	51.77d-f	55.33de
T ₉ - SC + SB cv. Shubhra (1:1 RP)	6.36a-d	5.08a-e	5.72a-d	40.54bc	32.37bc	36.46bc	62.57b-d	55.54b-d	59.00b-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	6.15b-e	4.91c-g	5.53b-e	38.70cd	30.85cd	34.77cd	57.90d-f	50.78e-g	54.34d-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	5.85c-f	4.66d-h	5.26c-f	32.44fg	25.78fg	29.11fg	52.94f-h	45.81hi	49.38gh
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	5.49ef	4.33g-i	4.91e-g	35.83d-f	28.37d-f	32.10d-f	57.71de	50.58d-f	54.14de
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	5.13fg	4.05ij	4.59gh	33.00e-g	26.09e-g	29.54e-g	54.22f-h	47.10g-i	50.66f-h
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	4.75g	3.73j	4.24h	26.57h	20.93h	23.75h	50.06h	42.93i	46.49h
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	5.78c-f	4.60e-i	5.19d-g	38.32cd	30.49cd	34.40cd	61.28c-e	54.16c-f	57.72c-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	5.63d-f	4.47f-i	5.05e-g	35.82d-f	28.45d-f	32.14d-f	56.25e-g	49.12f-h	52.69e-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	5.40fg	4.28h-j	4.84f-h	30.81gh	24.43gh	27.62gh	52.19gh	45.07hi	48.63gh
S.Em±	0.25	0.20	0.23	1.58	1.26	1.42	1.23	1.23	1.23
CV (%)	7.39	7.40	7.16	7.41	7.67	7.24	6.62	6.12	6.86

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 23 contd.....

Treatment	Leaf area (dm ² plant ⁻¹)					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	79.78a	72.79a	76.29a	50.83a	40.90a	45.87a
T ₃ - Sole sugar beet cv. Shubhra	75.05ab	68.06ab	71.55ab	47.48ab	38.07ab	42.78ab
T ₄ - Sole sugar beet cv. Magnolia	74.42c-f	67.44c-e	70.93c-e	41.20cd	32.79cd	36.99cd
T ₅ - Sole sugar beet cv. Calixta	74.63b-d	67.64bc	71.14bc	45.43bc	36.37bc	40.90bc
T ₆ - SC + SB cv. Cauvery (1:1 RP)	75.46a-c	68.48ab	71.97ab	45.27bc	36.24bc	40.76bc
T ₇ - SC + SB cv. Cauvery (1:2 RP)	72.14d-f	65.15c-e	68.65c-e	40.18de	31.98de	36.08de
T ₈ - SC + SB cv. Cauvery (1:3 RP)	71.58f-h	64.59e-g	68.09e-g	36.13e-g	28.62e-g	32.38e-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	75.26b-e	68.27b-d	71.76b-d	41.69cd	33.21cd	37.45cd
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	70.59e-g	63.60d-f	67.10d-f	37.84d-f	30.02d-f	33.93d-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	65.63g-i	58.64f-h	62.14f-h	34.14f-h	26.97f-h	30.55f-h
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	70.40e-h	63.41e-g	66.90d-g	37.02d-g	29.32d-g	33.17d-g
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	66.91hi	59.92gh	63.42gh	32.75gh	25.78gh	29.26gh
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	62.74i	55.76h	59.25h	29.55h	23.16h	26.35h
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	73.97d-f	66.99c-e	70.48e	40.96c-e	32.65cd	36.80cd
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	68.94f-h	61.95e-g	65.44e-g	37.37d-g	29.68d-f	33.52d-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	64.88g-i	57.89f-h	61.39f-h	33.92f-h	26.84f-h	30.38f-h
S.Em±	1.23	1.23	1.23	1.69	1.35	1.52
CV (%)	6.98	7.30	7.13	7.42	7.38	7.53

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion
Means followed by common letter do not differ significantly by DMRT @ p=0.05

Table 24: Leaf area index of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Leaf area index														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	0.69bc	0.55b	0.62bc	4.38ab	3.52ab	3.95ab	6.71b	6.00b	6.35b	7.98bc	7.28bc	7.63bc	5.08a	4.09a	4.59a
T ₃ - Sole sugar beet cv. Shubhra	0.62cd	0.49cd	0.56cd	3.89cd	3.10cd	3.50cd	6.2cd	5.52c-e	5.88c-e	7.50de	6.81de	7.16de	4.75ab	3.81ab	4.28ab
T ₄ - Sole sugar beet cv. Magnolia	0.53e-g	0.42e-g	0.47e-g	3.37ef	2.66ef	3.02ef	6.17d	5.46c-e	5.82de	7.44e	6.74de	7.09de	4.12c-f	3.28c-e	3.70c-e
T ₅ - Sole sugar beet cv. Calixta	0.57d-f	0.46d-f	0.52d-f	3.60de	2.86de	3.23de	6.19cd	5.48c-e	5.84c-e	7.46e	6.76de	7.11de	4.54bc	3.64bc	4.09bc
T ₆ - SC + SB cv. Cauvery (1:1 RP)	0.47gh	0.38gh	0.42gh	3.09fg	2.49fg	2.79fg	4.18g	3.71i	3.95h	5.03h	4.57h	4.80h	3.02hi	2.42hi	2.72gh
T ₇ - SC + SB cv. Cauvery (1:2 RP)	0.68bc	0.55b	0.62bc	4.36ab	3.50ab	3.93ab	5.95de	5.23e-g	5.59ef	7.21ef	6.52ef	6.86ef	4.02d-f	3.20d-f	3.61de
T ₈ - SC + SB cv. Cauvery (1:3 RP)	0.81a	0.65a	0.73a	4.63a	3.70a	4.17a	7.36a	6.47a	6.92a	8.95a	8.07a	8.51a	4.52bc	3.58bc	4.05bc
T ₉ - SC + SB cv. Shubhra (1:1 RP)	0.42hi	0.34hi	0.38hi	2.70gh	2.16gh	2.43gh	4.17g	3.70i	3.93h	5.02h	4.55h	4.78h	2.78ij	2.21h-j	2.50hi
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	0.62cd	0.49cd	0.55cd	3.87cd	3.08cd	3.48cd	5.79e	5.08fg	5.43f	7.06f	6.36f	6.71f	3.78ef	3.00d-f	3.39de
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	0.73b	0.58b	0.66b	4.06bc	3.22bc	3.64bc	6.62b	5.73bc	6.17bc	8.20b	7.33b	7.77b	4.27cd	3.37cd	3.82cd
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	0.37i	0.29i	0.33i	2.39h	1.89h	2.14h	3.85g	3.37i	3.61h	4.69h	4.23h	4.46h	2.47j	1.95j	2.21i
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	0.51fg	0.40fg	0.46fg	3.30ef	2.61ef	2.95ef	5.42f	4.71h	5.07g	6.69g	5.99g	6.34g	3.27gh	2.58gh	2.93fg
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	0.59de	0.47de	0.53de	3.32ef	2.62ef	2.97ef	6.26cd	5.37d-f	5.81de	7.84cd	6.97cd	7.41cd	3.69fg	2.89fg	3.29ef
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	0.39i	0.31i	0.35i	2.55h	2.03h	2.29h	4.09g	3.61i	3.85h	4.93h	4.47h	4.70h	2.73ij	2.18ij	2.45hi
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	0.56d-f	0.45d-f	0.51d-f	3.58de	2.85de	3.21de	5.62ef	4.91gh	5.27fg	6.89fg	6.20fg	6.54fg	3.74fg	2.97ef	3.35e
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	0.68bc	0.54bc	0.61bc	3.85cd	3.05cd	3.45cd	6.52bc	5.63cd	6.08b-d	8.11bc	7.24bc	7.67bc	4.24c-e	3.36cd	3.80cd
S.Em±	0.03	0.02	0.02	0.15	0.12	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.17	0.13	0.15
CV (%)	7.52	7.29	7.13	7.47	7.54	6.98	6.62	6.12	6.85	6.97	6.69	6.26	7.51	7.08	7.19

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

At 90 DAS, cultivar Cauvery in 1:3 RP recorded significantly higher LAI in 2010-11, 2011-12 and on pooled basis (7.36, 6.47 and 6.92, respectively) when compared to other treatments. Significantly lower LAI was recorded in cultivar Magnolia in 1:1 RP (3.85, 3.37 and 3.61, respectively). The LAI in the rest of treatments was intermediate.

At 120 DAS, cultivar Cauvery in 1:3 RP recorded significantly higher LAI in 2010-11, 2011-12 and on pooled basis (8.95, 8.07 and 8.51, respectively) when compared to other treatments. Significantly lower LAI was recorded in cultivar Magnolia under 1:1 RP (4.69, 4.23 and 4.46, respectively). The LAI in the rest of treatments was intermediate.

At harvest, sole cultivar Cauvery recorded significantly higher LAI in 2010-11, 2011-12 and on pooled basis (5.08, 4.09 and 4.59, respectively) when compared to other treatments. However, sole cultivar Shubhra recorded on par LAI (4.75, 3.81 and 4.28, respectively) as that of former treatment. Significantly lower LAI was recorded in cultivar Magnolia in 1:1 RP (2.47, 1.95 and 2.21, respectively). The LAI in the rest of treatments was intermediate.

4.2.1.5 Leaf area duration (Days)

Leaf area duration (LAD) of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 25).

Between 30- 60 DAS, cultivar Cauvery in 1:3 RP resulted in significantly higher LAD (81.67, 65.33 and 73.50 days, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, cultivar Cauvery in its sole cropping and in 1:2 RP in intercropping recorded on par LAD as that of former treatment. Lower LAD was noticed with cultivar Magnolia in 1:1 RP (41.31, 32.70 and 37.01 days, respectively). The LAD in the remaining treatments was intermediate.

Between 61-90 DAS, cultivar Cauvery grown in 1:3 RP recorded significantly higher LAD (179.90, 152.62 and 166.26 days, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. Significantly lower LAD was observed with cultivar Magnolia in 1:1 RP (93.54, 78.95 and 86.24 days, respectively). The LAD of the rest of treatments was intermediate.

Between 91-120 DAS, significantly higher LAD was observed in cultivar Cauvery grown in 1:3 RP (244.64, 218.18 and 231.41 days, respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. Significantly lower LAD was observed with cultivar Magnolia in 1:1 RP (128.10, 113.99 and 121.05 days, respectively). The LAD in the rest of treatments was intermediate.

Between 121- harvest, cultivar Cauvery in 1:3 RP accounted significantly higher LAD (302.94, 262.16 and 282.55 days, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, sole cultivar Cauvery remained on par with former treatment. Lower LAD was noticed with cultivar Magnolia in 1:1 RP (161.12, 139.10 and 150.11 days, respectively). The LAD in the rest of treatments was intermediate.

4.2.1.6 Dry matter accumulation in green foliage (g plant⁻¹)

Dry matter accumulation (DMA) in green foliage of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions (except at 30 DAS) during 2010-11, 2011-12 and on pooled basis (Table 26).

At 60 DAS, cultivar Cauvery in 1:1 RP with recorded significantly higher DMA in green foliage in 2010-11, 2011-12 and on pooled basis (33.91, 29.33 and 31.62 g plant⁻¹, respectively) when compared to sole cultivar Magnolia and sugar beet in 1:3 RP (irrespective of cultivars). However, rest of the treatments found on par with cultivar Cauvery in 1:1 RP. Significantly lower DMA in green foliage was noticed in cultivar Magnolia in 1:3 RP (31.03, 26.45 and 28.74 g plant⁻¹, respectively) as compared to Magnolia in 1:1 RP

At 90 DAS, sole cultivar Cauvery recorded significantly higher DMA in green foliage in 2010-11, 2011-12 and on pooled basis (55.94, 50.37 and 53.15 g, plant⁻¹ respectively) when compared to cultivar Magnolia in 1:1 RP and sugar beet in 1:2 and 1:3 RP (irrespective of sugar beet cultivars). However, rest of the treatments recorded comparable DMA in green foliage as that of sole Cauvery. Significantly lowest DMA in green foliage was noticed in cultivar Magnolia in 1:3 RP (50.34, 44.77 and 47.55 g plant⁻¹, respectively). The DMA in green foliage in the rest of treatments were intermediate.

Table 25: Leaf area duration (Days) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Leaf area duration (days)											
	30 to 60 DAS			61 to 90DAS			91 to 120 DAS			121 DAS to harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	75.92ab	61.00ab	68.46ab	166.27b	142.68b	154.47b	220.30bc	199.13b	209.72b	293.87ab	255.81ab	274.84ab
T ₃ - Sole sugar beet cv. Shubhra	67.61cd	53.94cd	60.77cd	151.86c-f	129.37c-e	140.62c-e	206.11de	184.94cd	195.52de	275.68cd	238.80bc	257.24cd
T ₄ - Sole sugar beet cv. Magnolia	58.47ef	46.26ef	52.37ef	143.12fg	121.89ef	132.50ef	204.24de	183.07cd	193.66de	260.16d-f	225.51c-e	242.83d-f
T ₅ - Sole sugar beet cv. Calixta	62.65de	49.81de	56.23de	146.95d-g	125.18d-f	136.07d-f	204.85de	183.68cd	194.27de	270.14c-e	234.03b-d	252.09c-e
T ₆ - SC + SB cv. Cauvery (1:1 RP)	53.42fg	42.94fg	48.18fg	109.15i	92.93h	101.04h	138.24h	124.13g	131.18h	181.11j	157.07i	169.09j
T ₇ - SC + SB cv. Cauvery (1:2 RP)	75.73ab	60.81ab	68.27ab	154.65c-e	131.06cd	142.86cd	197.39ef	176.22de	186.81ef	252.73f-h	218.54e-g	235.64f-h
T ₈ - SC + SB cv. Cauvery (1:3 RP)	81.67a	65.33a	73.50a	179.90a	152.62a	166.26a	244.64a	218.18a	231.41a	302.94a	262.16a	282.55a
T ₉ - SC + SB cv. Shubhra (1:1 RP)	46.90gh	37.44gh	42.17gh	103.11ij	87.81hi	95.46hi	137.82h	123.71g	130.77h	175.42jk	152.22ij	163.82jk
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	67.28cd	53.63cd	60.46cd	144.90e-g	122.43d-f	133.67d-f	192.74f	171.57e	182.15f	243.96gh	210.66fg	227.31gh
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	71.81bc	57.08bc	64.44bc	160.10bc	134.23bc	147.16bc	222.32b	195.86b	209.09b	280.59bc	240.78b	260.69bc
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	41.31h	32.70h	37.01h	93.54j	78.95i	86.24i	128.10h	113.99g	121.05h	161.12k	139.10j	150.11k
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	57.20ef	45.20ef	51.20ef	130.84h	109.77g	120.31g	181.70g	160.53f	171.11g	224.23i	192.82h	208.52i
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	58.73ef	46.24ef	52.48ef	143.67fg	119.74f	131.71ef	211.50cd	185.04cd	198.27cd	259.56e-g	221.95d-f	240.76e-g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	44.10h	35.09h	39.59h	99.60ij	84.65hi	92.12hi	135.26h	121.15g	128.20h	172.39jk	149.46ij	160.93jk
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	62.18de	49.39de	55.79de	138.10gh	116.37fg	127.23fg	187.78fg	166.61ef	177.20fg	239.19hi	206.17gh	222.68hi
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	67.89cd	53.83cd	60.86cd	155.62cd	130.30c-e	142.96cd	219.51bc	193.05bc	206.28bc	277.88c	238.33bc	258.10c
S.Em±	2.68	2.13	2.41	3.48	3.07	3.27	3.57	3.57	3.57	5.48	4.81	5.15
CV (%)	7.48	6.94	7.11	6.34	7.15	6.87	7.36	6.66	6.45	5.92	6.24	6.37

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 26: Dry matter accumulation in green foliage (g plant⁻¹) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Dry matter accumulation in green foliage (g plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	7.76a	6.19a	6.98a	33.33ab	28.75a-d	31.04a-c	55.94a	50.37a	53.15a
T ₃ - Sole sugar beet cv. Shubhra	7.73a	6.16a	6.95a	33.01ab	28.43a-d	30.72a-d	55.35ab	49.78ab	52.56ab
T ₄ - Sole sugar beet cv. Magnolia	7.70a	6.13a	6.92a	32.57b-e	27.99b-e	30.28b-f	54.67a-c	49.10a-c	51.88a-c
T ₅ - Sole sugar beet cv. Calixta	7.71a	6.14a	6.93a	32.73a-d	28.15a-c	30.44a-d	54.96a-c	49.39a-c	52.17a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	7.77a	6.20a	6.99a	33.91a	29.33a	31.62a	54.50a-d	48.93a-d	51.71a-d
T ₇ - SC + SB cv. Cauvery (1:2 RP)	7.75a	6.18a	6.97a	33.27ab	28.69a-c	30.98a-c	53.16b-g	47.59b-g	50.37b-g
T ₈ - SC + SB cv. Cauvery (1:3 RP)	7.74a	6.17a	6.96a	31.71c-f	27.13b-e	29.42c-f	51.63e-h	46.06e-h	48.84e-h
T ₉ - SC + SB cv. Shubhra (1:1 RP)	7.73a	6.16a	6.95a	33.78ab	29.20ab	31.49ab	53.91a-e	48.34a-e	51.12a-e
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	7.72a	6.15a	6.94a	32.88a-c	28.30a-d	30.59a-d	52.52c-h	46.95c-h	49.73c-h
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	7.71a	6.14a	6.93a	31.52d-g	26.94c-e	29.23d-f	51.09f-h	45.52f-h	48.30f-h
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	7.70a	6.13a	6.92a	33.59ab	29.01a-c	31.30ab	53.24b-f	47.67b-f	50.45b-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	7.70a	6.13a	6.92a	32.67a-d	28.09a-e	30.38a-e	51.80e-h	46.23e-h	49.01e-h
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	7.69a	6.12a	6.91a	31.03f	26.45e	28.74f	50.34h	44.77h	47.55h
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	7.72a	6.15a	6.94a	33.74ab	29.16ab	31.45ab	53.50a-f	47.93a-f	50.71a-f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	7.71a	6.14a	6.93a	32.80a-c	28.22a-d	30.51a-e	52.09d-h	46.52d-h	49.30d-h
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	7.69a	6.12a	6.91a	31.35ef	26.77de	29.06ef	50.71gh	45.14gh	47.92gh
S.Em±	0.05	0.05	0.05	0.44	0.44	0.44	0.86	0.86	0.86
CV (%)	6.09	6.36	6.21	6.31	6.69	6.47	5.80	6.13	5.96

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 26 contd.....

Treatment	Dry matter accumulation in green foliage (g plant ⁻¹)					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	59.71a	54.22a	56.96a	18.54a	14.97a	16.76a
T ₃ - Sole sugar beet cv. Shubhra	58.61ab	53.12ab	55.86ab	17.36ab	13.79ab	15.58ab
T ₄ - Sole sugar beet cv. Magnolia	56.81a-e	51.32a-e	54.06a-e	15.38b-e	11.81b-e	13.60b-e
T ₅ - Sole sugar beet cv. Calixta	57.68a-d	52.19a-d	54.93a-d	16.26a-d	12.69a-d	14.48a-d
T ₆ - SC + SB cv. Cauvery (1:1 RP)	58.01a-c	52.52a-c	55.26a-c	16.85a-c	13.28a-c	15.07a-c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	56.39a-e	50.90a-e	53.64a-e	15.16b-f	11.59b-f	13.38c-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	54.51c-g	49.02c-g	51.76c-g	13.66d-h	10.09e-i	11.88e-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	56.80a-e	51.31a-e	54.05a-e	15.67b-e	12.10b-e	13.89b-e
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	55.08b-f	49.59b-f	52.33b-f	14.07b-g	10.50d-h	12.29e-g
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	53.31e-g	47.82e-g	50.56e-g	12.57e-h	9.00g-j	10.79f-i
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	55.11b-f	49.62b-f	52.36b-f	13.70c-g	10.13e-h	11.92e-g
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	53.32e-g	47.83e-g	50.57e-g	12.08f-h	8.51h-j	10.30g-i
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	51.50g	46.01g	48.75g	10.55h	6.98j	8.77i
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	55.91b-f	50.42b-f	53.16b-f	14.58b-f	11.01c-g	12.80d-f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	54.21d-g	48.72d-g	51.46d-g	12.97e-h	9.40f-i	11.19f-h
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	52.48fg	46.99fg	49.73fg	11.33gh	7.76ij	9.55hi
S.Em±	1.23	1.23	1.23	1.09	1.09	1.09
CV (%)	5.84	6.26	6.04	13.12	17.44	14.97

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

At 120 DAS, sole cultivar Cauvery accounted significantly higher DMA in green foliage during both years and on pooled basis (59.71, 54.22 and 56.96 g plant⁻¹, respectively) when compared to other treatments. However, the sole sugar beet cultivars (Shubhra, Magnolia and Calixta), Cauvery and Shubhra cultivars in 1:1 RP and cultivar Cauvery in 1:2 RP remained on par with sole cultivar Cauvery. Significantly lowest DMA in green foliage was noticed in cultivar Magnolia in 1:3 RP (51.50, 46.01 and 48.75 g plant⁻¹, respectively). The DMA in green foliage in the rest of treatments were intermediate.

At harvest, significantly higher DMA in green foliage was observed in sole cultivar Cauvery (18.54, 14.97 and 16.76 g plant⁻¹, respectively) during both years and on pooled basis when compared to other treatments. However, the sole cultivars Shubhra and Calixta and cultivar Cauvery in 1:1 RP recorded on par DMA in green foliage as that of sole cultivar Cauvery. Significantly lowest DMA in green foliage was noticed with Magnolia in 1:3 RP (10.55, 6.98 and 8.77 g plant⁻¹, respectively). The DMA in green foliage in the rest of treatments were intermediate.

4.2.1.7 Dry matter accumulation in tuber (g plant⁻¹)

Dry matter accumulation (DMA) in tuber was significantly influenced by cultivars and row proportions of sugar beet in intercropping system at all stages of the observations during both years and on pooled basis (Table 27).

At 60 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher DMA in tuber in 2010-11, 2011-12 and on pooled basis (34.91, 29.59 and 32.25 g plant⁻¹, respectively) when compared to cultivar Magnolia grown in sole as well as in 1:2 RP and all the cultivars grown in 1:3 RP. However, rest of the treatments remained on par with Cauvery in 1:1 RP. Significantly lower DMA in tuber was noticed in cultivar Magnolia in 1:3 RP (33.84, 28.52 and 31.18 g plant⁻¹, respectively).

At 90 DAS, sole cultivar Cauvery recorded significantly higher DMA in tuber (53.58, 47.59 and 50.58 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, the sole cultivars Shubhra, Magnolia and Calixta, cultivar Cauvery in 1:1 RP recorded on par DMA in tuber as that of sole cultivar Cauvery. Significantly lower DMA in tuber was noticed in cultivar Magnolia in 1:3 RP (49.86, 43.87 and 46.86 g plant⁻¹, respectively). The DMA in tuber of the rest of treatments were intermediate.

At 120 DAS, sole cultivar Cauvery resulted in significantly higher DMA in tuber (110.51, 105.16 and 107.83 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, the sole cultivars Shubhra, Magnolia and Calixta, cultivars Cauvery and Shubhra in 1:1 RP and cultivar Cauvery in 1:2 RP remained on par with sole cultivar Cauvery. Significantly lower DMA in tuber was noticed in cultivar Magnolia in 1:3 RP (104.23, 98.88 and 101.55 g plant⁻¹, respectively). The DMA in tuber of the rest of treatments were intermediate.

At harvest, sole cultivar Cauvery accounted significantly higher DMA in tuber (211.48, 205.37 and 208.43 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, the sole cultivars Shubhra, Magnolia and Calixta; cultivars Cauvery, Shubhra and Calixta in 1:1 RP and cultivar Cauvery in 1:2 RP remained on par with sole cultivar Cauvery. Significantly lower DMA in tuber was noticed in cultivar Magnolia in 1:3 RP (205.20, 199.09 and 202.15 g plant⁻¹, respectively). The DMA in tuber of the rest of treatments were intermediate.

4.2.1.8 Total dry matter production (g plant⁻¹)

Total dry matter production (TDMP) of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions at different growth stages except at 30 DAS during 2010-11, 2011-12 and on pooled basis (Table 28).

At 60 DAS, cultivar Cauvery in 1:1 RP recorded significantly higher TDMP in 2010-11, 2011-12 and on pooled basis (68.82, 58.92 and 63.87 g plant⁻¹, respectively) when compared to cultivars Magnolia and Calixta in their sole cropping as well as in 1:2 and 1:3 RP and cultivars Cauvery and Shubhra in 1:3 RP. However, rest of the treatments were found on par with Cauvery in 1:1 row proportion. Significantly lower TDMP was noticed in cultivar Magnolia in 1:3 RP (64.87, 54.97 and 59.92 g plant⁻¹, respectively).

At 90 DAS, sole cultivar Cauvery recorded significantly higher TDMP (109.51, 97.96 and 103.73 g plant⁻¹, respectively) in 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, the sole cultivars Shubhra, Magnolia and Calixta; cultivars Cauvery and Shubhra in 1:1 RP remained on par with sole cultivar Cauvery. Cultivar Magnolia in 1:3 RP recorded

Table 27: Dry matter accumulation in tuber (g plant⁻¹) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Dry matter accumulation in tuber (g plant ⁻¹)					
	60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	34.48ab	29.16ab	31.82a-c	53.58a	47.59a	50.58a
T ₃ - Sole sugar beet cv. Shubhra	34.44ab	29.12ab	31.78a-c	53.21ab	47.22ab	50.21ab
T ₄ - Sole sugar beet cv. Magnolia	34.36b-d	29.04b-d	31.70b-e	52.68a-c	46.69a-c	49.68a-c
T ₅ - Sole sugar beet cv. Calixta	34.40a-c	29.08a-c	31.74a-d	52.92a-c	46.93a-c	49.92a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	34.91a	29.59a	32.25a	52.64a-c	46.65a-c	49.64a-c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	34.55ab	29.23ab	31.89a-c	51.71c-e	45.72c-e	48.71c-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	34.18b-d	28.86b-d	31.52c-f	50.77e-g	44.78e-g	47.77e-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	34.72ab	29.40ab	32.06ab	52.27b-d	46.28b-d	49.27b-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	34.39a-c	29.07a-d	31.73a-d	51.34d-f	45.35d-f	48.34d-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	34.14ef	28.82d-f	31.48d-f	50.38fg	44.39fg	47.38fg
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	34.53ab	29.21ab	31.87ab	51.71c-e	45.72c-e	48.71c-e
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	34.29b-d	28.97b-d	31.63b-c	50.78e-g	44.79e-g	47.78e-g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	33.84f	28.52f	31.18f	49.86g	43.87g	46.86g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	34.64ab	29.32ab	31.98a-c	51.96c-e	45.97c-e	48.96c-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	34.35a-c	29.03a-d	31.69a-c	51.05d-g	45.06d-g	48.05d-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	33.90ef	28.58ef	31.24ef	50.11g	44.12fg	47.11fg
S.Em±	0.12	0.12	0.12	0.43	0.43	0.43
CV (%)	5.63	5.74	6.18	6.43	5.62	6.24

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 27 contd.....

Treatment	Dry matter accumulation in tuber (g plant ⁻¹)					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	110.51a	105.16a	107.83a	211.48a	205.37a	208.43a
T ₃ - Sole sugar beet cv. Shubhra	109.56ab	104.21ab	106.88ab	210.53ab	204.42ab	207.48ab
T ₄ - Sole sugar beet cv. Magnolia	108.14a-d	102.79a-d	105.46a-d	209.11a-e	203.00a-d	206.06a-d
T ₅ - Sole sugar beet cv. Calixta	108.75a-c	103.40a-c	106.07a-c	209.72a-d	203.61a-c	206.67a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	109.38ab	104.03ab	106.70ab	210.35a-c	204.24ab	207.30ab
T ₇ - SC + SB cv. Cauvery (1:2 RP)	108.10a-d	102.75a-d	105.42a-d	209.07a-e	202.96a-d	206.02a-d
T ₈ - SC + SB cv. Cauvery (1:3 RP)	106.74b-f	101.39b-f	104.06b-f	207.71b-f	201.60b-e	204.66b-e
T ₉ - SC + SB cv. Shubhra (1:1 RP)	108.41a-d	103.06a-d	105.73a-d	209.38a-d	203.27a-c	206.33a-c
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	107.01b-d	101.66b-f	104.33b-f	207.98b-f	201.87b-e	204.93b-e
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	105.75d-f	100.40d-f	103.07df	206.72d-f	200.61c-e	203.67c-e
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	106.97b-f	101.62b-f	104.29bf	207.94b-f	201.83b-e	204.89b-e
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	105.70d-f	100.35d-f	103.02d-f	206.67d-f	200.56c-e	203.62c-e
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	104.23f	98.88f	101.55f	205.20e	199.09e	202.15e
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	107.51b-e	102.16b-e	104.83b-e	208.48a-e	202.37a-e	205.43a-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	106.27e-f	100.92c-f	103.59c-f	207.24c-f	201.13b-e	204.19b-e
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	104.92ef	99.57ef	102.24ef	205.89ef	199.78de	202.84de
S.Em±	1.01	1.01	1.01	1.14	1.14	1.14
CV (%)	6.36	5.71	6.09	5.94	6.37	6.18

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 28: Total dry matter production (g plant⁻¹) of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Total dry matter production (g plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	7.76a	6.19a	6.98a	67.81ab	57.91a-d	62.86a-c	109.51a	97.96a	103.73a
T ₃ - Sole sugar beet cv. Shubhra	7.73a	6.16a	6.95a	67.45a-c	57.55a-c	62.50a-d	108.55ab	97.00ab	102.77ab
T ₄ - Sole sugar beet cv. Magnolia	7.70a	6.13a	6.92a	66.93b-d	57.03b-f	61.98b-e	107.34a-c	95.79a-c	101.56a-c
T ₅ - Sole sugar beet cv. Calixta	7.71a	6.14a	6.93a	67.13b-d	57.23b-e	62.18b-e	107.87ab	96.32ab	102.09ab
T ₆ - SC + SB cv. Cauvery (1:1 RP)	7.77a	6.20a	6.99a	68.82a	58.92a	63.87a	107.13a-c	95.58a-c	101.35a-c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	7.75a	6.18a	6.97a	67.82ab	57.92a-d	62.87a-c	104.86b-f	93.31b-f	99.08b-f
T ₈ - SC + SB cv. Cauvery (1:3 RP)	7.74a	6.17a	6.96a	65.89c-e	55.99c-f	60.94c-f	102.39e-g	90.84e-g	96.61e-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	7.73a	6.16a	6.95a	68.50ab	58.60ab	63.55ab	106.17a-d	94.62a-d	100.39a-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	7.72a	6.15a	6.94a	67.27ad	57.37a-e	62.32a-d	103.85c-g	92.30c-g	98.07c-g
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	7.71a	6.14a	6.93a	65.66de	55.76d-f	60.71d-f	101.46fg	89.91fg	95.68fg
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	7.70a	6.13a	6.92a	68.12ab	58.22a-d	63.17ab	104.94b-f	93.39b-f	99.16b-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	7.70a	6.13a	6.92a	66.96b-d	57.06b-f	62.01b-e	102.57d-g	91.02d-g	96.79d-g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	7.69a	6.12a	6.91a	64.87e	54.97f	59.92f	100.19g	88.64g	94.41g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	7.72a	6.15a	6.94a	68.38ab	58.48a-c	63.43ab	105.45b-e	93.90b-e	99.67b-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	7.71a	6.14a	6.93a	67.15b-d	57.25b-e	62.20b-e	103.13d-g	91.58d-g	97.35d-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	7.69a	6.12a	6.91a	65.25e	55.35ef	60.30ef	100.81g	89.26g	95.03g
S.Em±	0.05	0.05	0.05	0.56	0.56	0.56	1.29	1.29	1.29
CV (%)	7.34	7.08	6.97	6.45	6.28	5.97	6.13	7.05	6.59

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Contd...

Table 28 contd.....

Treatment	Total dry matter production (g plant ⁻¹)					
	120 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	170.21a	159.38a	164.79a	230.02a	220.34a	225.18a
T ₃ - Sole sugar beet cv. Shubhra	168.16ab	157.33ab	162.74ab	227.89ab	218.21ab	223.05ab
T ₄ - Sole sugar beet cv. Magnolia	164.94a-e	154.11a-e	159.52a-e	224.49b-e	214.81b-d	219.65b-d
T ₅ - Sole sugar beet cv. Calixta	166.42a-d	155.59a-d	161.00a-d	225.98a-d	216.30a-d	221.14a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	167.38a-c	156.55a-c	161.96a-c	227.20a-c	217.52a-c	222.36ab
T ₇ - SC + SB cv. Cauvery (1:2 RP)	164.48a-e	153.65a-e	159.06a-e	224.23b-e	214.55b-g	219.39b-d
T ₈ - SC + SB cv. Cauvery (1:3 RP)	161.24c-g	150.41c-g	155.82c-g	221.37d-g	211.69d-i	216.53c-f
T ₉ - SC + SB cv. Shubhra (1:1 RP)	165.20a-e	154.37a-e	159.78a-e	225.05b-d	215.37b-d	220.21b-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	162.08b-g	151.25b-g	156.66b-g	222.05d-f	212.37c-h	217.21c-f
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	159.05e-g	148.22e-g	153.63e-g	219.29f-h	209.61f-i	214.45e-g
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	162.07b-g	151.24b-g	156.65b-g	221.64d-g	211.96c-h	216.80c-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	159.01e-g	148.18e-g	153.59e-g	218.75f-h	209.07gi	213.91e-g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	155.72g	144.89g	150.30g	215.75h	206.07i	210.91g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	163.41b-f	152.58b-f	157.99b-f	223.06c-f	213.38b-g	218.22b-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	160.47d-g	149.64d-g	155.05d-g	220.21e-h	210.53e-i	215.37d-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	157.39fg	146.56fg	151.97fg	217.22gh	207.54hi	212.38fg
S.Em±	2.24	2.24	2.24	1.67	1.67	1.67
CV (%)	7.38	6.87	7.15	6.30	6.36	5.83

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet

RP: Row proportion

significantly lower TDMP (100.19, 88.64 and 94.41 g plant⁻¹, respectively). The TDMP of sugar beet in the rest of treatments was intermediate.

At 120 DAS, significantly higher TDMP was observed in sole cultivar Cauvery during 2010-11, 2011-12 and on pooled basis (170.21, 159.38 and 164.79 g plant⁻¹, respectively) when compared to other treatments. However, the sole cultivars Shubhra, Magnolia and Calixta; cultivars Cauvery and Shubhra in 1:1 RP and cultivar Cauvery in 1:2 RP remained on par with sole cultivar Cauvery. Cultivar Magnolia in 1:3 RP resulted in significantly lower TDMP (155.72, 144.89 and 150.30 g plant⁻¹, respectively). The TDMP of sugar beet in the rest of treatments was intermediate.

At harvest, sole cultivar Cauvery accounted significantly higher TDMP (230.02, 220.34 and 225.18 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, the sole cultivars Shubhra and Calixta; cultivar Cauvery in 1:1 RP remained on par with former treatment. Significantly lower TDMP was noticed in cultivar Magnolia in 1:3 RP (215.75, 206.07 and 210.91 g plant⁻¹, respectively). The TDMP of sugar beet in the rest of treatments was intermediate.

4.2.2 Yield components and yield of sugar beet

4.2.2.1 Tuber weight (g plant⁻¹)

Significant differences were observed in tuber weight of sugar beet due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 29).

Sole cultivar Cauvery recorded significantly higher tuber weight (1193.00, 1169.14 and 1181.07 g plant⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, the sole cultivars Shubhra, Magnolia and Calixta; cultivar Cauvery in 1:1 RP recorded comparable tuber weight as that of former treatment. Cultivar Magnolia in 1:3 RP resulted in significantly lowest tuber weight (889.00, 871.22 and 880.11 g plant⁻¹, respectively). Tuber weight of sugar beet in the rest of treatments was intermediate.

Irrespective of cultivars, tuber weight decreased with increasing in the row proportion from 1:1 to 1:3. Accordingly, sugar beet in 1:1 RP recorded significantly higher tuber weight than 1:2 and 1:3 RP. The lowest tuber weight was recorded in 1:3 RP.

4.2.2.2 Tuber length (cm)

Tuber length of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 29).

Sole cultivar Cauvery recorded significantly higher tuber length (40.88, 38.43 and 39.65 cm, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, sole cultivars Shubhra, Magnolia and Calixta; cultivars Cauvery, Shubhra and Calixta in 1:1 RP and cultivar Cauvery 1:2 RP remained on par with former treatment. Lowest tuber length was recorded with cultivar Magnolia in 1:3 RP (31.92, 30.00 and 30.96 cm, respectively). Tuber length of sugar beet in the rest of treatments was intermediate.

Among the different row proportions, tuber length of sugar beet gradually decreased with increase in the RP of sugar beet from 1:1 to 1:3. Accordingly, higher tuber length was noticed in sugar beet under 1:1 RP when compared with 1:2 and 1:3 row proportions.

4.2.2.3 Tuber girth (cm)

Tuber girth of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 29).

Sole cultivar Cauvery recorded significantly higher tuber girth (29.89, 28.10 and 28.99 cm, respectively) during 2010-11, 2011-12 and on pooled basis when compared to rest of the treatments. However, sole cultivars shubhra, Magnolia and Calixta; cultivars Cauvery, Shubhra and Calixta in 1:1 RP and cultivar Cauvery 1:2 RP remained on par with sole cultivar Cauvery. Significantly lowest tuber girth was recorded with cultivar Magnolia in 1:3 RP (24.56, 23.09 and 23.82 cm, respectively). Tuber girth of sugar beet in the rest of treatments was intermediate.

Irrespective of sugar beet cultivars, tuber girth of sugar beet gradually decreased with increase in the RP of sugar beet from 1:1 to 1:3. Accordingly, higher tube girth was noticed in sugar beet under 1:1 RP than 1:2 and 1:3 RP.

Table 29: Yield parameters of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Tuber weight (g plant ⁻¹)			Tuber length (cm)			Tuber girth (cm)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	1193.00a	1169.14a	1181.07a	40.88a	38.43a	39.65a	29.89a	28.10a	28.99a
T ₃ - Sole sugar beet cv. Shubhra	1138.00ab	1115.24ab	1126.62ab	39.79ab	37.40ab	38.60ab	29.12ab	27.37ab	28.25ab
T ₄ - Sole sugar beet cv. Magnolia	1094.00a-d	1072.12a-c	1083.06a-d	38.45a-d	36.14a-d	37.30a-d	27.92a-d	26.24a-e	27.08a-e
T ₅ - Sole sugar beet cv. Calixta	1116.00ab	1093.68ab	1104.84ab	39.12a-c	36.77a-c	37.95a-c	28.46a-c	26.75a-c	27.61a-d
T ₆ - SC + SB cv. Cauvery (1:1 RP)	1113.00a-c	1090.74ab	1101.87a-c	38.18a-d	35.89a-d	37.03a-e	28.91ab	27.18ab	28.04a-c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	1041.00b-e	1020.18b-d	1030.59b-e	36.43a-e	34.24a-d	35.34a-g	27.74a-d	26.08a-e	26.91a-e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	1018.00b-f	997.64b-e	1007.82b-f	34.55c-e	32.48d-g	33.51d-g	26.18b-e	24.61c-g	25.39d-g
T ₉ - SC + SB cv. Shubhra (1:1 RP)	1049.00b-e	1028.02b-d	1038.51b-e	37.24a-d	35.01a-e	36.12a-e	28.18a-c	26.49a-d	27.33a-e
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	986.00c-g	966.28c-f	976.14c-g	35.11b-e	33.00c-g	34.06c-g	27.04b-f	25.42b-f	26.23b-g
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	948.00e-g	929.04d-f	938.52e-g	33.68de	31.66e-g	32.67e-g	25.68c-e	24.14e-g	24.91e-g
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	1019.00b-f	998.62b-e	1008.81b-f	35.82b-e	33.67b-g	34.75b-g	26.98b-f	25.36b-g	26.17b-g
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	952.00e-g	932.96d-f	942.48e-g	34.06de	32.02d-g	33.04d-g	25.71c-e	24.17d-g	24.94e-g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	889.00g	871.22f	880.11g	31.92e	30.00g	30.96g	24.56e	23.09g	23.82g
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	1027.00b-f	1006.46b-e	1016.73b-f	36.58a-e	34.39a-f	35.48a-f	27.52a-e	25.87a-e	26.69a-f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	972.00d-g	952.56c-f	962.28d-g	34.51c-e	32.44d-g	33.47d-g	26.27b-e	24.70c-g	25.48c-g
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	912.00fg	893.76ef	902.88fg	32.37e	30.43fg	31.40fg	24.88de	23.39fg	24.13fg
S.Em±	44.44	42.87	43.60	1.66	1.44	1.53	1.06	0.81	0.91
CV (%)	7.48	7.36	7.41	7.94	7.36	7.54	6.77	5.46	5.96

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

Table 30: Green foliage, tuber yield (t ha⁻¹) and harvest index of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Green foliage yield (t ha ⁻¹)			Tuber yield (t ha ⁻¹)			Harvest index		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	8.28a	7.70a	7.99a	88.68a	82.47a	85.58a	0.91a	0.91a	0.91a
T ₃ - Sole sugar beet cv. Shubhra	8.11a	7.54a	7.83a	82.74ab	76.95ab	79.84ab	0.91a	0.91a	0.91a
T ₄ - Sole sugar beet cv. Magnolia	7.96a	7.40a	7.68a	74.67b-d	69.44c	72.06bc	0.90a	0.90a	0.90a
T ₅ - Sole sugar beet cv. Calixta	8.04a	7.48a	7.76a	77.53bc	72.10bc	74.82bc	0.91a	0.91a	0.91a
T ₆ - SC + SB cv. Cauvery (1:1 RP)	3.72c	3.46c	3.59c	39.94g	37.14g	38.54h	0.91a	0.91a	0.91a
T ₇ - SC + SB cv. Cauvery (1:2 RP)	6.23b	5.79b	6.01b	66.54de	61.88de	64.21de	0.91a	0.91a	0.91a
T ₈ - SC + SB cv. Cauvery (1:3 RP)	6.58b	6.12b	6.35b	70.94cd	65.97cd	68.46cd	0.92a	0.92a	0.92a
T ₉ - SC + SB cv. Shubhra (1:1 RP)	3.65c	3.39c	3.52c	37.28g	34.67g	35.98h	0.91a	0.91a	0.91a
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	6.10b	5.67b	5.89b	62.12ef	57.77ef	59.95e-g	0.91a	0.91a	0.91a
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	6.49b	6.04b	6.26b	66.21de	61.58de	63.89d-f	0.91a	0.91a	0.91a
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	3.59c	3.34c	3.46c	33.80g	31.43g	32.62h	0.90a	0.90a	0.90a
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	5.98b	5.56b	5.77b	56.12f	52.19f	54.16g	0.90a	0.90a	0.90a
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	6.38b	5.93b	6.16b	59.81ef	55.62ef	57.72e-g	0.90a	0.90a	0.90a
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	3.62c	3.37c	3.49c	34.92g	32.47g	33.70h	0.91a	0.91a	0.91a
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	6.05b	5.63b	5.84b	58.22ef	54.15f	56.18fg	0.91a	0.91a	0.91a
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	6.44b	5.99b	6.21b	62.13ef	57.78ef	59.96e-g	0.91a	0.91a	0.91a
S.Em±	0.37	0.25	0.30	2.96	2.49	2.70	0.003	0.004	0.003
CV (%)	10.69	7.61	8.88	8.46	5.63	5.31	4.45	5.01	4.87

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 30a: Tuber yield (t ha⁻¹) of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

Cultivars	2010-11					2011-12					Pooled				
	Sole	Row proportions			Mean	Sole	Row proportions			Mean	Sole	Row proportions			Mean
		1:1	1:2	1:3			1:1	1:2	1:3			1:1	1:2	1:3	
Cauvery	88.68	39.94	66.54	70.94	66.53	82.47	37.14	61.88d	65.97	61.86	85.58	38.54	64.21	68.46	64.20
Shubhra	82.74	37.28	62.12	66.21	62.09	76.95	34.67	57.77	61.58	57.74	79.84	35.98	59.95	63.89	59.92
Magnolia	74.67	33.80	56.12	59.81	56.10	69.44	31.43	52.19	55.62	52.17	72.06	32.62	54.16	57.72	54.14
Calixta	77.53	34.92	58.22	62.13	58.20	72.10	32.47	54.15	57.78	54.13	74.82	33.70	56.18	59.96	56.17
Mean	80.90	36.48	60.75	64.77		75.24	33.92	54.70	60.23		78.07	35.21	58.62	62.50	

4.2.2.4 Green foliage yield (t ha^{-1})

Significant differences were noticed in green foliage yield of sugar beet due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 30).

All the sole sugar beet cultivars recorded higher green foliage yield than intercropped sugar beet in both years as well as on pooled basis. The significantly lowest green foliage yield was recorded in cultivar Magnolia in 1:1 RP (3.59, 3.34 and 3.46 t ha^{-1} , respectively).

Among the different row proportions of sugar beet, green foliage yield increased with increase in the RP of sugar beet from 1:1 to 1:3 (irrespective of sugar beet cultivars). Accordingly, higher green foliage yield was noticed in sugar beet under 1:3 RP when compared with 1:2 and 1:1 row proportions.

4.2.2.5 Tuber yield (t ha^{-1})

Tuber yield of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 30).

Sole cultivar Cauvery recorded significantly higher tuber yield (88.68, 82.47 and 85.58 t ha^{-1} , respectively) in both years as well as on pooled basis when compared with rest of the treatments. However, sole cultivar Shubhra recorded comparable tuber yield (82.74, 76.95 and 79.84 t ha^{-1} , respectively) as that of former treatment. Irrespective of sugar beet cultivars tuber yield increased with increase in the RP of sugar beet from 1:1 to 1:3. The higher tuber yield was noticed in sugar beet in 1:3 RP when compared with 1:2 and 1:1 row proportions. Significantly the lowest tuber yield was recorded in cultivar Magnolia under 1:1 RP (33.80, 31.43 and 32.62 t ha^{-1} , respectively).

4.2.2.6 Harvest index

The harvest index of sugar beet did not differ significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 30).

4.2.3 Quality parameters of sugar beet

4.2.3.1 Brix (%)

Brix percentage of sugar beet did not differ significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 31).

4.2.3.2 Sucrose (%)

Sucrose percentage of sugar beet did not differ significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 31).

4.2.3.3 Commercial beet sugar (%)

The commercial beet sugar (%) of sugar beet did not differ significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 32).

4.2.3.4 Sugar yield (t ha^{-1})

Sugar yield of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 32).

Sole cultivar Cauvery recorded significantly higher sugar yield (10.15, 9.38 and 9.76 t ha^{-1} , respectively) in both years as well as on pooled basis when compared with rest of the treatments. However, sole cultivar Shubhra recorded comparable sugar yield (9.35, 8.65 and 9.00 t ha^{-1} , respectively) as that of former treatment. Significantly lowest sugar yield was recorded in cultivar Magnolia in 1:1 RP (3.26, 3.01 and 3.13 t ha^{-1} , respectively).

Among the different row proportions of sugar beet, sugar yield increased with increase in the RP of sugar beet from 1:1 to 1:3 (irrespective of sugar beet cultivars). Significantly higher sugar yield was noticed in sugarcane: sugar beet in 1:3 RP when compared with 1:2 and 1:1 row proportions.

Table 31: Quality parameters of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Brix (%)			Sucrose (%)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	22.83a	22.79a	22.81a	17.68a	17.62a	17.65a
T ₃ - Sole sugar beet cv. Shubhra	22.74a	22.70a	22.72a	17.52a	17.46a	17.49a
T ₄ - Sole sugar beet cv. Magnolia	22.49a	22.45a	22.47a	17.26a	17.20a	17.23a
T ₅ - Sole sugar beet cv. Calixta	22.63a	22.60a	22.62a	17.43a	17.37a	17.40a
T ₆ - SC + SB cv. Cauvery (1:1 RP)	21.24a	21.21a	21.23a	15.87a	15.81a	15.84a
T ₇ - SC + SB cv. Cauvery (1:2 RP)	22.23a	22.20a	22.22a	16.88a	16.82a	16.85a
T ₈ - SC + SB cv. Cauvery (1:3 RP)	22.35a	22.32a	22.34a	17.03a	16.97a	17.00a
T ₉ - SC + SB cv. Shubhra (1:1 RP)	21.12a	21.09a	21.11a	15.68a	15.62a	15.65a
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	21.76a	21.73a	21.75a	16.41a	16.36a	16.38a
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	22.11a	22.08a	22.10a	16.69a	16.64a	16.66a
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	20.75a	20.73a	20.74a	15.32a	15.27a	15.30a
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	21.32a	21.29a	21.30a	16.03a	15.98a	16.00a
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	21.59a	21.56a	21.57a	16.28a	16.23a	16.25a
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	20.93a	20.90a	20.91a	15.49a	15.44a	15.47a
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	21.41a	21.38a	21.39a	16.15a	16.10a	16.12a
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	21.94a	21.90a	21.92a	16.52a	16.47a	16.49a
S.Em±	0.93	0.93	0.93	0.70	0.70	0.70
CV (%)	7.35	7.21	7.08	6.97	7.14	7.28

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 32: Quality parameters of sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatment	Commercial beet sugar (%)			Sugar yield (t ha ⁻¹)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	11.40a	11.35a	11.38a	10.15a	9.38a	9.76a
T ₃ - Sole sugar beet cv. Shubhra	11.27a	11.21a	11.24a	9.35ab	8.65ab	9.00ab
T ₄ - Sole sugar beet cv. Magnolia	11.07a	11.02a	11.05a	8.30bc	7.67b-d	7.98b-d
T ₅ - Sole sugar beet cv. Calixta	11.21a	11.15a	11.18a	8.72bc	8.02bc	8.37bc
T ₆ - SC + SB cv. Cauvery (1:1 RP)	10.02a	9.97a	9.99a	4.01fg	3.70i	3.86h
T ₇ - SC + SB cv. Cauvery (1:2 RP)	10.76a	10.71a	10.73a	7.18c-e	6.62d-f	6.90d-f
T ₈ - SC + SB cv. Cauvery (1:3 RP)	10.88a	10.82a	10.85a	7.74b-d	7.14c-e	7.44c-e
T ₉ - SC + SB cv. Shubhra (1:1 RP)	9.86a	9.81a	9.83a	3.69g	3.40i	3.54h
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	10.42a	10.37a	10.39a	6.49de	5.98f-g	6.24e-g
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	10.60a	10.55a	10.58a	7.04c-e	6.48e-g	6.76d-g
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	9.60a	9.56a	9.58a	3.26g	3.01i	3.13h
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	10.16a	10.11a	10.14a	5.73ef	5.28h	5.50g
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	10.33a	10.29a	10.31a	6.20de	5.74f-h	5.97fg
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	9.72a	9.68a	9.70a	3.40g	3.14i	3.27h
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	10.25a	10.21a	10.23a	6.01de	5.52gh	5.76fg
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	10.48a	10.43a	10.46a	6.53de	6.04f-h	6.29e-g
S.Em±	0.45	0.44	0.44	0.61	0.36	0.46
CV (%)	6.74	7.05	6.98	9.47	10.52	12.86

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane

SB: Sugar beet

RP: Row proportion

4.2.4 Nutrient uptake by sugar beet

4.2.4.1 Nitrogen uptake (kg ha^{-1})

The nitrogen uptake by sugar beet varied significantly due to intercropping of sugar beet cultivars in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 33).

Sole cultivar Cauvery recorded significantly higher nitrogen uptake (182.84, 174.37 and 178.61 kg ha^{-1} , respectively) in both years as well as on pooled basis when compared with rest of the treatments. However, sole cultivars Shubhra, Calixta and Magnolia cultivars found on par with former treatment. Significantly lowest nitrogen uptake was recorded in cultivar Magnolia in 1:1 RP (57.78, 54.99 and 56.38 kg ha^{-1} , respectively).

Among the different row proportions of sugar beet, nitrogen uptake increased with increase in the RP of sugar beet from 1:1 to 1:3 (irrespective of sugar beet cultivars). Significantly higher nitrogen uptake was noticed in 1:3 RP when compared with 1:2 and 1:1 row proportions.

4.2.4.2 Phosphorus uptake (kg ha^{-1})

Significant differences in phosphorus uptake by sugar beet was observed due to intercropping of sugar beet cultivars in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 33).

Significantly higher phosphorus uptake was observed in sole cultivar Cauvery (31.48, 30.13 and 30.80 kg ha^{-1} , respectively) and shubhra (31.18, 29.83 and 30.50 kg ha^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, the sole cultivars Magnolia and Calixta remained on par with former cultivars. Significantly lowest phosphorus uptake was recorded with cultivar Magnolia in 1:1 RP (10.00, 9.55 and 9.78 kg ha^{-1} , respectively).

Irrespective of sugar beet cultivars, phosphorus uptake by sugar beet gradually increased with increase in the RP of sugar beet from 1:1 to 1:3. Accordingly, higher phosphorus uptake was noticed in sugar beet under 1:3 RP than 1:2 and 1:1 RP.

4.2.4.3 Potassium uptake (kg ha^{-1})

The data regarding the potassium uptake of sugar beet was significantly influenced by intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 33).

Sole cultivar Cauvery recorded significantly higher potassium uptake (122.12, 117.13 and 119.62 kg ha^{-1} , respectively) in both years as well as on pooled basis when compared with rest of the treatments. However, sole cultivars Shubhra, Calixta and Magnolia found on par with former treatment. The significantly lowest potassium uptake was recorded in cultivar Magnolia in 1:1 RP (38.92, 37.27 and 38.09 kg ha^{-1} , respectively).

Among the different row proportions of sugar beet, potassium uptake increased with increase in the RP of sugar beet from 1:1 to 1:3 (irrespective of sugar beet cultivars). Significantly higher potassium uptake was noticed in 1:3 RP when compared with 1:2 and 1:1 row proportions.

4.2.5 Correlation studies (Table 34)

Sugar beet tuber yield showed significant and positive correlation with yield components such as tuber weight ($r=0.99$), tuber length ($r=0.99$) and tuber girth ($r=0.99$). Similarly, growth parameters like LAI ($r=0.97$), LAD ($r=0.99$), TDMP ($r=0.99$) and its accumulation in tuber ($r=0.99$) and leaves (green foliage) ($r=0.99$) were positively and significantly correlated with tuber yield.

4.3 Production efficiency indices of intercropping system

4.3.1 Sugarcane equivalent yield (t ha^{-1})

Intercropping of sugarcane and sugar beet cultivars in different row proportions had significant influence on sugarcane equivalent yield during 2010-11, 2011-12 and on pooled basis (Table 35). Among the different treatments, sugarcane (SC) + sugar beet (SB) (irrespective of cultivars) in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield (except cultivar Magnolia in 1:3 RP) when compared to SC + SB in 1:1 RP during 2010-11, 2011-12 and on pooled basis. Sole sugarcane and sugar beet recorded significantly lower sugarcane equivalent yield.

Table 33: Nutrient uptake (kg ha⁻¹) by sugar beet cultivars as influenced by row proportions of sugar beet in intercropping with sugarcane

Treatments	Nutrient uptake (kg ha ⁻¹)								
	Nitrogen			Phosphorous			Potassium		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T ₁ - Sole sugarcane (SC)	-	-	-	-	-	-	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	182.84a	174.37a	178.61a	31.48a	30.13a	30.80a	122.12a	117.13a	119.62a
T ₃ - Sole sugar beet cv. Shubhra	180.87ab	172.40a	176.64a	31.18a	29.83a	30.50a	121.04ab	116.05ab	118.55ab
T ₄ - Sole sugar beet cv. Magnolia	177.70a-c	169.23a-c	173.46a-c	30.70a-c	29.35ab	30.02ab	119.33a-c	114.34a-c	116.84a-c
T ₅ - Sole sugar beet cv. Calixta	179.13ab	170.66ab	174.89ab	30.91ab	29.56ab	30.24ab	120.10a-c	115.11ab	117.60a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	59.47f	56.68f	58.08f	10.26f	9.81e	10.03e	39.83f	38.19f	39.01f
T ₇ - SC + SB cv. Cauvery (1:2 RP)	117.00e	111.42e	114.21e	20.11e	19.23d	19.67d	78.44e	75.16e	76.80e
T ₈ - SC + SB cv. Cauvery (1:3 RP)	174.29b-d	165.85b-d	170.07b-d	29.89b-d	28.56bc	29.23bc	117.03b-d	112.08b-d	114.56b-d
T ₉ - SC + SB cv. Shubhra (1:1 RP)	58.80f	56.00f	57.40f	10.15f	9.71e	9.93e	39.46f	37.82f	38.64f
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	115.68e	110.10e	112.89e	19.91e	19.03d	19.47d	77.71e	74.43e	76.07e
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	172.37cd	163.93cd	168.15cd	29.60cd	28.27c	28.93c	115.99cd	111.03cd	113.51cd
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	57.78f	54.99f	56.38f	10.00f	9.55e	9.78e	38.92f	37.27f	38.09f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	113.65e	108.07e	110.86e	19.61e	18.72d	19.16d	76.62e	73.34e	74.98e
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	169.14d	160.70d	164.92d	29.11d	27.78c	28.45c	114.24d	109.28d	111.76d
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	58.19f	55.40f	56.79f	10.06f	9.62e	9.84e	39.13f	37.49f	38.31f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	114.54e	108.96e	111.75e	19.74e	18.86d	19.30d	77.10e	73.82e	75.46e
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	170.49d	162.05d	166.27d	29.32d	27.98c	28.65c	114.98d	110.02d	112.50d
S.Em±	2.30	2.24	2.27	0.38	0.37	0.37	1.44	1.40	1.42
CV (%)	7.04	6.58	7.35	6.90	6.84	7.19	7.34	6.57	6.95

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 34: Correlation of tuber yield (t ha⁻¹) with yield and growth parameters of sugar beet

SI. No	Parameters	'r' value*
I	Yield characters	
1.	Tuber weight	r = 0.99
2.	Tuber length	r = 0.99
3.	Tuber girth	r = 0.99
II	Growth characters	
1.	LAI	r = 0.97
2.	LAD	r = 0.99
3.	Total dry matter production	r = 0.99
4.	Dry matter accumulation in tuber	r = 0.99
5.	Dry matter accumulation in leaves	r = 0.99

Note: * Indicates significance level at 5 %

Table 35: Yield advantages of sugarcane and sugar beet intercropping system

Treatment	Sugarcane equivalent yield (t ha ⁻¹)			Land equivalent ratio			Area time equivalent ratio			System productivity index		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	103.56e	99.21e	101.39d	1.00c	1.00c	1.00c	1.00b	1.00b	1.00b	-	-	-
T ₂ - Sole sugar beet cv. Cauvery	48.37f	49.48f	48.93e	1.00c	1.00c	1.00c	1.00b	1.00b	1.00b	-	-	-
T ₃ - Sole sugar beet cv. Shubhra	45.13f	46.17f	45.65e	1.00c	1.00c	1.00c	1.00b	1.00b	1.00b	-	-	-
T ₄ - Sole sugar beet cv. Magnolia	40.73f	41.67f	41.20e	1.00c	1.00c	1.00c	1.00b	1.00b	1.00b	-	--	-
T ₅ - Sole sugar beet cv. Calixta	42.29f	43.26f	42.78e	1.00c	1.00c	1.00c	1.00b	1.00b	1.00b	-	-	-
T ₆ - SC + SB cv. Cauvery (1:1 RP)	120.63b-d	116.27b-d	118.45bc	1.41b	1.40b	1.41b	1.00b	1.00b	1.00b	162.56d	158.04d	160.30e
T ₇ - SC + SB cv. Cauvery (1:2 RP)	129.73a	126.32a	128.03a	1.66a	1.66a	1.66a	1.09a	1.08a	1.08a	187.60a-d	182.18a-c	184.89a-c
T ₈ - SC + SB cv. Cauvery (1:3 RP)	126.40a-c	124.24ab	125.32ab	1.65a	1.66a	1.66a	1.06a	1.07a	1.06a	186.20a-d	181.58a-c	183.89a-c
T ₉ - SC + SB cv. Shubhra (1:1 RP)	118.22b-d	114.58d	116.40c	1.40b	1.40b	1.40b	1.00b	0.99b	1.00b	169.41cd	165.62cd	167.52de
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	127.13ab	123.81a-c	125.47ab	1.66a	1.66a	1.66a	1.09a	1.08a	1.08a	194.88ab	189.91ab	192.40a-c
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	124.56a-d	122.84a-d	123.70a-c	1.66a	1.67a	1.67a	1.07a	1.08a	1.07a	193.92a-c	190.71ab	192.32a-c
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	117.82cd	114.78cd	116.30c	1.41b	1.42b	1.42b	1.00b	1.01b	1.01b	186.56a-d	183.57a-c	185.06a-d
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	124.27a-d	120.58a-d	122.43a-c	1.66a	1.65a	1.66a	1.08a	1.08a	1.08a	210.06a	203.79a	206.93a
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	120.47b-d	118.01bc	119.24bc	1.65a	1.66a	1.66a	1.06a	1.06a	1.06a	206.51a	201.91a	204.21a
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	117.26d	114.78cd	116.02c	1.40b	1.41b	1.41b	1.00b	1.00b	1.00b	177.82b-d	177.05b-d	177.44c-e
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	124.87a-d	121.83a-d	123.35a-c	1.66a	1.66a	1.66a	1.08a	1.08a	1.08a	202.15ab	198.26ab	200.21ab
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	120.84a-d	118.02a-d	119.43a-c	1.65a	1.65a	1.65a	1.05a	1.05a	1.05a	199.14ab	194.72ab	196.93a-c
S.Em±	3.12	3.18	3.00	0.05	0.04	0.03	0.03	0.03	0.03	8.82	7.85	7.41
CV (%)	6.25	5.47	7.10	5.86	4.52	4.29	4.90	4.67	4.45	11.41	10.38	9.69

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

4.3.2 Land equivalent ratio (LER)

Land equivalent ratio (LER) differed significantly due to sugar cane + sugar beet intercropping at different row ratio during 2010-11, 2011-12 and on pooled basis (Table 35). All the intercropping treatments recorded higher LER over sole cropping of either sugarcane or sugar beet. Among the intercropping system, irrespective of sugar beet cultivars SC + SB in 1:2 and 1:3 RP recorded significantly higher LER when compared to SC + SB in 1:1 row proportion.

4.3.3 Area time equivalent ratio (ATER)

Similar to land equivalent ratio area time equivalent ratio (ATER) also differed significantly due to intercropping of sugar beet cultivars in different row proportions with sugarcane on pooled basis (Table 35). All the intercropping systems recorded higher ATER over sole cropping of either sugarcane or sugar beet except SC + SB (Cauvery/Shubra) in 1:1 RP. Irrespective of sugar beet cultivars, intercropping of SC + SB in 1:2 and 1:3 RP recorded significantly higher area time equivalent ratio when compared to sugarcane + sugar beet in 1:1 RP.

4.3.4 System productivity index (SPI)

System productivity index (SPI) differed significantly due to intercropping of sugar beet cultivars with sugarcane at different row proportions during 2010-11, 2011-12 and on pooled basis (Table 35). Among the cropping system, irrespective of sugar beet cultivars, SC + SB in 1:2 and 1:3 RP recorded significantly higher SPI in 2010-11, 2011-12 and on pooled basis when compared with SC + SB in 1:1 RP. The latter treatments recorded lowest SPI.

4.3.5 Total sugar yield of intercropping system ($t\ ha^{-1}$)

Intercropping of sugar beet cultivars in different row proportions with sugarcane had significant influence on total sugar yield during 2010-11, 2011-12 and on pooled basis (Table 36). Irrespective of sugar beet cultivars, SC + SB in 1:2 and 1:3 RP recorded significantly higher total sugar yield when compared to 1:1 RP during 2010-11, 2011-12 and on pooled basis. Significantly lower total sugar yield was noticed in sole sugarcane and sugar beet cultivars.

4.4 Economics

4.4.1 Gross returns ($Rs.\ ha^{-1}$)

Significant differences were recorded in gross returns due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 37). Irrespective of sugar beet cultivars, SC + SB in 1:2 and 1:3 RP recorded significantly higher gross returns (except sugarcane + cv. Magnolia in 1:3 RP) when compared to SC + SB in 1:1 RP during 2010-11, 2011-12 and on pooled basis. Significantly lower gross returns were recorded in all the sole sugar beet cultivars.

4.4.2 Net returns ($Rs.\ ha^{-1}$)

Net returns differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 37). During 2010-11, sugarcane + Cauvery in 1:2 RP recorded significantly higher net returns ($Rs.\ 199087\ ha^{-1}$) when compared to sole crops. However, rest of the intercropping system treatments were found on par with former treatment, except sugarcane + cv. Calixta in 1:1 and 1:3 RP and cultivar Magnolia in 1:3 RP. Significantly lower net returns were noticed with sole sugar beet cultivars.

During 2011-12 and on pooled basis, sugarcane + Cauvery in 1:2 RP recorded significantly higher net returns ($Rs.\ 218446$ and $208766\ ha^{-1}$, respectively) when compared to sole crops. However, rest of the intercropping treatments recorded on par net returns as that of former treatment, except SC + SB (Calixta and Magnolia) in 1:3 RP and sole crops. Significantly lower net returns were noticed in sole sugar beet cultivars. In general highest net return is realised by SC + SB (Cauvery) in 1:2 RP.

4.4.3 B:C ratio

Significant differences were observed due to sugar cane + sugar beet intercropping across the various genotype of sugar beet in different row ratios during 2010-11, 2011-12 and on pooled basis (Table 37). Irrespective of sugar beet cultivars, SC + SB in 1:1 and 1:2 RP recorded significantly

Table 36: Total sugar yield of sugarcane and sugar beet intercropping system

Treatment	Sugar yield of sugarcane (t ha ⁻¹)			Sugar yield of sugar beet (t ha ⁻¹)			Total sugar yield (t ha ⁻¹)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	11.40a	10.73a	11.07a	-	-	-	11.40e	10.73e	11.07e
T ₂ - Sole sugar beet cv. Cauvery	-	-	-	10.15a	9.38a	9.76a	10.15ef	9.38ef	9.76ef
T ₃ - Sole sugar beet cv. Shubhra	-	-	-	9.35ab	8.65ab	9.00ab	9.35f	8.65fg	9.00fg
T ₄ - Sole sugar beet cv. Magnolia	-	-	-	8.30bc	7.67b-d	7.98b-d	8.30f	7.67g	7.98g
T ₅ - Sole sugar beet cv. Calixta	-	-	-	8.72bc	8.02bc	8.37bc	8.72f	8.02fg	8.37fg
T ₆ - SC + SB cv. Cauvery (1:1 RP)	10.83ab	10.18ab	10.50ab	4.01fg	3.70i	3.86h	14.84b-d	13.89b-d	14.36b-d
T ₇ - SC + SB cv. Cauvery (1:2 RP)	10.29ab	9.65ab	9.97ab	7.18c-e	6.62d-f	6.90d-f	17.47a	16.28a	16.87a
T ₈ - SC + SB cv. Cauvery (1:3 RP)	9.66b	9.14ab	9.40b	7.74b-d	7.14c-e	7.44c-e	17.40a	16.28a	16.84a
T ₉ - SC + SB cv. Shubhra (1:1 RP)	10.77ab	10.14ab	10.46ab	3.69g	3.40i	3.54h	14.46cd	13.54cd	14.00b-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	10.29ab	9.66ab	9.97ab	6.49de	5.98f-g	6.24e-g	16.78ab	15.64a	16.21a
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	9.74ab	9.31ab	9.53ab	7.04c-e	6.48e-g	6.76d-g	16.79ab	15.79a	16.29a
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	10.96ab	10.40ab	10.68ab	3.26g	3.01i	3.13h	14.22d	13.41d	13.81d
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	10.36ab	9.69ab	10.02ab	5.73ef	5.28h	5.50g	16.08a-d	14.97a-d	15.52a-d
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	9.63b	9.12ab	9.37b	6.20de	5.74f-h	5.97fg	15.83a-d	14.85a-d	15.34a-d
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	10.82ab	10.32ab	10.57ab	3.40g	3.14i	3.27h	14.22d	13.46cd	13.84cd
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	10.27ab	9.67ab	9.97ab	6.01de	5.52gh	5.76fg	16.28a-c	15.19ab	15.73ab
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	9.57b	9.01b	9.29b	6.53de	6.04f-h	6.29e-g	16.10a-d	15.05a-c	15.58a-c
S.Em±	0.49	0.48	0.48	0.61	0.36	0.46	0.70	0.56	0.61
CV (%)	8.24	8.44	8.31	9.47	10.52	12.86	9.49	10.34	9.87

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 37: Economics of sugarcane and sugar beet intercropping system

Treatment	Gross returns (Rs. ha ⁻¹)			Net returns (Rs. ha ⁻¹)			B:C ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	227832e	248026e	237929d	152171c	166109c	159140c	3.01de	3.03a-c	3.02c-e
T ₂ - Sole sugar beet cv. Cauvery	106416f	123709f	115062e	63585d	76814d	70199d	2.48f	2.64de	2.56f
T ₃ - Sole sugar beet cv. Shubhra	99288f	115422f	107355e	56457d	68527d	62492d	2.32fg	2.46ef	2.39fg
T ₄ - Sole sugar beet cv. Magnolia	89604f	104165f	96884e	46773d	57270d	52021d	2.09g	2.22f	2.16g
T ₅ - Sole sugar beet cv. Calixta	93036f	108154f	100595e	50205d	61259d	55732d	2.17g	2.31f	2.24g
T ₆ - SC + SB cv. Cauvery (1:1 RP)	265394b-d	290675b-d	278034bc	185621ab	201495ab	193558ab	3.33a	3.26a	3.29a
T ₇ - SC + SB cv. Cauvery (1:2 RP)	285404a	315802a	300603a	199087a	218446a	208766a	3.31ab	3.24ab	3.28ab
T ₈ - SC + SB cv. Cauvery (1:3 RP)	278083a-c	310607ab	294345ab	187457ab	207339ab	197398ab	3.07b-e	3.01a-c	3.04b-e
T ₉ - SC + SB cv. Shubhra (1:1 RP)	260094b-d	286452d	273273c	180613ab	197618ab	189116ab	3.27a-c	3.22ab	3.25a-d
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	279694ab	309527a-c	294611ab	193863ab	212747ab	203305ab	3.26a-d	3.20ab	3.23a-d
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	274041a-d	307089a-d	290565a-c	183936ab	204436ab	194186ab	3.04c-e	2.99bc	3.02de
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	259196cd	286956cd	273076c	180098ab	198575ab	189337ab	3.28a-c	3.25ab	3.26a-c
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	273404a-d	301455a-d	287430a-c	188233ab	205456ab	196845ab	3.21a-e	3.14a-c	3.18a-e
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	265042b-d	295036b-d	280039bc	175641b	193217b	184429b	2.96e	2.90cd	2.93e
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	257963d	286954cd	272459c	178742b	198428ab	188585ab	3.26a-d	3.24ab	3.25a-d
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	274722a-d	304574a-d	289648a-c	189319ab	208302ab	198810ab	3.22a-d	3.16ab	3.19a-d
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	265853a-d	295043a-d	280448a-c	176197b	192922b	184559b	2.97e	2.89cd	2.93e
S.Em±	6869	7962	7066	6869	7962	7066	0.09	0.09	0.08
CV (%)	5.25	5.47	5.11	7.81	8.17	7.63	5.23	5.30	4.95

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Market price : **2010-11** **2011-12**
 Sugarcane : Rs. 2200 tonne⁻¹ Rs.2500 tonne⁻¹
 Sugar beet : Rs. 1200 tonne⁻¹ Rs.1500 tonne⁻¹

higher B:C ratio when compared to 1:3 RP during 2010-11, 2011-12 and on pooled basis. Significantly lower B:C ratio was recorded in sole sugarcane and sugar beet.

4.5 Total uptake of nutrients by intercropping system

4.5.1 Total nitrogen uptake (kg ha^{-1})

The total uptake of nitrogen (by sugarcane and sugar beet) at harvest differed significantly due to intercropping of different row proportions of sugar beet cultivars with sugarcane during 2010-11, 2011-12 and on pooled basis (Table 38). Irrespective of cultivars, SC + SB in 1:3 RP accounted for significantly higher total nitrogen uptake followed by 1:2 and 1:1 RP during 2010-11, 2011-12 and on pooled basis. Significantly lower total nitrogen uptake was noticed in sole sugarcane and sugar beet.

4.5.2 Total phosphorus uptake (kg ha^{-1})

Total uptake of phosphorus (by sugarcane and sugar beet) at harvest was significantly influenced by intercropping of sugar beet cultivars in different row proportions with sugarcane during 2010-11, 2011-12 and on pooled basis (Table 38). Significantly higher total uptake of phosphorus was recorded with SC + SB (irrespective of cultivars) in 1:3 RP when compared to other row proportions (1:2 and 1:1). While, significantly lower total uptake of phosphorus was recorded in sole sugarcane in both years and on pooled basis (10.71, 10.35 and 10.53 kg ha^{-1} , respectively). Total uptake of phosphorus in the rest of the treatments was intermediate.

4.5.3 Total potassium uptake (kg ha^{-1})

The total uptake of potassium (by sugarcane and sugar beet) at harvest differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 38). Among the different treatments, SC + SB (irrespective of cultivars) in 1:3 RP accounted for significantly higher total potassium uptake followed by 1:2 and 1:1 RP. Significantly lower total potassium uptake was noticed in sole sugar beet cultivars.

4.6 Available nutrients status (kg ha^{-1}) in soil after the harvest of crops

4.6.1 Available nitrogen (kg ha^{-1})

The data regarding the available nitrogen status of the soil after the harvest of sugarcane and sugar beet was significantly influenced by intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 39). Sole sugarcane and sole sugar beet cultivars (Magnolia and Calixta) recorded significantly higher available nitrogen when compared to other treatments during 2010-11, 2011-12 and on pooled basis. However, sole cultivars Cauvery and Shubhra; sugarcane + cv. Magnolia and cv. Calixta in 1:1 RP and sugarcane + cv. Magnolia in 1:2 RP remained on par with former treatments. Significantly lower available nitrogen was noticed in sugarcane + cv. Cauvery in 1:3 RP (244, 247 and 245 kg ha^{-1} , respectively). Available nitrogen in the rest of the treatments was intermediate.

4.6.2 Available phosphorus ($\text{kg P}_2\text{O}_5 \text{ ha}^{-1}$)

The data on available phosphorous status of the soil after the harvest of sugarcane and sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 39). Sole sugarcane recorded significantly higher available phosphorous (42, 43 and 43 kg ha^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, SC + SB (Magnolia and Calixta) in 1:3 RP remained on par with former treatment. While, significantly lower available phosphorous was noticed in sugarcane + sugar beet (Cauvery) in 1:1 RP (32, 33 and 32 kg ha^{-1} , respectively). Available phosphorous in the rest of the treatments was intermediate.

4.6.3 Available potassium ($\text{kg K}_2\text{O ha}^{-1}$)

Available potassium status of the soil after the harvest of sugarcane and sugar beet varied significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 39). Sole Magnolia recorded significantly higher available potassium (366, 370 and 368 kg ha^{-1} , respectively) during 2010-11, 2011-12 and on pooled basis when compared to other treatments. However, sole sugarcane, sole Cauvery, Shubhra and Calixta; sugarcane + Magnolia and Calixta in 1:1 RP and sugarcane + cv. Magnolia in 1:2 RP

Table 38: Nutrient uptake (kg ha⁻¹) by sugarcane and sugar beet in intercropping system

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorous (kg P ₂ O ₅ ha ⁻¹)			Potassium (kg K ₂ O ha ⁻¹)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	174.00e	168.17d	171.09e	10.71e	10.35f	10.53f	176.68d	170.76d	173.72d
T ₂ - Sole sugar beet cv. Cauvery	182.84d	174.37d	178.61d	31.48b	30.13b	30.80b	122.12e	117.13e	119.62e
T ₃ - Sole sugar beet cv. Shubhra	180.87de	172.40d	176.64de	31.18b	29.83b	30.50b	121.04e	116.05e	118.55e
T ₄ - Sole sugar beet cv. Magnolia	177.70de	169.23d	173.46de	30.70b	29.35bc	30.02bc	119.33e	114.34e	116.84e
T ₅ - Sole sugar beet cv. Calixta	179.13de	170.66d	174.89de	30.91b	29.56b	30.24b	120.10e	115.11e	117.60e
T ₆ - SC + SB cv. Cauvery (1:1 RP)	228.25c	219.73c	223.99c	20.75d	19.95e	20.35e	211.23c	203.77c	207.50c
T ₇ - SC + SB cv. Cauvery (1:2 RP)	282.02b	270.49b	276.26b	29.62c	28.39cd	29.00cd	246.05b	236.73b	241.39b
T ₈ - SC + SB cv. Cauvery (1:3 RP)	334.22a	321.05a	327.63a	38.40a	36.81a	37.61a	278.66a	268.92a	273.79a
T ₉ - SC + SB cv. Shubhra (1:1 RP)	227.31c	219.52c	223.42c	20.63d	19.88e	20.25e	210.60c	203.87c	207.24c
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	280.42b	269.38b	274.90b	29.40c	28.20d	28.80d	245.04b	236.22b	240.63b
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	332.72a	319.37a	326.04a	38.13a	36.54a	37.33a	278.04a	268.12a	273.08a
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	227.06c	219.00c	223.03c	20.53d	19.75e	20.14e	210.82c	203.83c	207.33c
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	278.27b	267.52b	272.89b	29.09c	27.90d	28.50d	243.83b	235.29b	239.56b
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	329.64a	315.61a	322.62a	37.65a	36.02a	36.84a	276.44a	265.84a	271.14a
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	227.43c	219.38c	223.40c	20.58d	19.81e	20.20e	211.00c	204.02c	207.51c
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	279.38b	268.58b	273.98b	29.24c	28.05d	28.64d	244.52b	235.94b	240.23b
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	330.53a	316.84a	323.68a	37.83a	36.22a	37.03a	276.72a	266.46a	271.59a
S.Em±	2.64	2.58	2.61	0.37	0.36	0.36	2.08	2.05	2.06
CV (%)	5.83	6.12	5.81	6.23	6.47	5.89	5.70	6.24	6.09

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

Table 39: Available nutrients status (kg ha⁻¹) in soil after the harvest of crops in sugarcane and sugar beet intercropping system

Treatment	Available nitrogen (kg ha ⁻¹)			Available phosphorous (kg P ₂ O ₅ ha ⁻¹)			Available potassium (kg K ₂ O ha ⁻¹)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T ₁ - Sole sugarcane (SC)	289a	292a	290a	42a	43a	43a	364ab	368ab	366ab
T ₂ - Sole sugar beet cv. Cauvery	282a-c	285a-c	283a-c	34e-h	35c-f	35e-g	357a-e	361a-e	359a-e
T ₃ - Sole sugar beet cv. Shubhra	285ab	288ab	286ab	36d-g	37c-f	36d-g	360a-d	364a-d	3620a-d
T ₄ - Sole sugar beet cv. Magnolia	291a	294a	292a	37c-e	39b-d	38c-e	366a	370a	368a
T ₅ - Sole sugar beet cv. Calixta	288a	291a	289a	37c-f	38b-e	37c-f	363a-c	367a-c	365a-c
T ₆ - SC + SB cv. Cauvery (1:1 RP)	254cd	258cd	256cd	32h	33f	32g	324ef	329d-f	326d-f
T ₇ - SC + SB cv. Cauvery (1:2 RP)	250d	253d	252d	34e-h	35d-f	34e-g	320f	324f	322f
T ₈ - SC + SB cv. Cauvery (1:3 RP)	244d	247d	245d	37c-f	38b-e	37c-f	313f	318f	316f
T ₉ - SC + SB cv. Shubhra (1:1 RP)	259b-d	263b-d	261b-d	32gh	33f	33g	329b-f	334b-f	331b-f
T ₁₀ - SC + SB cv. Shubhra (1:2 RP)	254cd	257cd	256cd	35d-h	36c-f	35d-g	324ef	328ef	326ef
T ₁₁ - SC + SB cv. Shubhra (1:3 RP)	248d	251d	250d	37c-f	38b-e	38c-f	318f	322f	320f
T ₁₂ - SC + SB cv. Magnolia (1:1 RP)	270a-d	273a-d	272a-d	36d-g	37c-f	36d-g	340a-f	344a-f	342a-f
T ₁₃ - SC + SB cv. Magnolia (1:2 RP)	263a-d	266a-d	265a-d	38b-d	39bc	39b-d	333a-f	337a-f	335a-f
T ₁₄ - SC + SB cv. Magnolia (1:3 RP)	257b-d	260b-d	259b-d	42ab	43ab	42ab	327d-f	331d-f	329d-f
T ₁₅ - SC + SB cv. Calixta (1:1 RP)	263a-d	266a-d	265a-d	33f-h	34ef	340fg	333a-f	337a-f	335a-f
T ₁₆ - SC + SB cv. Calixta (1:2 RP)	258b-d	261b-d	260b-d	37c-f	38b-e	37c-f	328c-f	332c-f	330c-f
T ₁₇ - SC + SB cv. Calixta (1:3 RP)	253d	256d	255d	40a-c	41ab	41a-c	323ef	327ef	325ef
S.Em±	9.70	9.82	9.76	1.35	1.39	1.37	12.30	12.47	12.38
CV (%)	6.33	6.57	5.89	5.89	6.18	6.57	5.47	6.33	5.89

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: SC: Sugarcane SB: Sugar beet RP: Row proportion

remained on par with former treatment. Significantly lower available potassium was noticed in sugarcane + cv. Cauvery in 1:3 RP (313, 318 and 316 kg ha⁻¹, respectively). Available potassium in the rest of the treatments was intermediate.

Experiment–II: Performance of sugar beet to sources of nitrogen and liquid manures

4.7 Growth components of sugar beet

4.7.1 Plant height (cm)

The data on plant height as influenced by sources of nitrogen, liquid manures and their interactions at various growth stages (30, 60, 90, 120 DAS and at harvest) of sugar beet during 2010-11, 2011-12 and on pooled basis are presented in Table 40.

At 30DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher plant height (25.53, 23.00 and 24.27 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par plant height (24.39, 21.97 and 23.18 cm, respectively) as that of SN₁. While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) (SN₅) recorded significantly lower plant height 20.82, 18.76 and 19.79 cm, respectively.

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher plant height when compared to control (LM₅) in both years and on pooled basis. The lowest plant height was recorded in treatment LM₅ (19.24, 17.33 and 18.28 cm, respectively).

The plant height of sugar beet differed significantly due to interaction of sources of nitrogen (SN) and liquid manures (LM). Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher plant height in both years and on pooled basis (27.59, 24.86 and 26.23 cm, respectively). Significantly lower plant height was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (18.26, 16.45 and 17.35 cm, respectively).

At 60DAS, SN₁ treatment which received 100 per cent RDN through inorganic fertilizer recorded significantly higher plant height (48.28, 45.12 and 46.70 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₂ and SN₃ were however found on par with SN₁. Significantly lower plant height was recorded in SN₅ (43.37, 40.96 and 42.17 cm, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher plant height when compared to control (LM₅) in both years and on pooled basis. The lowest plant height was recorded in treatment LM₅ (41.95, 39.63 and 40.79 cm, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher plant height in both years and on pooled basis (50.13, 46.85 and 48.49 cm, respectively). Significantly lower plant height was recorded in SN₅LM₅ (38.96, 38.55 and 38.75 cm, respectively).

At 90DAS, significantly higher plant height was recorded with treatments SN₁ (54.23, 52.65 and 53.44cm, respectively) and SN₂ (53.53, 51.97 and 52.75 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₃ and SN₄ were however found on par with SN₁ and SN₂. Significantly lower plant height was recorded in SN₅ (50.03, 48.69 and 49.36 cm, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher plant height when compared to control (LM₅) in both years and on pooled basis. The lowest plant height was recorded in treatment LM₅ (49.09, 47.78 and 48.44 cm, respectively).

Among the treatment combinations, significantly higher plant height was recorded with SN₁LM₄ in both years and on pooled basis (55.84, 54.21 and 55.02 cm, respectively). However, rest of the treatments were found on par with SN₁LM₄ except SN₃LM₅ and SN₄LM₅. The treatment combination (SN₅LM₅) recorded significantly lower plant height (48.07, 47.26 and 47.67 cm, respectively).

Table 40: Plant height (cm) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Plant height (cm)								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	25.53a	23.00a	24.27a	48.28a	45.12a	46.70a	54.23a	52.65a	53.44a
SN ₂	24.39ab	21.97ab	23.18ab	47.29a	44.20ab	45.74ab	53.53a	51.97a	52.75a
SN ₃	23.48bc	21.16bc	22.32bc	46.23a-c	43.20a-c	44.71a-c	52.50ab	50.97ab	51.73ab
SN ₄	22.46cd	20.23cd	21.35c	45.04bc	42.09bc	43.56bc	51.40ab	49.91ab	50.65ab
SN ₅	20.82d	18.76d	19.79d	43.37c	40.96c	42.17c	50.03b	48.69b	49.36b
S.Em±	0.55	0.48	0.34	0.98	0.81	0.88	0.86	0.81	0.82
CV (%)	9.13	8.93	8.35	8.25	7.31	7.64	6.33	6.17	6.14
Liquid manures (LM)									
LM ₁	24.50a	22.07a	23.29a	47.18a	44.09a	45.64a	53.36a	51.80a	52.58a
LM ₂	24.17a	21.77a	22.97a	46.90a	43.83a	45.37a	53.07a	51.52a	52.29a
LM ₃	23.88a	21.51a	22.69a	46.59a	43.54a	45.06a	52.74a	51.20a	51.97a
LM ₄	24.90a	22.44a	23.67a	47.59a	44.48a	46.03a	53.44a	51.88a	52.66a
LM ₅	19.24b	17.33b	18.28b	41.95b	39.63b	40.79b	49.09b	47.78b	48.44b
S.Em±	0.42	0.38	0.28	0.97	0.88	0.85	0.94	0.93	0.90
CV (%)	6.98	6.95	6.71	8.17	7.86	7.36	6.96	7.11	6.77
Interactions (SN x LM)									
SN ₁ LM ₁	26.95ab	24.28ab	25.62ab	49.50ab	46.26ab	47.88ab	55.59ab	53.97ab	54.78ab
SN ₁ LM ₂	26.61a-c	23.97a-c	25.29a-c	49.23a-c	46.01ab	47.62a-c	55.24a-c	53.63a-c	54.43a-c
SN ₁ LM ₃	26.28a-d	23.68a-d	24.98a-d	49.06a-c	45.85a-c	47.45a-c	54.83a-c	53.23a-c	54.03a-c
SN ₁ LM ₄	27.59a	24.86a	26.23a	50.13a	46.85a	48.49a	55.84a	54.21a	55.02a
SN ₁ LM ₅	20.21j-l	18.21j-l	19.21-p	43.49a-d	40.64a-d	42.07a-e	49.66a-d	48.21a-c	48.93a-d
SN ₂ LM ₁	25.60a-e	23.06a-e	24.33a-f	48.49a-c	45.32a-d	46.91a-d	54.60a-c	53.01a-c	53.81a-c
SN ₂ LM ₂	25.41a-e	22.89a-e	24.15b-f	48.21a-c	45.06a-d	46.64a-d	54.45a-d	52.86a-c	53.65a-d
SN ₂ LM ₃	25.23a-f	22.73a-f	23.98b-g	47.91a-c	44.78a-d	46.35a-d	54.17a-d	52.59a-c	53.38a-d
SN ₂ LM ₄	25.91a-e	23.34a-e	24.62a-e	48.86a-c	45.66a-c	47.26a-c	54.92a-c	53.32a-c	54.12a-c
SN ₂ LM ₅	19.81kl	17.85kl	18.83m-p	42.97a-d	40.16a-d	41.57a-c	49.53a-d	48.09a-c	48.81a-d
SN ₃ LM ₁	24.63a-g	22.19a-g	23.41c-h	47.30a-c	44.21a-d	45.76a-d	53.41a-d	51.85a-c	52.63a-d
SN ₃ LM ₂	24.42a-g	22.00b-g	23.21c-h	47.05a-c	43.97a-d	45.51a-d	53.20a-d	51.65a-c	52.42a-d
SN ₃ LM ₃	24.26b-h	21.86b-h	23.06d-h	46.68a-c	43.63a-d	45.16a-e	52.86a-d	51.32a-c	52.09a-d
SN ₃ LM ₄	24.92a-g	22.45a-g	23.68b-h	47.64a-c	44.52a-d	46.08a-d	53.83a-d	52.26a-c	53.04a-d
SN ₃ LM ₅	19.18kl	17.28kl	18.23n-p	42.46b-c	39.68b-d	41.07b-c	49.20b-d	47.77b-c	48.49b-d
SN ₄ LM ₁	23.54c-i	21.21c-i	22.38fj	45.99a-d	42.98a-d	44.48a-e	52.29a-d	50.77a-c	51.53a-d
SN ₄ LM ₂	23.19d-j	20.89d-j	22.04gk	45.66a-d	42.67a-d	44.16a-e	51.77a-d	50.26a-c	51.01a-d
SN ₄ LM ₃	22.90e-j	20.63e-j	21.76h-k	45.35a-d	42.38a-d	43.86a-e	51.39a-d	49.89a-c	50.64a-d
SN ₄ LM ₄	23.95b-h	21.58b-h	22.77e-i	46.32a-d	43.29a-d	44.81a-e	52.56a-d	51.03a-c	51.80a-d
SN ₄ LM ₅	18.71l	16.86l	17.79op	41.87cd	39.13cd	40.50de	49.01cd	47.58bc	48.29cd
SN ₅ LM ₁	21.79g-k	19.63h-k	20.71j-m	44.61a-d	41.69a-d	43.15a-e	50.66a-d	49.18a-c	49.92a-d
SN ₅ LM ₂	21.21h-l	19.11h-l	20.16lk-n	44.35a-d	41.45a-d	42.90a-e	50.33a-d	48.87a-c	49.60a-d
SN ₅ LM ₃	20.70i-l	18.65i-l	19.68l-o	43.93a-d	41.06a-d	42.50a-e	50.05a-d	48.59a-c	49.32a-d
SN ₅ LM ₄	22.14f-k	19.95f-k	21.05i-l	45.00a-d	42.06a-d	43.53a-e	51.05a-d	49.57a-c	50.31a-d
SN ₅ LM ₅	18.26l	16.45l	17.35p	38.96d	38.55d	38.75e	48.07d	47.26c	47.67d
S.Em±	0.94	0.84	0.63	2.17	1.96	1.89	2.10	2.09	2.02

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

Contd....

Table 40 contd.....

Treatment	Plant height (cm)					
	120 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	59.03a	57.31a	58.17a	41.27a	39.68a	40.47a
SN ₂	57.57ab	55.90ab	56.73ab	40.05ab	38.51ab	39.28ab
SN ₃	56.26a-c	54.63a-c	55.45a-c	38.75a-c	37.26a-c	38.00a-c
SN ₄	55.13bc	53.52bc	54.32bc	37.43bc	35.99bc	36.71bc
SN ₅	52.52c	52.14c	52.33c	36.21c	34.82c	35.51c
S.Em±	1.26	1.02	0.75	0.90	0.87	0.89
CV (%)	8.72	7.22	5.24	9.03	8.87	8.98
Liquid manures (LM)						
LM ₁	57.52a	55.84a	56.68a	39.88a	38.35a	39.11a
LM ₂	57.14a	55.48a	56.31a	39.47a	37.95a	38.71a
LM ₃	56.77a	55.12a	55.94a	39.15a	37.64a	38.40a
LM ₄	58.00a	56.31a	57.15a	40.20a	38.65a	39.43a
LM ₅	51.09b	50.75b	50.92b	35.00b	33.66b	34.33b
S.Em±	1.38	1.02	0.79	0.70	0.67	0.68
CV (%)	9.52	7.20	5.52	6.96	6.78	6.87
Interactions (SN x LM)						
SN ₁ LM ₁	60.62ab	58.85ab	59.73ab	42.84ab	41.19ab	42.01ab
SN ₁ LM ₂	60.11a-c	58.36a-c	59.24a-c	42.48a-c	40.85a-c	41.67a-c
SN ₁ LM ₃	59.85a-d	58.11a-d	58.98a-d	42.11a-d	40.49a-d	41.30a-d
SN ₁ LM ₄	61.34a	59.55a	60.44a	43.04a	41.38a	42.21a
SN ₁ LM ₅	53.23e-i	51.68a-e	52.46e-i	35.87g-k	34.49g-k	35.18g-j
SN ₂ LM ₁	58.95a-e	57.23a-e	58.09a-e	41.44a-f	39.85a-f	40.65a-f
SN ₂ LM ₂	58.60a-f	56.89a-e	57.74a-f	40.93a-g	39.36a-g	40.15a-g
SN ₂ LM ₃	58.20a-h	56.50a-e	57.35a-g	40.70a-h	39.13a-h	39.91a-h
SN ₂ LM ₄	59.38a-e	57.65a-e	58.51a-e	41.71a-e	40.11a-e	40.91a-e
SN ₂ LM ₅	52.75e-i	51.21b-e	51.98f-i	35.46h-k	34.10h-k	34.78h-j
SN ₃ LM ₁	57.45a-h	55.78a-e	56.62a-h	39.85a-j	38.32a-j	39.09a-i
SN ₃ LM ₂	57.05a-h	55.39a-e	56.22a-h	39.44a-j	37.92a-j	38.68a-i
SN ₃ LM ₃	56.71a-h	55.06a-e	55.89a-h	39.12a-k	37.62a-k	38.37a-j
SN ₃ LM ₄	57.86a-h	56.17a-e	57.01a-h	40.33a-i	38.78a-i	39.56a-h
SN ₃ LM ₅	52.25f-i	50.73c-e	51.49f-i	35.00i-k	33.65i-k	34.32j
SN ₄ LM ₁	56.08a-h	54.45a-e	55.27a-h	38.32a-k	36.85a-k	37.59a-j
SN ₄ LM ₂	55.73a-h	54.11a-e	54.92a-h	37.95a-k	36.49a-k	37.22a-j
SN ₄ LM ₃	55.39ah	53.78a-e	54.59a-h	37.55b-k	36.11b-k	36.83b-j
SN ₄ LM ₄	56.53a-h	54.88a-e	55.70a-h	38.70a-k	37.21a-k	37.95a-j
SN ₄ LM ₅	51.89hi	50.38de	51.14hi	34.61jk	33.28jk	33.95ij
SN ₅ LM ₁	54.48b-h	52.89a-e	53.68b-h	36.95d-k	35.53d-k	36.24d-j
SN ₅ LM ₂	54.21c-h	52.63a-e	53.42c-h	36.54e-k	35.13e-k	35.83e-j
SN ₅ LM ₃	53.70d-i	52.14a-e	52.92d-i	36.26f-k	34.87f-k	35.57f-j
SN ₅ LM ₄	54.89b-h	53.29a-e	54.09b-h	37.22c-k	35.79c-k	36.51c-j
SN ₅ LM ₅	45.33i	49.77e	47.55i	34.07k	32.76k	33.42j
S.Em±	3.08	2.27	1.77	1.56	1.50	1.53

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

At 120 DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher plant height (59.03, 57.31 and 58.17 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₂ and SN₃ were however found on par with SN₁. While, significantly lower plant was recorded with SN₅ in both years and on pooled basis (52.52, 52.14 and 52.33 cm, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher plant height when compared to control (LM₅) in both years and on pooled basis. The lowest tuber yield was recorded in treatment LM₅ (51.09, 50.75 and 50.92 cm, respectively).

Among the interactions, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher plant height in both years and on pooled basis (61.34, 59.55 and 60.44 cm, respectively). Significantly lower plant height was recorded in SN₅LM₅ (45.33, 49.77 and 47.55 cm, respectively).

At harvest, among the sources of nitrogen, SN₁ treatment recorded significantly higher plant height (41.27, 39.68 and 40.47 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₂ and SN₃ were however found on par with SN₁, whereas, SN₅ recorded significantly lower plant height (36.21, 34.82 and 35.51, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher plant height when compared to control (LM₅) in both years and on pooled basis. The lowest plant height was recorded in treatment LM₅ (35.00, 33.66 and 34.33 cm, respectively).

Among SN x LM interactions, SN₁LM₄ recorded significantly higher plant height in both years and on pooled basis (43.04, 41.38 and 42.21 cm, respectively) while significantly lower plant height recorded in SN₅LM₅ (34.07, 32.76 and 33.42 cm, respectively).

4.7.2 Number of leaves per plant

Sources of nitrogen, liquid manures and their interactions influenced the number of leaves per plant of sugar beet significantly at all the growth stages (30, 60, 90, 120 DAS and at harvest) during 2010-11 and 2011-12 and on pooled basis (Table 41).

At 30 DAS, significantly higher number of leaves per plant was recorded with treatments SN₁ (8.35, 8.11 and 8.23, respectively) and SN₂ (8.07, 7.83 and 7.95, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₃ however found on par with SN₁ and SN₂. Significantly lower number of leaves per plant was recorded in SN₅ (7.08, 6.87 and 6.98, respectively) in both years and on pooled basis.

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher number of leaves per plant when compared to control (LM₅) in both years and on pooled basis. Whereas lower number of leaves per plant was recorded in treatment LM₅ (6.35, 6.16 and 6.25, respectively).

The interaction effect (SN x LM) was found significant. Among the treatment combinations, SN₁LM₄ recorded significantly higher number of leaves per plant in both years and on pooled basis (8.77, 8.51 and 8.64, respectively). Significantly lower number of leaves per plant was recorded in SN₅LM₅ (5.75, 5.58 and 5.66, respectively). The similar trend was noticed at 60 DAS.

At 90 DAS, among the sources of nitrogen, SN₁ treatment recorded significantly higher number of leaves per plant (21.51, 20.68 and 21.10, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, treatments SN₂ and SN₃ were found on par with SN₁. While, SN₅ treatment accounted for significantly lower number of leaves per plant (19.60, 18.85 and 19.22, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher number of leaves per plant when compared to control (LM₅) in both years and on pooled basis. The lowest number of leaves per plant was recorded in treatment LM₅ (18.95, 18.22 and 18.59, respectively).

Among the treatment combinations, treatment SN₁LM₄ accounted significantly higher number of leaves per plant in both years and on pooled basis (22.17, 21.32 and 21.75, respectively). Significantly lower number of leaves per plant was recorded in SN₅LM₅ (18.46, 17.75 and 18.11, respectively).

At 120 DAS, among the sources of nitrogen, SN₁ treatment which received 100 per cent RDN through inorganic fertilizer recorded significantly higher number of leaves per plant (24.60, 23.89 and 24.25, respectively) compared to other sources of nitrogen in both years and on pooled basis. The

Table 41: Number of leaves per plant of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Number of leaves per plant								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	8.35a	8.11a	8.23a	15.57a	15.11a	15.34a	21.51a	20.68a	21.10a
SN ₂	8.07a	7.83a	7.95a	15.16ab	14.72ab	14.94ab	21.07ab	20.26ab	20.67ab
SN ₃	7.77ab	7.55ab	7.66ab	14.72a-c	14.29a-c	14.50a-c	20.60a-c	19.81a-c	20.20a-c
SN ₄	7.44bc	7.22bc	7.33bc	14.24bc	13.83bc	14.04bc	20.14bc	19.37bc	19.76bc
SN ₅	7.08c	6.87c	6.98c	13.85c	13.45c	13.65c	19.60c	18.85c	19.22c
S.Em±	0.18	0.18	0.18	0.34	0.32	0.22	0.35	0.36	0.34
CV (%)	9.12	8.87	9.03	9.21	8.65	5.86	6.53	7.11	6.61
Liquid manures (LM)									
LM ₁	8.12a	7.89a	8.00a	15.08a	14.64a	14.86a	21.05a	20.24a	20.65a
LM ₂	8.06a	7.82a	7.94a	14.96a	14.53a	14.74a	20.91a	20.11a	20.51a
LM ₃	7.97a	7.74a	7.85a	14.83a	14.39a	14.61a	20.81a	20.01a	20.41a
LM ₄	8.22a	7.98a	8.10a	15.23a	14.78a	15.01a	21.20a	20.38a	20.79a
LM ₅	6.35b	6.16b	6.25b	13.44b	13.05b	13.25b	18.95b	18.22b	18.59b
S.Em±	0.14	0.14	0.14	0.26	0.26	0.18	0.28	0.38	0.30
CV (%)	6.98	6.35	6.65	7.01	6.99	5.03	5.21	7.37	5.83
Interactions (SN x LM)									
SN ₁ LM ₁	8.71a	8.46ab	8.59a	16.08ab	15.61ab	15.84ab	22.05ab	21.20a	21.62ab
SN ₁ LM ₂	8.64ab	8.39a-c	8.52ab	15.94a-c	15.48a-c	15.71a-c	22.00ab	21.15a	21.57a-c
SN ₁ LM ₃	8.56ab	8.31a-c	8.43a-c	15.79a-d	15.33a-d	15.56a-d	21.91ab	21.06ab	21.48a-c
SN ₁ LM ₄	8.77a	8.51a	8.64a	16.33a	15.85a	16.09a	22.17a	21.32a	21.75a
SN ₁ LM ₅	7.09f-h	6.88g-i	6.98g-i	13.70e-i	13.30e-i	13.50h-k	19.43d-h	18.68a-d	19.05d-h
SN ₂ LM ₁	8.46a-c	8.21a-d	8.33a-d	15.63a-f	15.17a-f	15.40a-e	21.61a-c	20.78a-c	21.20a-d
SN ₂ LM ₂	8.42a-d	8.17a-e	8.29a-e	15.52a-f	15.07a-g	15.30a-e	21.44a-d	20.62a-d	21.03a-e
SN ₂ LM ₃	8.34a-d	8.10a-f	8.22a-e	15.38a-g	14.93a-g	15.15a-f	21.33a-e	20.51a-d	20.92a-e
SN ₂ LM ₄	8.52ab	8.27a-c	8.39a-c	15.67a-e	15.21a-e	15.44a-e	21.76a-c	20.92a-c	21.34a-d
SN ₂ LM ₅	6.60g-i	6.41h-j	6.51h-j	13.61f-i	13.21f-i	13.41h-k	19.21e-h	18.47a-d	18.84e-h
SN ₃ LM ₁	8.19a-e	7.95a-f	8.07a-f	15.12a-i	14.68a-i	14.90a-g	21.08a-e	20.27a-d	20.68a-g
SN ₃ LM ₂	8.12a-f	7.88a-g	8.00a-g	14.98a-i	14.54a-i	14.76a-h	20.94a-f	20.13a-d	20.53a-g
SN ₃ LM ₃	8.03a-f	7.80a-g	7.92a-g	14.75a-i	14.32a-i	14.53a-i	20.86a-f	20.06a-d	20.46a-g
SN ₃ LM ₄	8.30a-e	8.06a-f	8.18a-f	15.25a-h	14.81a-h	15.03a-g	21.20a-e	20.38a-d	20.79a-f
SN ₃ LM ₅	6.23hi	6.05ij	6.14ij	13.48g-i	13.09f-i	13.29i-k	18.93f-h	18.20b-d	18.56f-h
SN ₄ LM ₁	7.83a-f	7.60a-g	7.71a-g	14.52a-i	14.10a-i	14.31d-k	20.57a-g	19.78a-d	20.18a-h
SN ₄ LM ₂	7.74a-f	7.51a-g	7.62a-g	14.44a-i	14.02a-i	14.23d-k	20.40a-h	19.62a-d	20.01a-h
SN ₄ LM ₃	7.64b-f	7.42b-g	7.53b-g	14.37a-i	13.95a-i	14.16d-k	20.29a-h	19.51ad	19.90a-h
SN ₄ LM ₄	7.92a-f	7.69a-g	7.81a-g	14.62a-i	14.19a-i	14.40c-j	20.72a-g	19.92a-d	20.32a-h
SN ₄ LM ₅	6.07i	5.89j	5.98j	13.28hi	12.89hi	13.08jk	18.74gh	18.02cd	18.38gh
SN ₅ LM ₁	7.43c-g	7.21d-h	7.32d-h	14.06b-i	13.65b-i	13.85f-k	19.96b-h	19.19a-d	19.57a-h
SN ₅ LM ₂	7.37d-g	7.16e-h	7.27e-h	13.93c-i	13.52c-i	13.72g-k	19.78c-h	19.02a-d	19.40b-h
SN ₅ LM ₃	7.27e-g	7.06f-h	7.17f-h	13.84d-i	13.44d-i	13.64g-k	19.65c-h	18.89a-d	19.27c-h
SN ₅ LM ₄	7.58b-g	7.36c-h	7.47c-h	14.28b-i	13.86a-i	14.07e-k	20.16a-h	19.38a-d	19.77a-h
SN ₅ LM ₅	5.75i	5.58j	5.66j	13.14i	12.76i	12.95k	18.46h	17.75d	18.11h
S.Em±	0.31	0.30	0.31	0.59	0.58	0.41	0.62	0.84	0.68

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

Contd....

Table 41 contd.....

Treatment	Number of leaves per plant					
	120 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	24.60a	23.89a	24.25a	13.95a	13.41a	13.68a
SN ₂	24.30ab	23.59ab	23.95ab	13.43ab	12.92ab	13.17ab
SN ₃	23.89a-c	23.19a-c	23.54a-c	12.90bc	12.41bc	12.65bc
SN ₄	23.33bc	22.65bc	22.99bc	12.38cd	11.90cd	12.14cd
SN ₅	22.62c	21.96c	22.29c	11.86d	11.40d	11.63d
S.Em±	0.40	0.39	0.22	0.30	0.28	0.19
CV (%)	6.57	6.55	5.70	9.06	8.80	6.21
Liquid manures (LM)						
LM ₁	24.26a	23.55a	23.90a	13.40a	12.88a	13.14a
LM ₂	24.11a	23.41a	23.76a	13.22a	12.71a	12.97a
LM ₃	23.97a	23.27a	23.62a	13.07a	12.57a	12.82a
LM ₄	24.37a	23.66a	24.02a	13.54a	13.02a	13.28a
LM ₅	22.04b	21.39b	21.72b	11.29b	10.86b	11.08b
S.Em±	0.52	0.55	0.40	0.23	0.22	0.16
CV (%)	8.50	9.16	6.63	6.97	6.96	5.47
Interactions (SN x LM)						
SN ₁ LM ₁	25.12a	24.39ab	24.76a	14.61a	14.05ab	14.33ab
SN ₁ LM ₂	25.01a	24.28ab	24.64a	14.44a-c	13.88a-c	14.16ab
SN ₁ LM ₃	24.93ab	24.20ab	24.56a	14.27a-d	13.72a-d	13.99a-c
SN ₁ LM ₄	25.29a	24.55a	24.92a	14.77a	14.20a	14.48a
SN ₁ LM ₅	22.68ab	22.02ab	22.35a-c	11.67i-m	11.22i-m	11.44k-o
SN ₂ LM ₁	24.79ab	24.07ab	24.43ab	14.02a-e	13.48a-e	13.75a-e
SN ₂ LM ₂	24.70ab	23.98ab	24.34ab	13.84a-f	13.31a-f	13.58a-f
SN ₂ LM ₃	24.57ab	23.85ab	24.21ab	13.71a-g	13.18a-g	13.44a-g
SN ₂ LM ₄	24.88ab	24.16ab	24.52ab	14.13a-d	13.59a-d	13.86a-d
SN ₂ LM ₅	22.57ab	21.91ab	22.24a-c	11.46j-m	11.02j-m	11.24i-o
SN ₃ LM ₁	24.36ab	23.65ab	24.00ab	13.41a-i	12.89a-i	13.15b-h
SN ₃ LM ₂	24.22ab	23.51ab	23.86ab	13.19a-j	12.68a-j	12.93c-i
SN ₃ LM ₃	24.09ab	23.39ab	23.74ab	13.01a-k	12.51a-k	12.76d-j
SN ₃ LM ₄	24.47ab	23.76ab	24.12ab	13.59a-h	13.07a-h	13.33a-g
SN ₃ LM ₅	22.30ab	21.65ab	21.97a-c	11.32k-m	10.88k-m	11.10m-o
SN ₄ LM ₁	23.85ab	23.16ab	23.51a-c	12.75c-l	12.26c-l	12.51f-k
SN ₄ LM ₂	23.67ab	22.98ab	23.32a-c	12.60d-m	12.12d-m	12.36g-l
SN ₄ LM ₃	23.46ab	22.78ab	23.12a-c	12.51d-m	12.03d-m	12.27g-m
SN ₄ LM ₄	23.92ab	23.22ab	23.57a-c	12.90b-k	12.40b-k	12.65j-j
SN ₄ LM ₅	21.75ab	21.11ab	21.43bc	11.12lm	10.69lm	10.90no
SN ₅ LM ₁	23.15ab	22.48ab	22.82a-c	12.19f-m	11.72f-m	11.95h-n
SN ₅ LM ₂	22.96ab	22.29ab	22.62a-c	12.04g-m	11.58g-m	11.81i-o
SN ₅ LM ₃	22.80ab	22.14ab	22.47a-c	11.85h-m	11.39h-m	11.62j-o
SN ₅ LM ₄	23.29ab	22.61ab	22.95a-c	12.32e-m	11.85e-m	12.09h-n
SN ₅ LM ₅	20.89b	20.28b	20.58c	10.90n	10.48m	10.69o
S.Em±	1.17	1.22	0.90	0.52	0.50	0.36

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

treatments which received 75 per cent RDN through IF +25 % RDN through VC and PM in equal proportion (SN₂) and 50 per cent RDN through IF + 50 per cent RDN through VC and PM in equal proportion (SN₃) were significantly higher however, found on par with SN₁. Significantly lower number of leaves per plant was recorded in SN₅ (22.62, 21.96 and 22.29, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher number of leaves per plant when compared to control (LM₅) in both years and on pooled basis. The lowest number of leaves per plant was recorded in treatment LM₅ (22.04, 21.39 and 21.72, respectively).

Among the treatment combinations, all the treatment combinations recorded significantly higher number of leaves per plant in both years and on pooled basis when compared with SN₅LM₅. Significantly lower number of leaves per plant was recorded in SN₅LM₅ (20.89, 20.28 and 20.58, respectively).

At harvest, among the sources of nitrogen, SN₁ recorded significantly higher number of leaves per plant (13.95, 13.41 and 13.68, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ recorded on par number of leaves per plant (13.43, 12.92 and 13.17, respectively) as that of SN₁. While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) (SN₅) recorded significantly lower number of leaves per plant (11.86, 11.40 and 11.63, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher number of leaves per plant when compared to control (LM₅) in both years and on pooled basis. The lowest number of leaves per plant was recorded in treatment LM₅ (11.29, 10.86 and 11.08, respectively).

Among the treatment combinations, SN₁LM₄ resulted in significantly higher number of leaves per plant during both years and on pooled basis (14.77, 14.20 and 14.48, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃, SN₂LM₄ and SN₃LM₄ remained on par with former treatment combination. Significantly lower number of leaves per plant was recorded in SN₅LM₅ (10.90, 10.48 and 10.69, respectively).

4.7.3 Leaf area (dm² plant⁻¹)

Leaf area of sugar beet differed significantly at various growth stages due to sources of nitrogen, liquid manures and their interactions during 2010-11, 2011-12 and on pooled basis (Table 42).

At 30DAS, among the sources of nitrogen, treatment SN₁ accounted significantly higher leaf area (7.11, 6.35 and 6.73 dm² plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ recorded on par leaf area (6.08, 5.43 and 5.75 dm² plant⁻¹, respectively) as that of SN₁. The treatment SN₅ recorded significantly lower leaf area (3.34, 2.98 and 3.16 dm² plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher leaf area (5.76, 5.14 and 5.45 dm² plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ found on par with LM₄. The lowest leaf area was recorded in treatment LM₅ (3.99, 3.56 and 3.77 dm² plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher leaf area in both years and on pooled basis (7.79, 6.96 and 7.38 dm² plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ found on par with SN₁LM₄. Significantly lower leaf area was recorded by SN₅LM₅ (2.49, 2.22 and 2.36 dm² plant⁻¹, respectively). The similar trend was observed at 60 DAS.

At 90DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher leaf area (69.19, 62.21 and 65.70 dm² plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par leaf area (64.88, 57.90 and 61.39 dm² plant⁻¹, respectively) as that of SN₁. Significantly lower leaf area was recorded in treatment SN₅ which received 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (53.17, 46.18 and 49.68 dm² plant⁻¹, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher leaf area (60.68 to 63.54, 53.69 to 56.55 and 57.18 to 60.04 dm² plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. The lowest leaf area was recorded in treatment LM₅ (56.37, 49.39 and 52.88 dm² plant⁻¹, respectively).

Table 42: Leaf area (dm² plant⁻¹) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Leaf area (dm ² plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	7.11a	6.35a	6.73a	47.61a	42.10a	44.85a	69.19a	62.21a	65.70a
SN ₂	6.08ab	5.43ab	5.75ab	43.30ab	38.29ab	40.79ab	64.88ab	57.90ab	61.39ab
SN ₃	5.09bc	4.54bc	4.81bc	39.16bc	34.64bc	36.90bc	60.75bc	53.76bc	57.26bc
SN ₄	4.18cd	3.73cd	3.96cd	35.15cd	31.08cd	33.12cd	56.73cd	49.75cd	53.24cd
SN ₅	3.34d	2.98d	3.16d	31.58d	27.93d	29.76d	53.17d	46.18d	49.68d
S.Em±	0.12	0.11	0.12	0.92	0.81	0.86	0.92	0.92	0.92
CV (%)	9.20	9.45	9.11	9.02	8.97	9.26	6.13	6.58	6.28
Liquid manures (LM)									
LM ₁	5.54ab	4.95ab	5.25ab	40.94ab	36.20ab	38.57ab	62.52a	55.54a	59.03a
LM ₂	5.36ab	4.79ab	5.07ab	40.03ab	35.40ab	37.72ab	61.62a	54.63a	58.13a
LM ₃	5.15b	4.60b	4.87b	39.09b	34.57b	36.83b	60.68a	53.69a	57.18a
LM ₄	5.76a	5.14a	5.45a	41.95a	37.10a	39.52a	63.54a	56.55a	60.04a
LM ₅	3.99c	3.56c	3.77c	34.79c	30.77c	32.78c	56.37b	49.39b	52.88b
S.Em±	0.10	0.09	0.09	0.72	0.64	0.68	0.72	0.72	0.72
CV (%)	7.29	7.32	7.05	7.07	6.74	7.13	5.67	5.16	5.37
Interactions (SN x LM)									
SN ₁ LM ₁	7.56ab	6.75ab	7.15ab	49.76ab	44.01ab	46.88ab	71.35ab	64.36ab	67.85ab
SN ₁ LM ₂	7.34a-c	6.56a-c	6.95a-c	48.71a-c	43.08a-c	45.90a-c	70.30a-c	63.31a-c	66.81a-c
SN ₁ LM ₃	7.10a-c	6.35a-c	6.72a-c	47.62a-d	42.11a-d	44.86a-d	69.20a-d	62.22a-d	65.71a-d
SN ₁ LM ₄	7.79a	6.96a	7.38a	51.20a	45.28a	48.24a	72.78a	65.80a	69.29a
SN ₁ LM ₅	5.74f-h	5.13f-h	5.43f-h	40.74f-j	36.03f-j	38.39f-j	62.33c-j	55.34c-j	58.84c-j
SN ₂ LM ₁	6.52de	5.83de	6.18de	45.21b-f	39.98b-f	42.60b-f	66.80a-f	59.81a-f	63.30a-f
SN ₂ LM ₂	6.33ef	5.66ef	5.99ef	44.25c-g	39.13c-g	41.69c-g	65.84a-g	58.85a-g	62.34a-g
SN ₂ LM ₃	6.10e-g	5.45e-g	5.78e-g	43.28d-h	38.28d-h	40.78d-h	64.87a-h	57.88a-h	61.37a-h
SN ₂ LM ₄	6.73c-e	6.01c-e	6.37c-e	45.99b-e	40.67b-e	43.33b-e	67.58a-e	60.59a-e	64.08a-e
SN ₂ LM ₅	4.69i-k	4.19i-k	4.44i-k	37.75i-m	33.38i-m	35.56i-m	59.33f-m	52.35f-m	55.84f-m
SN ₃ LM ₁	5.48gh	4.90gh	5.19gh	40.77f-j	36.06f-j	38.41f-j	62.36c-j	55.37c-k	58.86c-j
SN ₃ LM ₂	5.31hi	4.74hi	5.03hi	39.82g-k	35.22g-k	37.52g-k	61.41b-k	54.42d-k	57.91d-k
SN ₃ LM ₃	5.09h-j	4.54h-j	4.81h-j	38.62h-l	34.16h-l	36.39h-l	60.21e-l	53.22e-l	56.72e-l
SN ₃ LM ₄	5.73f-h	5.12f-h	5.42f-h	41.77e-i	36.94e-i	39.36e-i	63.36b-i	56.37b-i	59.86b-i
SN ₃ LM ₅	3.82l-n	3.41l-n	3.62l-n	34.83k-n	30.81k-n	32.82k-n	56.42i-m	49.43i-m	52.93i-m
SN ₄ LM ₁	4.52jk	4.04jk	4.28jk	36.36j-n	32.16j-n	34.26j-n	57.95g-m	50.96g-m	54.46g-m
SN ₄ LM ₂	4.34kl	3.88kl	4.11kl	35.62j-n	31.50j-n	33.56j-n	57.21h-m	50.22h-m	53.72h-m
SN ₄ LM ₃	4.15k-m	3.71k-m	3.93k-m	34.89k-n	30.85k-n	32.87k-n	56.47i-m	49.49i-m	52.98i-m
SN ₄ LM ₄	4.70i-k	4.20i-k	4.45i-k	37.17i-m	32.87i-m	35.02i-m	58.76f-m	51.77f-m	55.27f-m
SN ₄ LM ₅	3.18n	2.84n	3.01n	31.69no	28.03no	29.86no	53.28mn	46.29mn	49.78mn
SN ₅ LM ₁	3.62mn	3.24mn	3.43mn	32.57m-o	28.81m-o	30.69m-o	54.16k-n	47.17k-n	50.67k-n
SN ₅ LM ₂	3.47mn	3.10n	3.28mn	31.75no	28.08no	29.92no	53.34l-n	46.35l-n	49.85l-n
SN ₅ LM ₃	3.29n	2.94n	3.12n	31.05no	27.46no	29.25no	52.63mn	45.65mn	49.14mn
SN ₅ LM ₄	3.83l-n	3.42l-n	3.63l-n	33.61l-o	29.73l-o	31.67l-o	55.20j-n	48.21j-n	51.71j-n
SN ₅ LM ₅	2.49o	2.22o	2.36o	28.93o	25.58o	27.26o	50.51n	43.53n	47.02n
S.Em±	0.22	0.19	0.21	1.61	1.42	1.51	1.61	1.61	1.61

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

Contd.....

Table 42 contd.....

Treatment	Leaf area (dm ² plant ⁻¹)					
	120 DAS			At Harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	82.18a	75.13a	78.65a	50.25a	46.26a	48.26a
SN ₂	77.87ab	70.82ab	74.34ab	45.48ab	41.87ab	43.67ab
SN ₃	73.74bc	66.68bc	70.21bc	40.90bc	37.65bc	39.28bc
SN ₄	69.72cd	62.67cd	66.19cd	36.66c	33.75cd	35.20c
SN ₅	66.16d	59.10d	62.63d	32.77c	30.16d	31.47c
S.Em±	0.92	0.92	0.92	0.97	0.89	0.93
CV (%)	6.83	6.31	7.04	9.08	9.13	8.87
Liquid manures (LM)						
LM ₁	75.51a	68.46a	71.98a	43.30ab	39.86ab	41.58ab
LM ₂	74.61a	67.55a	71.08a	42.21ab	38.86ab	40.53ab
LM ₃	73.67a	66.61a	70.14a	41.21b	37.93b	39.57b
LM ₄	76.52a	69.47a	73.00a	44.35a	40.82a	42.59a
LM ₅	69.36b	62.31b	65.83b	34.99c	32.21c	33.60c
S.Em±	0.72	0.72	0.72	0.75	0.69	0.72
CV (%)	5.87	5.27	6.57	7.08	7.17	6.95
Interactions (SN x LM)						
SN ₁ LM ₁	84.33ab	77.28ab	80.81ab	53.20ab	48.97ab	51.09ab
SN ₁ LM ₂	83.29ab	76.23ab	79.76ab	51.94a-c	47.81a-c	49.88a-c
SN ₁ LM ₃	82.19a-c	75.14a-c	78.66a-c	50.75a-d	46.72a-d	48.73a-d
SN ₁ LM ₄	85.77a	78.72a	82.24a	54.39a	50.07a	52.23a
SN ₁ LM ₅	75.32d-i	68.26d-i	71.79d-i	40.99h-k	37.73h-k	39.36h-k
SN ₂ LM ₁	79.79a-e	72.73a-e	76.26a-e	48.02b-f	44.21b-f	46.11b-f
SN ₂ LM ₂	78.82a-f	71.77a-f	75.30a-f	46.83c-g	43.10c-g	44.97c-g
SN ₂ LM ₃	77.85a-g	70.80a-g	74.33a-h	45.79d-h	42.15d-h	43.97d-h
SN ₂ LM ₄	80.56a-d	73.51a-d	77.04a-d	49.01b-e	45.11b-e	47.06b-e
SN ₂ LM ₅	72.32g-l	65.27g-h	68.79g-l	37.76j-n	34.76j-n	36.26j-n
SN ₃ LM ₁	75.35d-h	68.29d-h	71.82b-h	42.98f-j	39.56f-j	41.27f-j
SN ₃ LM ₂	74.39d-j	67.34d-j	70.87d-j	41.75g-k	38.43g-k	40.09g-k
SN ₃ LM ₃	73.20e-k	66.14e-k	69.67e-k	40.69h-k	37.46h-k	39.07h-k
SN ₃ LM ₄	76.35c-h	69.29c-h	72.82c-h	44.16e-i	40.65e-i	42.41e-i
SN ₃ LM ₅	69.41i-m	62.35i-m	65.88i-m	34.93l-o	32.15l-o	33.54l-o
SN ₄ LM ₁	70.94g-l	63.88g-l	67.41g-l	38.21j-m	35.18j-m	36.69j-m
SN ₄ LM ₂	70.20h-l	63.14h-l	66.67h-l	37.30k-o	34.34k-o	35.82k-o
SN ₄ LM ₃	69.46h-l	62.41h-l	65.93h-l	36.55k-o	33.65k-o	35.10k-o
SN ₄ LM ₄	71.75f-l	64.69f-l	68.22f-l	39.22l-i	36.10l-i	37.66l-i
SN ₄ LM ₅	66.26lm	59.21lm	62.74lm	32.02op	29.47op	30.74op
SN ₅ LM ₁	67.15k-m	60.09k-n	63.62k-m	34.11p	31.40p	32.75p
SN ₅ LM ₂	66.33lm	59.27lm	62.80lm	33.23m-p	30.59m-o	31.91m-p
SN ₅ LM ₃	65.62lm	58.57lm	62.09lm	32.26n-p	29.70n-p	30.98n-p
SN ₅ LM ₄	68.19j-m	61.13j-m	64.66j-m	34.97l-o	32.19l-o	33.58l-o
SN ₅ LM ₅	63.50m	56.45m	59.97m	29.27p	26.94p	28.11p
S.Em±	1.61	1.61	1.61	1.68	1.55	1.62

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermicompost and CU: cow urine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher leaf area in both years and on pooled basis (72.78, 65.80 and 69.29 dm² plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃ and SN₂LM₄ treatments were found on par with SN₁LM₄. Whereas application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) recorded significantly lower leaf area (50.51, 43.53 and 47.02 dm² plant⁻¹, respectively). Similar trend was noticed due to the treatments effect on the leaf area at 120 DAS.

At harvest, among the sources of nitrogen, treatment SN₁ accounted significantly higher leaf area (50.25, 46.26 and 48.26 dm² plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ recorded on par leaf area (45.48, 41.87 and 43.67 dm² plant⁻¹, respectively) as that of SN₁. The treatment namey SN₅ recorded significantly lower leaf area (32.77, 30.16 and 31.47 dm² plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher leaf area (44.35, 40.82 and 42.59 dm² plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ found on par with LM₄. The lowest leaf area was recorded in treatment LM₅ (34.99, 32.21 and 33.60 dm² plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher leaf area in both years and on pooled basis (54.39, 50.07 and 52.23 dm² plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ found on par with SN₁LM₄. Significantly lower leaf area of 29.27, 26.94 and 28.11 dm² plant⁻¹, respectively was recorded by SN₅LM₅.

4.7.4 Leaf area index (LAI)

Sources of nitrogen, liquid manures and their interactions influenced the leaf area index (LAI) of sugar beet significantly at all the growth stages during 2010-11 and 2011-12 and on pooled basis (Table 43).

At 30 DAS, among the sources of nitrogen, treatment SN₁ accounted significantly higher LAI (0.71, 0.63 and 0.67, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ recorded on par LAI (0.61, 0.54 and 0.58, respectively) as that of SN₁. While, treatment SN₅ recorded significantly lower LAI (0.33, 0.30 and 0.32, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher LAI (0.58, 0.51 and 0.55, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ found on par with LM₄. The lowest LAI was recorded in treatment LM₅ (0.40, 0.36 and 0.38, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher LAI in both years and on pooled basis (0.78, 0.70 and 0.74, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ found on par with SN₁LM₄. Significantly lower LAI 0.25, 0.22 and 0.24, respectively was recorded by SN₅LM₅. Leaf area index recorded at 60DAS showed a similar trend as that of 30 DAS.

At 90 DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher LAI (6.92, 6.22 and 6.57, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par LAI (6.49, 5.79 and 6.14, respectively) as that of SN₁. Significantly lower LAI was recorded in treatment SN₅ which received 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (5.32, 4.62 and 4.97, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher LAI (6.07 to 6.35, 5.37 to 5.65 and 5.72 and 6.00, respectively) when compared to control (LM₅) in both years and on pooled basis. The lowest LAI was recorded in treatment LM₅ (5.64, 4.94 and 5.29, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher LAI in both years and on pooled basis (7.28, 6.58 and 6.93, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃ and SN₂LM₄ treatments were found on par with SN₁LM₄. Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) recorded significantly lower LAI of 5.05, 4.35 and 4.70, respectively. Leaf area index recorded at 120 DAS followed the trend observed at 90 DAS.

Table 43: Leaf area index of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Leaf area index								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	0.71a	0.63a	0.67a	4.76a	4.21a	4.49a	6.92a	6.22a	6.57a
SN ₂	0.61ab	0.54ab	0.58ab	4.33ab	3.83ab	4.08ab	6.49ab	5.79ab	6.14ab
SN ₃	0.51bc	0.45bc	0.48bc	3.92bc	3.46bc	3.69bc	6.08bc	5.38bc	5.73bc
SN ₄	0.42cd	0.37cd	0.40cd	3.51bc	3.11cd	3.31cd	5.67cd	4.97cd	5.32cd
SN ₅	0.33d	0.30d	0.32d	3.16c	2.79d	2.98d	5.32d	4.62d	4.97d
S.Em±	0.01	0.01	0.01	0.09	0.08	0.09	0.09	0.09	0.09
CV (%)	9.20	9.45	9.14	9.02	9.15	9.23	6.11	6.58	6.23
Liquid manures (LM)									
LM ₁	0.55ab	0.49ab	0.52ab	4.09ab	3.62ab	3.86ab	6.25a	5.55a	5.90a
LM ₂	0.54ab	0.48ab	0.51bab	4.00ab	3.54ab	3.77ab	6.16a	5.46a	5.81a
LM ₃	0.51b	0.46b	0.49b	3.91b	3.46b	3.68b	6.07a	5.37a	5.72a
LM ₄	0.58a	0.51a	0.55a	4.19a	3.71a	3.95a	6.35a	5.65a	6.00a
LM ₅	0.40c	0.36c	0.38c	3.48c	3.08c	3.28c	5.64b	4.94b	5.29b
S.Em±	0.01	0.01	0.01	0.07	0.06	0.07	0.07	0.07	0.07
CV (%)	7.29	7.13	7.03	7.07	6.97	7.14	5.57	5.16	5.19
Interactions (S N x LM)									
SN ₁ LM ₁	0.76ab	0.67ab	0.72ab	4.98ab	4.40ab	4.69ab	7.13ab	6.44ab	6.79ab
SN ₁ LM ₂	0.73ab	0.66ab	0.70ab	4.87a-c	4.31a-c	4.59a-c	7.03a-c	6.33a-c	6.68a-c
SN ₁ LM ₃	0.71ab	0.63ab	0.67bc	4.76a-d	4.21a-d	4.49a-d	6.92a-d	6.22a-d	6.57a-d
SN ₁ LM ₄	0.78a	0.70a	0.74a	5.12a	4.53a	4.82a	7.28a	6.58a	6.93a
SN ₁ LM ₅	0.57fg	0.51e-f	0.54fg	4.07e-i	3.60f-j	3.84e-i	6.23c-j	5.53c-j	5.88c-j
SN ₂ LM ₁	0.65de	0.58cd	0.62c-e	4.52b-e	4.00b-f	4.26b-e	6.68a-f	5.98a-f	6.33a-f
SN ₂ LM ₂	0.63de	0.57d	0.60de	4.43c-f	3.91c-g	4.17c-f	6.58a-g	5.89a-g	6.23a-h
SN ₂ LM ₃	0.61ef	0.55de	0.58e-f	4.33d-f	3.83d-h	4.08d-g	6.49a-h	5.79a-h	6.14a-h
SN ₂ LM ₄	0.67cd	0.60cd	0.64cd	4.60d-e	4.07b-e	4.33b-e	6.76a-e	6.06a-e	6.41a-e
SN ₂ LM ₅	0.47ij	0.42h-j	0.44j-l	3.77h-l	3.34i-m	3.56h-l	5.93f-m	5.23f-m	5.58f-m
SN ₃ LM ₁	0.55gh	0.49fg	0.52gh	4.08e-i	3.61f-j	3.84e-i	6.24c-j	5.54c-j	5.89c-j
SN ₃ LM ₂	0.53gh	0.47f-h	0.50g-i	3.98f-j	3.52g-k	3.75f-j	6.14d-k	5.44d-k	5.79f-k
SN ₃ LM ₃	0.51hi	0.45gi	0.48h-j	3.86g-k	3.42h-l	3.64g-k	6.02e-l	5.32e-l	5.67e-l
SN ₃ LM ₄	0.57fg	0.51ef	0.54fg	4.18e-h	3.69e-i	3.94e-h	6.34d-i	5.64b-i	5.99b-i
SN ₃ LM ₅	0.38kl	0.34k-m	0.36m-o	3.48j-m	3.08k-n	3.28j-m	5.64i-m	4.94i-m	5.29i-m
SN ₄ LM ₁	0.45j	0.40ij	0.43j-l	3.64i-m	3.22j-m	3.43i-m	5.80g-m	5.10g-m	5.45g-m
SN ₄ LM ₂	0.43jk	0.39jk	0.41k-m	3.56i-m	3.15j-m	3.36i-m	5.72h-m	5.02h-m	5.37h-m
SN ₄ LM ₃	0.42jk	0.37j-l	0.39l-n	3.49j-m	3.09k-m	3.29j-m	5.65i-m	4.95i-m	5.30i-m
SN ₄ LM ₄	0.47ij	0.42h-j	0.45i-k	3.72h-l	3.29i-m	3.50h-l	5.88f-m	5.18f-m	5.53f-m
SN ₄ LM ₅	0.32m	0.28n	0.30p	3.17mn	2.80no	2.99mn	5.33mn	4.63mn	4.98mn
SN ₅ LM ₁	0.36lm	0.32l-n	0.34n-p	3.26l-n	2.88m-o	3.07l-n	5.42k-n	4.72k-n	5.07k-n
SN ₅ LM ₂	0.35lm	0.31mn	0.33op	3.18mn	2.81no	2.99mn	5.33l-n	4.64l-n	4.98l-n
SN ₅ LM ₃	0.33lm	0.29mn	0.31op	3.10mn	2.75no	2.93mn	5.26mn	4.56mn	4.91mn
SN ₅ LM ₄	0.38kl	0.34k-m	0.36mn	3.36k-m	2.97l-o	3.17k-n	5.52j-n	4.82j-n	5.17j-n
SN ₅ LM ₅	0.25n	0.22o	0.24q	2.89n	2.56o	2.73n	5.05n	4.35n	4.70n
S.Em±	0.02	0.02	0.02	0.16	0.14	0.15	0.16	0.16	0.16

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

Contd....

Table 43 contd.....

Treatment	Leaf area index					
	120 DAS			At Harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	8.22a	7.51a	7.87a	5.03a	4.63a	4.83a
SN ₂	7.79ab	7.08ab	7.43ab	4.55ab	4.19ab	4.37ab
SN ₃	7.37bc	6.67bc	7.02bc	4.09bc	3.77bc	3.93bc
SN ₄	6.97cd	6.27cd	6.62cd	3.67bc	3.37cd	3.52bc
SN ₅	6.62d	5.91d	6.26d	3.28c	3.02d	3.15c
S.Em±	0.09	0.09	0.09	0.10	0.09	0.09
CV (%)	9.08	9.11	8.97	9.04	9.25	9.09
Liquid manures (LM)						
LM ₁	7.55a	6.85a	7.20a	4.33ab	3.99ab	4.16ab
LM ₂	7.46a	6.76a	7.11a	4.22ab	3.89ab	4.05ab
LM ₃	7.37a	6.66a	7.01a	4.12b	3.79b	3.96b
LM ₄	7.65a	6.95a	7.30a	4.43a	4.08a	4.26a
LM ₅	6.94b	6.23b	6.58b	3.50c	3.22c	3.36c
S.Em±	0.07	0.07	0.07	0.08	0.07	0.07
CV (%)	7.08	7.00	7.03	7.09	7.12	6.98
Interactions (SN x LM)						
SN ₁ LM ₁	8.43ab	7.73ab	8.08ab	5.32ab	4.90ab	5.11ab
SN ₁ LM ₂	8.33ab	7.62ab	7.98ab	5.19a-c	4.78a-c	4.99a-c
SN ₁ LM ₃	8.22a-c	7.51a-c	7.87a-c	5.08a-d	4.67a-d	4.87a-d
SN ₁ LM ₄	8.58a	7.87a	8.22a	5.44a	5.01a	5.22a
SN ₁ LM ₅	7.53e-i	6.83d-i	7.18d-i	4.10h-k	3.77h-k	3.94h-k
SN ₂ LM ₁	7.98a-e	7.27a-e	7.63a-e	4.80b-f	4.42b-f	4.61b-f
SN ₂ LM ₂	7.88a-f	7.18a-f	7.53a-g	4.68c-g	4.31c-g	4.50c-g
SN ₂ LM ₃	7.79b-g	7.08b-g	7.43b-g	4.58d-h	4.21d-h	4.40d-h
SN ₂ LM ₄	8.06a-d	7.35a-d	7.70a-d	4.90b-e	4.51b-e	4.71b-e
SN ₂ LM ₅	7.23g-l	6.53g-l	6.88g-l	3.78j-n	3.48j-m	3.63j-n
SN ₃ LM ₁	7.53d-i	6.83b-h	7.18d-i	4.30f-j	3.96f-j	4.13f-j
SN ₃ LM ₂	7.44d-j	6.73d-j	7.09d-j	4.18g-k	3.84g-k	4.01g-k
SN ₃ LM ₃	7.32e-k	6.61e-k	6.97e-k	4.07h-k	3.75h-k	3.91h-k
SN ₃ LM ₄	7.63c-h	6.93c-h	7.28c-h	4.42e-i	4.07e-i	4.24e-i
SN ₃ LM ₅	6.94i-m	6.24i-m	6.59i-m	3.49l-o	3.22l-m	3.35l-o
SN ₄ LM ₁	7.09g-l	6.39g-l	6.74g-l	3.82j-m	3.52j-m	3.67j-m
SN ₄ LM ₂	7.02h-l	6.31h-l	6.67h-l	3.73j-o	3.43k-n	3.58k-o
SN ₄ LM ₃	6.95h-l	6.24h-l	6.59h-l	3.66k-o	3.36k-n	3.51k-o
SN ₄ LM ₄	7.17f-l	6.47f-l	6.82f-l	3.92i-l	3.61i-l	3.77i-l
SN ₄ LM ₅	6.63lm	5.92lm	6.27lm	3.20op	2.95n-o	3.07op
SN ₅ LM ₁	6.71k-m	6.01k-m	6.36k-m	3.41l-p	3.14l-o	3.28l-p
SN ₅ LM ₂	6.63lm	5.93lm	6.28lm	3.32m-p	3.06m-o	3.19m-p
SN ₅ LM ₃	6.56lm	5.86lm	6.21lm	3.23n-p	2.97no	3.10n-p
SN ₅ LM ₄	6.82j-m	6.11j-m	6.47j-m	3.50l-o	3.22l-n	3.36l-o
SN ₅ LM ₅	6.35m	5.64m	6.00m	2.93p	2.69o	2.81p
S.Em±	0.16	0.16	0.16	0.17	0.16	0.16

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

At harvest, among the sources of nitrogen, treatment SN₁ accounted significantly higher LAI (5.03, 4.63 and 4.83, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ recorded on par LAI (4.55, 4.19 and 4.37, respectively) as that of SN₁. While, treatment SN₅ recorded significantly lower LAI (3.28, 3.02 and 3.15, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher LAI (4.43, 4.08 and 4.26, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ were on par with LM₄. The lowest LAI was recorded in treatment LM₅ (3.50, 3.22 and 3.36, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher LAI in both years and on pooled basis (5.44, 5.01 and 5.22, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ were found to be on par with SN₁LM₄. Lower LAI recorded by SN₅LM₅ (2.93, 2.69 and 2.81, respectively) was found to be significantly lower.

4.7.5 Leaf area duration (LAD)

The data on leaf area duration (LAD) as influenced by sources of nitrogen, liquid manures and their interactions at various growth stages (30-60, 61-90, 91-120 DAS and 121-harvest) of sugar beet during 2010-11, 2011-12 and on pooled basis are presented in Table 44.

Between 30-60DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher LAD (82.07, 72.68 and 77.37 days, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ was however found on par with SN₁. Significantly lower LAD was recorded in SN₅ (52.39, 46.37 and 49.37 days, respectively).

Among the liquid manures treatments LM₄ recorded significantly higher LAD (71.56, 63.36 and 67.46 days, respectively) when compared to control (LM₅) in both years and on pooled basis. The treatments LM₁ and LM₂ were however found to be on par with LM₄. The lowest LAD was recorded in treatment LM₅ (58.16, 51.49 and 54.82 days, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher LAD in both years and on pooled basis (88.49, 78.36 and 77.38 days, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ treatments were found on par with SN₁LM₄. Significantly lower LAD was recorded in SN₅LM₅ (47.12, 41.71 and 44.42 days, respectively). Leaf area duration recorded between 60-90 and 90-120DAS showed a similar trend as that of 30 DAS.

During 121DAS- harvest, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher LAD (297.98, 273.12 and 285.55 days, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment SN₂ was however found on par with SN₁. Significantly lower LAD was recorded in SN₅ (222.58, 200.85 and 211.71, respectively).

Among the liquid manures treatments LM₄ recorded significantly higher LAD (271.96, 248.16 and 260.06 days, respectively) when compared to control (LM₅) in both years and on pooled basis. The treatments LM₁ and LM₂ were however found to be on par with LM₄. The lowest LAD was recorded in treatment LM₅ (234.79, 212.67 and 223.73 days, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher LAD in both years and on pooled basis (315.35, 289.76 and 302.56 days, respectively). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ treatments were found on par with SN₁LM₄. Significantly lower LAD was recorded in SN₅LM₅ (208.73, 187.63 and 198.18 days, respectively).

4.7.6 Dry matter accumulation in green foliage (g plant⁻¹)

The data on dry matter accumulation (DMA) in green foliage at various growth stages viz., 30, 60, 90, 120 DAS and at harvest as influenced by sources of nitrogen, liquid manures and their interactions are presented in Table 45.

At 30DAS, among the sources of nitrogen, significantly higher DMA in green foliage recorded with application of 100 per cent RDN through inorganic fertilizer (SN₁) (7.49, 6.34 and 6.92 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments which receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) which recorded on par DMA in green foliage (7.46, 6.30 and 6.88 g plant⁻¹,

Table 44: Leaf area duration (LAD) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Leaf area duration (days)					
	30 to 60 DAS			61 to 90 DAS		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	82.07a	72.68a	77.37a	175.20a	156.46a	165.83a
SN ₂	74.06b	65.58b	69.82b	162.27b	144.28b	153.27b
SN ₃	66.38c	58.77c	62.57c	149.87c	132.60c	141.24c
SN ₄	58.99d	52.23d	55.61d	137.82d	121.25d	129.53d
SN ₅	52.39e	46.37e	49.38e	127.13e	111.17e	119.15e
S.Em±	1.56	1.38	1.47	2.75	2.59	2.67
CV (%)	9.18	9.31	9.16	7.08	7.54	7.30
Liquid manures (LM)						
LM ₁	69.72ab	61.73ab	65.72ab	155.19ab	137.61ab	146.40ab
LM ₂	68.09ab	60.29ab	64.19ab	152.48ab	135.05ab	143.76ab
LM ₃	66.36b	58.75b	62.56b	149.65b	132.39b	141.02b
LM ₄	71.56a	63.36a	67.46a	158.23a	140.47a	149.35a
LM ₅	58.16c	51.49c	54.82c	136.74c	120.23c	128.49c
S.Em±	1.22	1.08	1.15	2.16	2.03	2.09
CV (%)	7.09	7.19	6.98	5.55	5.91	5.72
Interactions (SN x LM)						
SN ₁ LM ₁	85.98ab	76.14ab	81.06ab	181.66ab	162.55ab	172.11ab
SN ₁ LM ₂	84.09a-c	74.46a-c	79.27a-c	178.52a-c	159.59a-c	169.05a-c
SN ₁ LM ₃	82.08a-d	72.68a-d	77.38a-d	175.23a-d	156.49a-d	165.86a-d
SN ₁ LM ₄	88.49a	78.36a	83.42a	185.97a	166.61a	176.29a
SN ₁ LM ₅	69.72f-j	61.74f-j	65.73f-j	154.61f-j	137.06f-j	145.83f-j
SN ₂ LM ₁	77.60b-f	68.72b-f	73.16b-f	168.01b-f	149.69b-f	158.85b-f
SN ₂ LM ₂	75.87c-g	67.18c-g	71.53c-g	165.13c-g	146.98c-g	156.05c-g
SN ₂ LM ₃	74.08d-h	65.59d-h	69.83d-h	162.22d-h	144.23d-h	153.23d-h
SN ₂ LM ₄	79.09b-e	70.03b-e	74.56b-e	170.35b-e	151.90b-e	161.12b-e
SN ₂ LM ₅	63.66i-m	56.36i-m	60.01i-m	145.62i-m	128.59i-m	137.11i-m
SN ₃ LM ₁	69.38f-j	61.43f-j	65.41f-j	154.69f-j	137.14f-j	145.92f-j
SN ₃ LM ₂	67.70g-k	59.94g-k	63.82g-k	151.84g-k	134.46g-k	143.15g-k
SN ₃ LM ₃	65.57h-l	58.05h-l	61.81h-l	148.25h-l	131.08h-l	139.67h-l
SN ₃ LM ₄	71.25e-i	63.09e-i	67.17e-i	157.69e-i	139.97e-i	148.83e-i
SN ₃ LM ₅	57.98l-p	51.33l-p	54.66l-p	136.88k-n	120.36k-n	128.62k-n
SN ₄ LM ₁	61.33j-o	54.30j-o	57.81j-o	141.47j-o	124.69j-o	133.08j-o
SN ₄ LM ₂	59.95k-p	53.07k-p	56.51k-p	139.25j-n	122.59j-n	130.92j-n
SN ₄ LM ₃	58.56l-p	51.84l-p	55.20l-p	137.04k-n	120.51k-n	128.78k-n
SN ₄ LM ₄	62.81i-n	55.61i-n	59.21i-n	143.90i-m	126.97i-m	135.43i-m
SN ₄ LM ₅	52.31o-q	46.30p-q	49.30o-q	127.45no	111.47no	119.46no
SN ₅ LM ₁	54.29n-q	48.07n-q	51.18n-q	130.10m-o	113.97m-o	122.04m-o
SN ₅ LM ₂	52.83o-q	46.77o-q	49.80o-q	127.64no	111.65no	119.64no
SN ₅ LM ₃	51.51pq	45.60pq	48.56pq	125.52no	109.65no	117.59no
SN ₅ LM ₄	56.17m-p	49.72m-p	52.94m-p	133.22l-o	116.91l-o	125.07l-o
SN ₅ LM ₅	47.12q	41.71q	44.42q	119.16o	103.67o	111.41o
S.Em±	2.73	2.42	2.58	4.82	4.54	4.68

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

Contd....

Table 44 contd.....

Treatment	Leaf area duration (days)					
	91 to 120 DAS			120DAS to harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	227.06a	206.00a	216.53a	297.98a	273.12a	285.55a
SN ₂	214.13b	193.07b	203.60b	277.54b	253.53b	265.54b
SN ₃	201.73c	180.67c	191.20c	257.94c	234.75c	246.35c
SN ₄	189.68d	168.62d	179.15d	239.36d	216.93d	228.14d
SN ₅	178.99e	157.93e	168.46e	222.58e	200.85e	211.71e
S.Em±	2.75	2.75	2.75	4.24	4.07	4.15
CV (%)	5.87	6.24	6.18	6.45	6.68	6.50
Liquid manures (LM)						
LM ₁	207.05ab	185.99ab	196.52ab	267.33ab	243.72ab	255.53ab
LM ₂	204.34ab	183.27ab	193.81ab	262.84ab	239.42ab	251.13ab
LM ₃	201.51b	180.45b	190.98b	258.47b	235.23b	246.85b
LM ₄	210.09a	189.03a	199.56a	271.96a	248.16a	260.06a
LM ₅	188.61c	167.54c	178.07c	234.79c	212.67c	223.73c
S.Em±	2.16	2.16	2.16	3.31	3.18	3.24
CV (%)	5.06	5.48	5.76	5.24	5.22	5.08
Interactions (SN x LM)						
SN ₁ LM ₁	233.52ab	212.46ab	222.99ab	309.45ab	284.07ab	296.76ab
SN ₁ LM ₂	230.38a-c	209.32a-c	219.85a-c	304.26a-c	279.11a-c	291.69a-c
SN ₁ LM ₃	227.09a-d	206.03a-d	216.56a-d	299.12a-d	274.17a-d	286.64a-d
SN ₁ LM ₄	237.83a	216.77a	227.30a	315.36a	289.76a	302.56a
SN ₁ LM ₅	206.47f-j	185.41f-j	195.94f-j	261.68g-k	238.48g-k	250.08g-k
SN ₂ LM ₁	219.88b-f	198.81b-f	209.34b-f	287.56b-f	263.11b-f	275.34b-f
SN ₂ LM ₂	216.99c-g	195.93c-g	206.46c-g	282.71c-g	258.47c-g	270.59c-g
SN ₂ LM ₃	214.08d-h	193.02d-h	203.55d-h	278.20d-h	254.14d-h	266.17d-h
SN ₂ LM ₄	222.21b-e	201.15b-e	211.68b-e	291.54b-e	266.91b-e	279.22b-e
SN ₂ LM ₅	197.48i-m	176.42i-m	186.95i-m	247.68i-n	225.06i-h	236.37i-h
SN ₃ LM ₁	206.56f-j	185.49f-j	196.03f-j	266.23f-j	242.68f-j	254.45f-j
SN ₃ LM ₂	203.70g-k	182.64g-k	193.17g-k	261.33g-k	237.99g-k	249.66g-k
SN ₃ LM ₃	200.12h-l	179.05h-l	189.59h-l	256.25h-l	233.10h-l	244.67h-l
SN ₃ LM ₄	209.55e-i	188.49e-i	199.02e-i	271.14e-i	247.37e-i	259.26e-i
SN ₃ LM ₅	188.74k-n	167.68k-n	178.21k-n	234.75l-o	212.63l-o	223.69l-o
SN ₄ LM ₁	193.33j-n	172.27j-n	182.80j-n	245.59j-n	222.89j-n	234.24j-n
SN ₄ LM ₂	191.11j-n	170.05j-n	180.58j-n	241.87j-o	219.33j-o	230.60j-o
SN ₄ LM ₃	188.90k-n	167.84k-n	178.37k-n	238.53k-o	216.12k-o	227.33k-o
SN ₄ LM ₄	195.76i-m	174.70i-m	185.23i-m	249.67i-m	226.78i-m	238.23i-m
SN ₄ LM ₅	179.31no	158.25no	168.78no	221.13op	199.53op	210.33op
SN ₅ LM ₁	181.96m-o	160.90m-o	171.43m-o	227.83m-p	205.86m-p	216.85m-p
SN ₅ LM ₂	179.50no	158.44no	168.97no	224.00n-p	202.18n-p	213.09n-p
SN ₅ LM ₃	177.38no	156.32no	166.85no	220.24op	198.60op	209.42op
SN ₅ LM ₄	185.08l-o	164.02l-o	174.55l-o	232.10l-p	209.98l-p	221.04l-p
SN ₅ LM ₅	171.02o	149.96o	160.49o	208.73p	187.63p	198.18p
S.Em±	4.82	4.82	4.82	7.40	7.10	7.25

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

Table 45: Dry matter accumulation in green foliage (g plant⁻¹) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Dry matter accumulation in green foliage (g plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	7.49a	6.34a	6.92a	32.62a	29.64a	31.13a	53.39a	49.04a	51.22a
SN ₂	7.46ab	6.30ab	6.88ab	31.40a	28.42a	29.91a	51.79ab	47.44ab	49.62ab
SN ₃	7.40bc	6.24bc	6.82bc	29.70b	26.71b	28.21b	49.48bc	45.13bc	47.30bc
SN ₄	7.35c	6.20c	6.78bc	28.41bc	25.43c	26.92c	46.61c	42.26bc	44.44c
SN ₅	7.32c	6.17c	6.74c	27.45c	24.46c	25.96c	44.40c	40.04c	42.22c
S.Em±	0.02	0.02	0.02	0.44	0.44	0.44	0.38	0.38	0.38
CV (%)	7.24	7.47	7.34	6.89	6.26	6.93	7.58	8.25	7.18
Liquid manures (LM)									
LM ₁	7.44a	6.29a	6.86a	30.91ab	27.92ab	29.42ab	51.01ab	46.65ab	48.83ab
LM ₂	7.43a	6.27a	6.85a	30.54ab	27.55ab	29.05ab	50.40ab	46.04ab	48.22ab
LM ₃	7.42a	6.26a	6.84a	30.10b	27.11b	28.60b	49.79b	45.43b	47.61b
LM ₄	7.45a	6.30a	6.87a	31.30a	28.32a	29.81a	51.89a	47.53a	49.71a
LM ₅	7.29b	6.13b	6.71b	26.74c	23.76c	25.25c	42.60c	38.24c	40.42c
S.Em±	0.02	0.02	0.02	0.35	0.35	0.35	0.58	0.58	0.58
CV (%)	5.98	5.18	6.07	5.58	5.10	5.85	5.62	6.12	6.08
Interactions (SN x LM)									
SN ₁ LM ₁	7.55ab	6.39a	6.97a	34.16ab	31.17ab	32.67ab	56.00a	51.64ab	53.82ab
SN ₁ LM ₂	7.53a-c	6.38a	6.96a	33.83a-c	30.84ab	32.34a-c	55.63ab	51.27a-c	53.45ab
SN ₁ LM ₃	7.52a-d	6.37ab	6.95ab	33.52a-c	30.54a-c	32.03a-c	55.06ab	50.71a-c	52.89a-c
SN ₁ LM ₄	7.56a	6.40a	6.98a	34.55a	31.57a	33.06a	57.02a	52.66a	54.84a
SN ₁ LM ₅	7.31e-g	6.16j-m	6.74j-m	27.05h-j	24.06i-k	25.55h-j	43.26k-m	38.91l-n	41.09kl
SN ₂ LM ₁	7.50a-e	6.35a-d	6.93a-d	32.72a-d	29.73a-d	31.22a-d	54.21a-d	49.85a-e	52.03a-d
SN ₂ LM ₂	7.48a-f	6.33a-e	6.90a-e	32.44a-d	29.46a-d	30.95a-d	53.85a-d	49.49a-e	51.67a-d
SN ₂ LM ₃	7.47a-f	6.32a-e	6.89a-e	31.79be	28.80b-e	30.29b-e	53.14a-d	48.78a-e	50.96a-e
SN ₂ LM ₄	7.51a-d	6.36a-c	6.94a-c	33.20a-c	30.21a-c	31.70a-c	54.78a-c	50.42a-d	52.60a-c
SN ₂ LM ₅	7.31e-g	6.16j-m	6.74j-m	26.88ij	23.89i-k	25.39ij	43.01lm	38.65mn	40.83kl
SN ₃ LM ₁	7.43a-g	6.27c-g	6.85c-g	30.55d-g	27.56d-g	29.05d-g	51.5b-f2	47.17c-g	49.35b-f
SN ₃ LM ₂	7.42a-g	6.26d-h	6.84d-h	30.31d-g	27.33d-g	28.82d-g	50.69c-g	46.33d-h	48.51c-g
SN ₃ LM ₃	7.41a-g	6.25e-i	6.83e-i	29.64e-h	26.66e-h	28.15e-h	50.09d-h	45.74r-i	47.92d-h
SN ₃ LM ₄	7.44a-g	6.29b-f	6.86b-f	31.27c-f	28.28c-f	29.77c-f	52.68a-e	48.32a-f	50.50a-e
SN ₃ LM ₅	7.29fg	6.14k-m	6.71k-m	26.74ij	23.75i-k	25.25ij	42.43lm	38.07mn	40.25l
SN ₄ LM ₁	7.38a-g	6.22f-k	6.80f-k	29.14f-i	26.15f-j	27.64f-j	47.98f-j	43.63g-k	45.81f-j
SN ₄ LM ₂	7.37a-g	6.21f-k	6.79f-k	28.68f-j	25.69g-k	27.19f-j	47.39f-k	43.03g-l	45.21f-k
SN ₄ LM ₃	7.37a-g	6.21f-k	6.79f-k	28.34g-j	25.35g-k	26.85g-j	46.58g-l	42.23h-m	44.41g-l
SN ₄ LM ₄	7.40a-g	6.24e-j	6.82e-j	29.29e-i	26.31f-i	27.80e-i	48.91e-i	44.55f-j	46.73e-i
SN ₄ LM ₅	7.27g	6.12lm	6.69lm	26.62ij	23.64jk	25.13ij	42.21m	37.85n	40.03l
SN ₅ LM ₁	7.34c-g	6.19g-l	6.77g-l	27.99g-j	25.00g-k	26.50g-j	45.33i-m	40.98j-n	43.16i-l
SN ₅ LM ₂	7.33d-g	6.18h-m	6.76h-m	27.44h-j	24.45h-k	25.95h-j	44.44j-m	40.09k-n	42.27j-l
SN ₅ LM ₃	7.32e-g	6.17i-m	6.75i-m	27.20h-j	24.21h-k	25.70h-j	44.06j-m	39.71k-n	41.88j-l
SN ₅ LM ₄	7.35b-g	6.20f-l	6.78f-l	28.20g-j	25.22g-k	26.71g-j	46.05j-m	41.70i-n	43.88h-l
SN ₅ LM ₅	7.25g	6.09m	6.67m	26.43j	23.44lk	24.94j	42.09h-m	37.74n	39.92l
S.Em±	0.04	0.04	0.04	0.79	0.79	0.79	1.31	1.31	1.31

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

Contd....

Table 45 contd.....

Treatment	Dry matter accumulation in green foliage (g plant ⁻¹)					
	120 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	60.75a	56.06a	58.40a	23.50a	21.55a	22.52a
SN ₂	57.93ab	53.25ab	55.59ab	20.17ab	18.22ab	19.19ab
SN ₃	54.48bc	49.79bc	52.14bc	17.24bc	15.28bc	16.26bc
SN ₄	51.93cd	47.24cd	49.59cd	13.97cd	12.02cd	13.00cd
SN ₅	49.63d	44.94d	47.28d	10.74d	8.79d	9.76d
S.Em±	0.60	0.60	0.60	0.94	0.94	0.94
CV (%)	7.26	7.66	7.45	12.85	11.45	12.24
Liquid manures (LM)						
LM ₁	57.11 ab	52.42ab	54.77ab	19.58ab	17.63ab	18.61 ab
LM ₂	56.36ab	51.68ab	54.02ab	18.81ab	16.86ab	17.84ab
LM ₃	55.48b	50.80b	53.14b	17.87b	15.92b	16.89b
LM ₄	57.84a	53.15a	55.49a	20.60a	18.64a	19.62a
LM ₅	47.93c	43.24c	45.58c	8.76c	6.80c	7.78c
S.Em±	0.78	0.78	0.78	0.79	0.79	0.79
CV (%)	5.87	5.99	5.72	8.97	7.94	8.56
Interactions (SN x LM)						
SN ₁ LM ₁	64.21 ab	59.52a	61.87a	27.22ab	25.27ab	26.25ab
SN ₁ LM ₂	63.39ab	58.71ab	61.05ab	26.61ab	24.65ab	25.63ab
SN ₁ LM ₃	62.60a-c	57.91ab	60.26ab	25.63a-c	23.68a-c	24.66a-c
SN ₁ LM ₄	64.77a	60.08a	62.43a	28.04a	26.08a	27.06a
SN ₁ LM ₅	48.76l-n	44.07l-n	46.42k-n	9.99m-o	8.04k-m	9.02l-n
SN ₂ LM ₁	61.04a-e	56.35a-d	58.70a-d	23.24a-e	21.28a-d	22.26a-e
SN ₂ LM ₂	59.86a-f	55.18a-e	57.52a-e	22.50a-f	20.54a-e	21.52a-f
SN ₂ LM ₃	58.57b-g	53.88b-f	56.23b-f	21.80b-g	19.84b-e	20.82b-e
SN ₂ LM ₄	61.88a-d	57.19a-c	59.53a-c	24.12a-d	22.16a-d	23.14a-d
SN ₂ LM ₅	48.32l-n	43.63l-n	45.98l-n	9.21m-o	7.26k-m	8.24mn
SN ₃ LM ₁	56.58d-i	51.89d-h	54.23d-h	19.96c-h	18.01b-g	18.98c-h
SN ₃ LM ₂	55.87e-j	51.18e-i	53.52e-i	19.24d-i	17.29b-h	18.26c-j
SN ₃ LM ₃	54.91f-k	50.23e-j	52.57e-j	17.58e-j	15.63e-i	16.60d-j
SN ₃ LM ₄	57.28c-h	52.59c-g	54.93c-g	20.76c-g	18.80c-f	19.78b-g
SN ₃ LM ₅	47.77mn	43.08mn	45.43mn	8.65no	6.70lm	7.67mn
SN ₄ LM ₁	53.15g-m	48.47g-l	50.81g-l	16.04g-l	14.09f-j	15.06f-l
SN ₄ LM ₂	52.80h-n	48.12g-m	50.46g-m	14.75h-m	12.79g-k	13.77gm
SN ₄ LM ₃	51.96h-n	47.27h-n	49.61h-n	14.06i-n	12.10h-l	13.08h-n
SN ₄ LM ₄	54.10g-l	49.41f-k	51.75f-k	16.98f-k	15.03e-i	16.01e-k
SN ₄ LM ₅	47.63mn	42.94mn	45.29mn	8.04o	6.08lm	7.06n
SN ₅ LM ₁	50.57j-n	45.88j-n	48.22j-n	11.45k-o	9.50j-m	10.47j-n
SN ₅ LM ₂	49.89k-n	45.20j-n	47.55j-n	10.98l-o	9.03j-m	10.01k-n
SN ₅ LM ₃	49.38k-n	44.69k-n	47.04k-n	10.28l-o	8.33k-m	9.31l-n
SN ₅ LM ₄	51.15i-n	46.46i-n	48.81i-n	13.09j-o	11.14i-m	12.12i-n
SN ₅ LM ₅	47.14n	42.46n	44.80n	7.90o	5.95m	6.92n
S.Em±	1.74	1.74	1.74	1.77	1.77	1.77

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

respectively) as that of SN₁. Significantly lower DMA in green foliage was recorded in SN₅ (7.32, 6.17 and 6.74 g plant⁻¹, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher DMA in green foliage when compared to control (LM₅) in both years and on pooled basis. The lowest DMA in green foliage was recorded in control treatment (LM₅) (7.29, 6.13 and 6.71 g plant⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher DMA in green foliage in both years and on pooled basis (7.56, 6.40 and 6.98 g plant⁻¹, respectively). Significantly lower DMA in green foliage was recorded in SN₅LM₅ (7.25, 6.09 and 6.67 g plant⁻¹, respectively).

At 60DAS, significantly higher DMA in green foliage was recorded with treatments SN₁ (32.62, 29.64 and 31.13 g plant⁻¹, respectively) and SN₂ (31.40, 28.42 and 29.91 g plant⁻¹, respectively) and were on par compared to other sources of nitrogen in both years and on pooled basis. Significantly lower DMA in green foliage was recorded in SN₅ (27.45, 24.46 and 25.96 g plant⁻¹, respectively) as compared to SN₁.

Among the liquid manures, treatment LM₄ resulted in significantly higher DMA in green foliage (31.30, 28.32 and 29.81 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ were on par with LM₄. The lowest DMA in green foliage was recorded in treatment LM₅ (26.74, 23.76 and 25.25 g plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher DMA in green foliage in both years and on pooled basis (34.55, 31.57 and 33.06 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were on par with SN₁LM₄. Significantly lower DMA in green foliage was recorded by SN₅LM₅ (26.43, 23.44 and 24.94 g plant⁻¹, respectively).

At 90 DAS, among the sources of nitrogen, significantly higher DMA in green foliage recorded with SN₁ (53.39, 49.04 and 51.22 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments SN₂ which recorded on par DMA in green foliage (51.79, 47.44 and 49.62 g plant⁻¹, respectively) as that of SN₁. Significantly lower DMA in green foliage was recorded in SN₅ (44.40, 40.04 and 42.22 g plant⁻¹, respectively).

Among the liquid manures, significantly higher DMA in green foliage recorded with treatment LM₄ (51.89, 47.53 and 49.71 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ were on par with LM₄. The lowest DMA in green foliage was recorded in treatment LM₅ (42.60, 38.24 and 40.42 g plant⁻¹, respectively).

Among the treatment combinations, significantly higher DMA in green foliage recorded by SN₁LM₄ in both years and on pooled basis (57.02, 52.66 and 54.84g plant⁻¹, respectively). whereas, significantly lower DMA in green foliage was recorded in SN₅LM₅ (42.09, 37.74 and 39.92 g plant⁻¹, respectively).

At 120 DAS, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher DMA in green foliage (60.75, 56.06 and 58.40 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments which receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par DMA in green foliage (57.93, 53.25 and 55.59 g plant⁻¹, respectively) as that of SN₁. Significantly lower DMA of 49.63, 44.94 and 47.28 g plant⁻¹, respectively in green foliage was recorded in SN₅.

Among the liquid manures treatments LM₄ recorded significantly higher DMA in green foliage (57.84, 53.15 and 55.49 g plant⁻¹, respectively) in both years and on pooled basis. The treatments LM₁ and LM₂ were however found on par with LM₄. The lowest DMA in green foliage was recorded in treatment LM₅ (47.93, 43.24 and 45.58 g plant⁻¹, respectively).

Among the treatment combinations, treatment SN₁LM₄ applied with 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS recorded significantly higher DMA in green foliage in both years and on pooled basis (64.77, 60.08 and 62.43 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were found on par with SN₁LM₄. While, SN₅LM₅ accounted significantly lower DMA in green foliage (47.14, 42.46 and 44.80 g plant⁻¹, respectively).

Similar trend was observed with respect to influence of sources of nitrogen, liquid manures and their interactions on DMA in green foliage at harvest.

4.7.7 Dry matter accumulation in tuber

The data on dry matter accumulation (DMA) in tuber at various growth stages *viz.*, 60, 90, 120 DAS and at harvest as influenced by sources of nitrogen, liquid manures and their interactions are presented in Table 46.

At 60 DAS, among the sources of nitrogen, significantly higher DMA in tuber was recorded with treatments SN₁ (33.23, 30.99 and 32.11 g plant⁻¹, respectively) and SN₂ (33.16, 30.92 and 32.04 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, SN₃ found to be on par with SN₁ and SN₂. Significantly lower DMA in tuber was recorded in SN₅ (32.63, 30.39 and 31.51 g plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher DMA in tuber (33.23, 30.99 and 32.11 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ were on par with LM₄ with lowest DMA in tuber recorded in treatment LM₅ (32.37, 30.13 and 31.25 g plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher DMA in tuber in both years and on pooled basis (33.50, 31.26 and 32.38 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ remained on par with former treatment combination. SN₅LM₅ resulted in significantly lower DMA in tuber of 32.04, 29.80 and 30.92 g plant⁻¹, respectively.

At 90DAS, among the sources of nitrogen, significantly higher DMA in tuber was recorded with treatments SN₁ (57.06, 53.16 and 55.11g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, SN₂ was found on par with SN₁. Significantly lower DMA in tuber was recorded in SN₅ (53.86, 49.97 and 51.91 g plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher DMA in tuber (56.93, 53.03 and 54.98 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ found on par with LM₄. The lowest DMA in tuber was recorded in treatment LM₅ (52.63, 48.74 and 50.68 g plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher DMA in tuber in both years and on pooled basis (58.18, 54.29 and 56.24g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃, SN₂LM₄, SN₃LM₁ and SN₃LM₄ remained on par with former treatment combination. SN₅LM₅ resulted in significantly lower DMA in tuber of 51.97, 48.07 and 50.02 g plant⁻¹, respectively.

At 120 DAS, among the sources of nitrogen, significantly higher DMA in tuber was recorded with treatments SN₁ (105.44, 100.23 and 102.83 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, SN₂ recorded on par DMA in tuber (104.10, 98.89 and 101.50 g plant⁻¹, respectively) as that of SN₁. Significantly lower DMA in tuber was recorded in SN₅ (98.86, 93.65 and 96.25 g plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher DMA in tuber (104.40, 99.19 and 101.80 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. However, treatments LM₁ and LM₂ were on par with LM₄. The lowest DMA in tuber was recorded in treatment LM₅ (97.27, 92.06 and 94.66 g plant⁻¹, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher DMA in tuber in both years and on pooled basis (108.22, 103.01 and 105.61 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃ and SN₂LM₄ treatments were found on par with SN₁LM₄. While, treatment SN₅LM₅ resulted in significantly lower DMA in tuber of 96.41, 91.19 and 93.80 g plant⁻¹, respectively.

At harvest, among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher DMA in tuber (199.44, 193.79 and 196.61 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) which recorded on par DMA in tuber (198.10, 192.45 and 195.28 g plant⁻¹, respectively) as that of SN₁. Significantly lower DMA in tuber was recorded in SN₅ (192.86, 187.21 and 190.03 g plant⁻¹, respectively).

Table 46: Dry matter accumulation in tuber (g plant⁻¹) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Dry matter accumulation in tuber (g plant ⁻¹)					
	60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	33.23a	30.99a	32.11a	57.06a	53.16a	55.11a
SN ₂	33.16a	30.92a	32.04a	56.66ab	52.76ab	54.71ab
SN ₃	33.06ab	30.82ab	31.94b	56.14b	52.25b	54.20b
SN ₄	32.91b	30.67b	31.79b	55.28c	51.38c	53.33c
SN ₅	32.63c	30.39c	31.51c	53.86d	49.97d	51.91d
S.Em±	0.06	0.06	0.06	0.25	0.25	0.25
CV (%)	6.75	7.06	6.95	7.74	7.88	7.81
Liquid manures (LM)						
LM ₁	33.17ab	30.93ab	32.05ab	56.69ab	52.79ab	54.74ab
LM ₂	33.13ab	30.89ab	32.01b	56.50ab	52.61ab	54.55ab
LM ₃	33.09b	30.85b	31.97b	56.25b	52.36b	54.31b
LM ₄	33.23a	30.99a	32.11a	56.93a	53.03a	54.98a
LM ₅	32.37c	30.13c	31.25c	52.63c	48.74c	50.68c
S.Em±	0.05	0.05	0.05	0.19	0.19	0.19
CV (%)	5.58	5.98	5.79	6.28	6.43	6.24
Interactions (SN x LM)						
SN ₁ LM ₁	33.38ab	31.14ab	32.26ab	58.09ab	54.20ab	56.15ab
SN ₁ LM ₂	33.36ab	31.12ab	32.24a-c	58.00ab	54.10ab	56.05ab
SN ₁ LM ₃	33.35ab	31.11a-c	32.23a-c	57.80ab	53.90a-c	55.85a-c
SN ₁ LM ₄	33.50a	31.26a	32.38a	58.18a	54.29a	56.24a
SN ₁ LM ₅	32.57g-i	30.33i-k	31.45k-m	53.22a-k	49.33i-k	51.27j-l
SN ₂ LM ₁	33.33ab	31.08a-c	32.20a-c	57.65a-d	53.76a-c	55.71a-c
SN ₂ LM ₂	33.31ab	31.07a-c	32.19a-c	57.49a-d	53.60a-d	55.54a-d
SN ₂ LM ₃	33.29a-c	31.05a-d	32.17b-d	57.38a-d	53.49a-d	55.43a-e
SN ₂ LM ₄	33.34ab	31.10a-c	32.22a-c	57.74a-c	53.85a-c	55.80a-c
SN ₂ LM ₅	32.54g-i	30.30j-l	31.42lm	53.02i-k	49.13i-k	51.08k-m
SN ₃ LM ₁	33.23a-d	30.99a-d	32.11b-f	57.13a-e	53.23a-e	55.18a-e
SN ₃ LM ₂	33.20a-d	30.96a-e	32.08b-g	56.96a-e	53.07a-e	55.01b-f
SN ₃ LM ₃	33.17a-d	30.93b-e	32.05c-g	56.70b-e	52.80a-f	54.75c-g
SN ₃ LM ₄	33.27a-c	31.03a-d	32.15b-e	57.25a-e	53.35a-e	55.30a-e
SN ₃ LM ₅	32.42hi	30.18kl	31.30mn	52.69jk	48.80i-k	50.75lm
SN ₄ LM ₁	33.08b-e	30.84b-f	31.96e-h	56.26d-g	52.36c-f	54.31e-g
SN ₄ LM ₂	33.05b-e	30.81c-g	31.93f-h	55.93e-g	52.03d-f	53.98f-h
SN ₄ LM ₃	33.01b-f	30.77b-g	31.89g-i	55.60f-g	51.70e-g	53.65gh
SN ₄ LM ₄	33.12b-e	30.88b-f	32.00d-g	56.37c-g	52.47b-f	54.42d-g
SN ₄ LM ₅	32.28ij	30.04lm	31.16n	52.24k	48.35jk	50.30l-m
SN ₅ LM ₁	32.84d-g	30.60f-i	31.72ij	54.31hi	50.42g-i	52.36ij
SN ₅ LM ₂	32.73e-h	30.49g-j	31.61jk	54.12hi	50.23g-i	52.18ij
SN ₅ LM ₃	32.64f-i	30.40g-k	31.52kl	53.80h-j	49.91h-j	51.86jk
SN ₅ LM ₄	32.92c-g	30.68e-h	31.80hi	55.10gh	51.21f-h	53.16hi
SN ₅ LM ₅	32.04j	29.80m	30.92o	51.97lk	48.07lk	50.02lm
S.Em±	0.11	0.11	0.11	0.43	0.43	0.43

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

Contd....

Table 46 contd.....

Treatment	Dry matter accumulation in tuber (g plant ⁻¹)					
	120 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	105.44a	100.23a	102.83a	199.44a	193.79a	196.61a
SN ₂	104.10ab	98.89ab	101.50ab	198.10ab	192.45ab	195.28ab
SN ₃	102.54b	97.33bc	99.94bc	196.54bc	190.89bc	193.72bc
SN ₄	100.73c	95.51cd	98.12cd	194.73cd	189.07cd	191.90cd
SN ₅	98.86d	93.65d	96.25d	192.86d	187.21d	190.03d
S.Em±	0.54	0.54	0.54	0.79	0.79	0.79
CV (%)	7.65	7.55	7.28	7.56	7.60	7.58
Liquid manures (LM)						
LM ₁	103.83ab	98.62ab	101.22ab	197.83a	192.18a	195.00a
LM ₂	103.37ab	98.16ab	100.76ab	197.37a	191.72a	194.54a
LM ₃	102.80b	97.59b	100.19b	196.80a	191.15a	193.97a
LM ₄	104.40a	99.19a	101.80a	198.40a	192.75a	195.58a
LM ₅	97.27c	92.06c	94.66c	191.27b	185.62b	188.44b
S.Em±	0.41	0.41	0.41	0.61	0.61	0.61
CV (%)	6.58	6.09	6.57	6.27	6.23	6.22
Interactions (SN x LM)						
SN ₁ LM ₁	107.39ab	102.17ab	104.78ab	201.39ab	195.73ab	198.56ab
SN ₁ LM ₂	107.00a-c	101.79a-c	104.39ab	201.00a-c	195.35ab	198.17a-c
SN ₁ LM ₃	106.40a-d	101.18a-d	103.79a-c	200.40a-d	194.74a-c	197.57a-d
SN ₁ LM ₄	108.22a	103.01a	105.61a	202.22a	196.57a	199.39a
SN ₁ LM ₅	98.20n-q	92.99n-q	95.59k-n	192.20k-n	186.55j-m	189.37k-n
SN ₂ LM ₁	106.04a-e	100.83a-e	103.44a-c	200.04a-d	194.39a-d	197.22a-e
SN ₂ LM ₂	105.67a-e	100.46a-f	103.06a-d	199.67a-e	194.02a-e	196.84a-e
SN ₂ LM ₃	105.10a-e	99.88a-f	102.49a-e	199.10a-f	193.44a-f	196.27a-f
SN ₂ LM ₄	106.07a-e	100.85a-e	103.46a-c	200.07a-d	194.41a-d	197.24a-e
SN ₂ LM ₅	97.64o-q	92.43o-q	95.03l-n	191.64l-n	185.99k-m	188.81l-n
SN ₃ LM ₁	104.11c-h	98.89c-h	101.50b-g	198.11a-h	192.45a-g	195.28a-h
SN ₃ LM ₂	103.57d-i	98.35d-i	100.96c-h	197.57a-i	191.91a-h	194.74a-i
SN ₃ LM ₃	103.03e-j	97.82e-j	100.42c-i	197.03b-j	191.38b-i	194.20b-j
SN ₃ LM ₄	104.72b-g	99.51b-g	102.12b-f	198.72a-g	193.07a-f	195.90a-g
SN ₃ LM ₅	97.29pq	92.07pq	94.68mn	191.29mn	185.63k-m	188.46l-n
SN ₄ LM ₁	101.89g-l	96.67g-l	99.28e-j	195.89d-l	190.23c-k	193.06d-l
SN ₄ LM ₂	101.40h-m	96.19h-m	98.79f-k	195.40e-m	189.75d-l	192.57e-m
SN ₄ LM ₃	100.95i-n	95.74i-n	98.34g-l	194.95f-n	189.30e-m	192.12f-n
SN ₄ LM ₄	102.58f-k	97.36f-k	99.97d-i	196.58c-k	190.92b-j	193.75c-k
SN ₄ LM ₅	96.83pq	91.61pq	94.22n	190.83n	185.17l-m	188.00mn
SN ₅ LM ₁	99.73k-p	94.52k-p	97.12i-n	193.73h-n	188.08g-m	190.90h-n
SN ₅ LM ₂	99.21l-q	94.00l-q	96.61j-n	193.21i-n	187.56h-m	190.39i-n
SN ₅ LM ₃	98.53m-q	93.32m-q	95.92j-n	192.53j-n	186.88i-m	189.70j-n
SN ₅ LM ₄	100.43j-o	95.22j-o	97.82h-m	194.43g-n	188.78f-m	191.60g-n
SN ₅ LM ₅	96.41q	91.19q	93.80n	190.41n	184.75m	187.58n
S.Em±	0.92	0.92	0.92	1.36	1.36	1.36

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher DMA in tuber (196.80 to 198.40, 191.15 to 192.75 and 193.97 to 195.58 g plant⁻¹, respectively) when compared to control (LM₅) in both years and on pooled basis. The lowest DMA in tuber was recorded in treatment LM₅ (191.27, 185.62 and 188.44 g plant⁻¹, respectively).

The interaction effect due to sources of nitrogen (SN) and liquid manures (LM) on DMA in tuber was found to be significant. Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher DMA in tuber in both years and on pooled basis (202.22, 196.57 and 199.39 g plant⁻¹, respectively). Significantly lower DMA in tuber was recorded in SN₅LM₅ (190.41, 184.75 and 187.58 g plant⁻¹, respectively).

4.7.8 Total dry matter production (g plant⁻¹)

Total dry matter production (TDMP) of sugar beet varied significantly due to sources of nitrogen, liquid manures and their interactions during 2010-11, 2011-12 and on pooled basis (Table 47).

At 30DAS, among the sources of nitrogen, significantly higher TDMP was recorded with application of 100 per cent RDN through inorganic fertilizer (SN₁) (7.49, 6.34 and 6.92 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) which recorded on par TDMP (7.46, 6.30 and 6.88 g plant⁻¹, respectively) as that of SN₁. Significantly lower TDMP was recorded in SN₅ (7.32, 6.17 and 6.74 g plant⁻¹, respectively) as compared to SN₁.

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher TDMP when compared to control (LM₅) in both years and on pooled basis. The lowest TDMP was recorded in treatment LM₅ (7.29, 6.13 and 6.71 g plant⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher TDMP in both years and on pooled basis (7.56, 6.40 and 6.98 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃ and SN₂LM₄ remained on par with former treatment combination. Significantly lower TDMP was recorded in SN₅LM₅ (7.25, 6.09 and 6.67 g plant⁻¹, respectively).

At 60 DAS, among the sources of nitrogen, significantly higher TDMP was recorded with treatments SN₁ (65.85, 60.63 and 63.24 g plant⁻¹, respectively) and SN₂ (64.57, 59.34 and 61.95 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. Significantly lower TDMP was recorded in SN₅ (60.09, 54.86 and 57.47 g plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher TDMP (64.53, 59.30 and 61.92 g plant⁻¹, respectively) in both years and on pooled basis. However, treatments LM₁ and LM₂ found on par with LM₄. The lowest TDMP was recorded in treatment LM₅ (59.11, 53.89 and 56.50 g plant⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher TDMP in both years and on pooled basis (68.05, 62.83 and 65.44 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower TDMP was recorded in SN₅LM₅ (58.47, 53.24 and 55.85 g plant⁻¹, respectively).

At 90 DAS, among the sources of nitrogen, significantly higher TDMP recorded with SN₁ (110.45, 102.20 and 106.33 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, SN₂ recorded on par TDMP (108.45, 100.20 and 104.33 g plant⁻¹, respectively) as that of SN₁. While, SN₅ recorded significantly lower TDMP (98.26, 90.01 and 94.13 g plant⁻¹, respectively).

Among the liquid manures, treatment LM₄ resulted in significantly higher TDMP (108.82, 100.57 and 104.69 g plant⁻¹, respectively) in both years and on pooled basis. Whereas, treatments LM₁ and LM₂ were on par with LM₄. The lowest TDMP of 95.23, 86.98 and 91.10 g plant⁻¹, respectively was recorded in treatment LM₅.

Table 47: Total dry matter production (g plant⁻¹) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Total dry matter production (g plant ⁻¹)								
	30 DAS			60 DAS			90 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	7.49a	6.34a	6.92a	65.85a	60.63a	63.24a	110.45a	102.20a	106.33a
SN ₂	7.46ab	6.30ab	6.88ab	64.57a	59.34a	61.95a	108.45ab	100.20ab	104.33ab
SN ₃	7.40bc	6.24bc	6.82bc	62.76b	57.53b	60.15b	105.63bc	97.38bc	101.50bc
SN ₄	7.35c	6.20c	6.78c	61.32c	56.09c	58.71c	101.89c	93.64cd	97.77c
SN ₅	7.32c	6.17c	6.74c	60.09c	54.86c	57.47c	98.26d	90.01d	94.13d
S.Em±	0.02	0.02	0.02	0.40	0.40	0.40	0.46	0.46	0.46
CV (%)	7.24	7.67	7.35	7.44	7.66	7.54	7.69	7.83	7.75
Liquid manures (LM)									
LM ₁	7.44a	6.29a	6.86a	64.08ab	58.85ab	61.47ab	107.70ab	99.45ab	103.57ab
LM ₂	7.43a	6.27a	6.85a	63.67ab	58.44ab	61.06ab	106.90ab	98.65ab	102.77ab
LM ₃	7.42a	6.26a	6.84a	63.19b	57.96b	60.58b	106.04b	97.79b	101.92b
LM ₄	7.45a	6.30a	6.87a	64.53a	59.30a	61.92a	108.82a	100.57a	104.69a
LM ₅	7.29b	6.13b	6.71b	59.11c	53.89c	56.50c	95.23c	86.98c	91.10c
S.Em±	0.02	0.02	0.02	0.36	0.36	0.36	0.66	0.66	0.66
CV (%)	5.98	6.18	6.07	6.24	6.39	5.98	6.43	6.52	6.18
Interactions (SN x LM)									
SN ₁ LM ₁	7.55ab	6.39a	6.97a	67.54ab	62.31ab	64.93ab	114.09ab	105.84ab	109.97ab
SN ₁ LM ₂	7.53a-c	6.38a	6.96a	67.19ab	61.96ab	64.58a-c	113.62ab	105.37ab	109.50ab
SN ₁ LM ₃	7.52a-d	6.37ab	6.95ab	66.87a-c	61.64a-c	64.26a-c	112.86a-c	104.61a-c	108.74a-c
SN ₁ LM ₄	7.56a	6.40a	6.98a	68.05a	62.83a	65.44a	115.20a	106.95a	111.07a
SN ₁ LM ₅	7.31e-g	6.16j-m	6.74j-m	59.61k-l	54.39k-n	57.00j-m	96.48kl	88.23m-o	92.36kl
SN ₂ LM ₁	7.50a-e	6.35a-d	6.93a-d	66.04a-d	60.82a-d	63.43a-d	111.86a-d	103.61a-d	107.74a-d
SN ₂ LM ₂	7.48a-f	6.33a-c	6.90a-e	65.76a-d	60.53a-d	63.14a-d	111.33a-d	103.08a-d	107.21a-d
SN ₂ LM ₃	7.47a-f	6.32a-c	6.89a-e	65.08b-e	59.85b-e	62.46b-e	110.51a-e	102.26a-e	106.39a-e
SN ₂ LM ₄	7.51a-d	6.36a-c	6.94a-c	66.53a-c	61.30a-c	63.92a-c	112.52a-c	104.27a-c	108.40a-d
SN ₂ LM ₅	7.31e-g	6.16j-m	6.74j-m	59.43l-n	54.20l-n	56.81k-m	96.03kl	87.78m-o	91.90kl
SN ₃ LM ₁	7.43a-g	6.27c-g	6.85c-g	63.77d-g	58.54b-g	61.16d-g	108.65b-f	100.40b-f	104.53e-f
SN ₃ LM ₂	7.42a-g	6.26d-h	6.84d-h	63.52d-h	58.29g-h	60.90d-h	107.65c-d	99.40c-g	103.52c-g
SN ₃ LM ₃	7.41a-g	6.25e-i	6.83e-i	62.82e-i	57.59e-i	60.20e-i	106.79d-g	98.54d-h	102.67d-g
SN ₃ LM ₄	7.44a-g	6.29b-f	6.86d-f	64.54c-f	59.31c-f	61.92c-f	109.93a-e	101.68a-e	105.80a-e
SN ₃ LM ₅	7.29fg	6.14k-m	6.71k-m	59.16l-n	53.94l-n	56.55lm	95.12l	86.87no	91.00l
SN ₄ LM ₁	7.38a-g	6.22f-k	6.80f-k	62.22f-k	56.99f-k	59.60f-k	104.24f-i	95.99f-j	100.12f-i
SN ₄ LM ₂	7.37a-g	6.21f-k	6.79f-k	61.73g-l	56.50g-l	59.12g-l	103.32f-j	95.07g-k	99.19f-i
SN ₄ LM ₃	7.37a-g	6.21f-j	6.79f-k	61.35g-m	56.12g-m	58.73g-l	102.18g-j	93.93h-l	98.06g-j
SN ₄ LM ₄	7.40a-g	6.24e-j	6.82e-j	62.41f-j	57.18f-j	59.80e-j	105.27e-j	97.02e-i	101.15e-h
SN ₄ LM ₅	7.27g	6.12lm	6.69lm	58.90mn	53.68mn	56.29lm	94.45l	86.20no	90.32l
SN ₅ LM ₁	7.34c-g	6.19g-l	6.77g-l	60.83i-n	55.60i-n	58.22h-m	99.64i-l	91.39j-n	95.52i-l
SN ₅ LM ₂	7.33d-g	6.18h-m	6.76hm	60.17j-n	54.94j-n	57.56i-m	98.57j-l	90.32k-o	94.44j-l
SN ₅ LM ₃	7.32e-g	6.17i-m	6.75i-m	59.84j-n	54.61j-n	57.22j-m	97.87j-l	89.62l-o	93.74j-l
SN ₅ LM ₄	7.35b-g	6.20f-l	6.78f-n	61.12h-n	55.89h-n	58.51g-m	101.16h-k	92.91i-m	97.03h-k
SN ₅ LM ₅	7.25g	6.09m	6.67m	58.47n	53.24n	55.85m	94.06l	85.81o	89.94l
S.Em±	0.04	0.04	0.04	0.80	0.80	0.80	1.47	1.47	1.47

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

Contd....

Table 47 contd.....

Treatment	Total dry matter production (g plant ⁻¹)					
	120 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	166.19a	156.29a	161.24a	222.94a	215.33a	219.14a
SN ₂	162.04ab	152.14ab	157.09ab	218.27ab	210.67ab	214.47ab
SN ₃	157.02bc	147.12bc	152.07bc	213.78bc	206.17bc	209.98bc
SN ₄	152.66cd	142.76bc	147.71bc	208.70cd	201.09cd	204.90cd
SN ₅	148.49d	138.59c	143.54c	203.60d	196.00d	199.80d
S.Em±	0.91	0.91	0.91	1.61	1.61	1.61
CV (%)	8.24	8.39	8.31	7.92	8.03	7.97
Liquid manures (LM)						
LM ₁	160.94ab	151.04ab	155.99ab	217.41ab	209.80ab	213.61ab
LM ₂	159.73ab	149.83ab	154.78ab	216.18ab	208.58ab	212.38ab
LM ₃	158.28b	148.38b	153.33b	214.67b	207.06b	210.87b
LM ₄	162.24a	152.34a	157.29a	219.00a	211.39a	215.20a
LM ₅	145.20c	135.30c	140.25c	200.03c	192.42c	196.23c
S.Em±	0.98	0.98	0.98	1.02	1.02	1.02
CV (%)	6.40	6.56	6.67	5.85	6.34	6.37
Interactions (SN x LM)						
SN ₁ LM ₁	171.60a	161.69a	166.64a	228.61ab	221.00ab	224.80ab
SN ₁ LM ₂	170.39ab	160.49ab	165.44ab	227.61ab	220.00ab	223.80a-c
SN ₁ LM ₃	168.99a-c	159.09a-c	164.04a-c	226.03a-c	218.42a-c	222.22ad
SN ₁ LM ₄	172.99a	163.09a	168.04a	230.26a	222.65a	226.46a
SN ₁ LM ₅	146.96m-p	137.06m-p	142.01n-p	202.19l-n	194.59l-n	198.39m-p
SN ₂ LM ₁	167.08a-d	157.18a-d	162.13a-d	223.28a-d	215.67a-d	219.48a-e
SN ₂ LM ₂	165.53a-e	155.63a-e	160.58a-e	222.16a-e	214.56a-e	218.36a-f
SN ₂ LM ₃	163.67b-f	153.77b-f	158.72b-f	220.89b-f	213.29b-f	217.09b-g
SN ₂ LM ₄	167.94a-d	158.04a-d	162.99a-d	224.18a-d	216.57a-d	220.38a-e
SN ₂ LM ₅	145.96n-p	136.06n-p	141.01n-p	200.85mn	193.24mn	197.05n-p
SN ₃ LM ₁	160.69d-h	150.78e-h	155.73d-h	218.07c-h	210.46c-h	214.26d-i
SN ₃ LM ₂	159.44e-i	149.53e-i	154.49e-i	216.81d-i	209.20d-i	213.00e-j
SN ₃ LM ₃	157.94f-j	148.04f-j	152.99f-j	214.61e-j	207.00e-j	210.80f-k
SN ₃ LM ₄	162.00c-g	152.10c-g	157.05c-g	219.48c-g	211.87c-g	215.68c-h
SN ₃ LM ₅	145.06op	135.16op	140.11op	199.94mn	192.33mn	196.13op
SN ₄ LM ₁	155.04g-l	145.14g-l	150.09g-l	211.92g-k	204.32g-k	208.12h-l
SN ₄ LM ₂	154.20h-m	144.30h-m	149.25h-m	210.15h-l	202.54h-l	206.34i-m
SN ₄ LM ₃	152.91i-n	143.01i-n	147.96i-l	209.01i-l	201.40i-l	205.20j-n
SN ₄ LM ₄	156.68f-k	146.77f-k	151.73f-k	213.56f-j	205.95f-j	209.76g-k
SN ₄ LM ₅	144.46op	134.56op	139.51op	198.86n	191.25n	195.06p
SN ₅ LM ₁	150.30k-p	140.40j-p	145.35j-p	205.18k-n	197.57k-n	201.37l-p
SN ₅ LM ₂	149.10k-p	139.20k-p	144.15k-p	204.20k-n	196.59k-n	200.39l-p
SN ₅ LM ₃	147.91l-p	138.01l-p	142.96l-p	202.81l-n	195.21l-n	199.01m-p
SN ₅ LM ₄	151.58j-o	141.68j-o	146.63j-o	207.52j-m	199.91j-m	203.72k-o
SN ₅ LM ₅	143.55p	133.65p	138.60p	198.31n	190.70n	194.50p
S.Em±	2.18	2.18	2.18	2.28	2.28	2.28

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF

SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion

SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion

SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion

SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS

LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS

LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS

LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS

LM₅- Control (no spray)

Among the treatment combinations, SN₁LM₄ accounted significantly higher TDMP in both years and on pooled basis (115.20, 106.95 and 111.07 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂, SN₂LM₃, SN₂LM₄ and SN₃LM₄ treatments were found on par with SN₁LM₄. Significantly lower TDMP was recorded in SN₅LM₅ (94.06, 85.81 and 89.94 g plant⁻¹, respectively).

At 120 DAS, among the sources of nitrogen, the treatment which received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher TDMP (166.19, 156.29 and 161.24 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, the treatment which receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par TDMP (162.04, 152.14 and 157.09 g plant⁻¹, respectively) as that of SN₁. Significantly lower TDMP of 148.49, 138.59 and 143.54 g plant⁻¹, respectively was recorded in treatment SN₅ which received 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion.

Among the liquid manures treatments, foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (LM₄) recorded significantly higher TDMP (162.24, 152.34 and 157.29 g plant⁻¹, respectively). However, the treatment which received soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS (LM₁) and foliar spray of VW (20 %) at 30 and 60 DAS (LM₂) recorded on par TDMP as that of LM₄. The lowest TDMP was recorded in treatment LM₅ (145.20, 135.30 and 140.25 g plant⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher TDMP in both years and on pooled basis (172.99, 163.09 and 168.04 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower TDMP was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (143.55, 133.65 and 138.60 g plant⁻¹, respectively).

At harvest, among the sources of nitrogen, the treatment which received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher TDMP (222.94, 215.33 and 219.14 g plant⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, the treatment which receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par TDMP (218.27, 210.67 and 214.47 g plant⁻¹, respectively) as that of SN₁. Significantly lower TDMP was recorded in treatment SN₅ which received 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (203.60, 196.00 and 199.80 g plant⁻¹, respectively).

Among the liquid manures treatments, foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (LM₄) recorded significantly higher TDMP (219.00, 211.39 and 215.20 g plant⁻¹, respectively). However, the treatment which received soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS (LM₁) and foliar spray of VW (20 %) at 30 and 60 DAS (LM₂) recorded on par TDMP as that of LM₄. The lowest TDMP of 200.03, 192.42 and 196.23 g plant⁻¹, respectively was recorded in treatment LM₅.

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher TDMP in both years and on pooled basis (230.26, 222.65 and 226.46 g plant⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower TDMP was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (198.31, 190.70 and 194.50 g plant⁻¹, respectively).

4.8 Yield and yield components of sugar beet

4.8.1 Tuber weight (g plant⁻¹)

The tuber weight of sugar beet was significantly influenced by the application of sources of nitrogen, liquid manures and their interaction during 2010-11, 2011-12 and on pooled basis (Table 48).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher tuber weight (1165.25, 1142.40 and 1153.82 g plant⁻¹, respectively)

Table 48: Yield parameters of sugar beet at harvest as influenced by sources of nitrogen and liquid manures

Treatment	Tuber weight (g plant ⁻¹)			Tuber length (cm)			Tuber girth (cm)		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	1165.25a	1142.40a	1153.82a	39.30a	36.73a	38.01a	28.00a	26.23a	27.11a
SN ₂	1107.52ab	1085.80ab	1096.66ab	37.40ab	34.96ab	36.18ab	27.63a	25.88a	26.75a
SN ₃	1033.26bc	1013.00bc	1023.13bc	36.08bc	33.72bc	34.90bc	27.38a	25.59a	26.49a
SN ₄	967.78cd	948.80cd	958.29cd	34.94bc	32.65bc	33.79bc	26.44ab	24.86ab	25.65ab
SN ₅	908.41d	890.60d	899.51d	33.72c	31.52c	32.62c	25.24b	23.97b	24.60b
S.Em±	24.34	23.87	24.11	0.82	0.76	0.79	0.57	0.46	0.50
CV (%)	9.10	8.99	9.32	8.70	9.01	8.85	8.14	7.03	7.44
Liquid manures (LM)									
LM ₁	1095.48ab	1074.00ab	1084.74ab	37.33a	34.88a	36.10a	27.75a	25.93a	26.84a
LM ₂	1074.88ab	1053.80ab	1064.34ab	36.87a	34.46a	35.66a	27.63a	25.82a	26.72a
LM ₃	1057.94b	1037.20b	1047.57b	36.60a	34.21a	35.41a	27.46a	25.66a	26.56a
LM ₄	1116.70a	1094.80a	1105.75a	37.80a	35.33a	36.56a	27.87a	26.04a	26.96a
LM ₅	837.22c	820.80c	829.01c	32.84b	30.69b	31.76b	23.99b	23.07b	23.53b
S.Em±	18.54	18.18	18.36	0.65	0.61	0.63	0.67	0.56	0.61
CV (%)	6.93	6.67	6.64	6.98	6.98	6.35	9.61	8.58	8.98
Interactions (SN x LM)									
SN ₁ LM ₁	1244.40ab	1220.00ab	1232.20ab	40.80ab	38.13ab	39.46ab	28.58a	26.71ab	27.64a
SN ₁ LM ₂	1218.90a-c	1195.00a-c	1206.95a-c	40.36a-c	37.72a-c	39.04a-c	28.44ab	26.58ab	27.51ab
SN ₁ LM ₃	1210.74-ac	1187.00a-c	1198.87a-c	39.63a-d	37.04a-d	38.34a-d	28.27ab	26.42ab	27.34ab
SN ₁ LM ₄	1263.78a	1239.00a	1251.39a	41.61a	38.89a	40.25a	28.85a	26.96a	27.90a
SN ₁ LM ₅	888.42m-p	871.00m-p	879.71m-p	34.09e-i	31.86e-i	32.98e-i	25.84ab	24.46ab	25.15ab
SN ₂ LM ₁	1179.12a-e	1156.00a-e	1167.56a-e	38.63a-e	36.10a-e	37.36a-e	28.16ab	26.32ab	27.24ab
SN ₂ LM ₂	1155.66a-f	1133.00a-f	1144.33a-f	38.28a-f	35.78a-f	37.03a-f	28.10ab	26.26ab	27.18ab
SN ₂ LM ₃	1134.24a-g	1112.00a-g	1123.12a-g	37.70a-g	35.23a-g	36.46a-g	28.02ab	26.19ab	27.11ab
SN ₂ LM ₄	1198.50a-d	1175.00a-d	1186.75a-d	39.10a-e	36.54a-e	37.82a-e	28.24ab	26.39ab	27.31ab
SN ₂ LM ₅	870.06n-p	853.00n-p	861.53n-p	33.31f-i	31.13f-i	32.22f-i	25.60ab	24.24ab	24.92ab
SN ₃ LM ₁	1090.38c-i	1069.00c-i	1079.69c-i	37.15a-h	34.72a-h	35.94a-h	27.84ab	26.02ab	26.93ab
SN ₃ LM ₂	1073.04d-j	1052.00d-j	1062.52d-j	36.72a-i	34.32a-i	35.52a-i	27.75ab	25.93ab	26.84ab
SN ₃ LM ₃	1053.66e-k	1033.00e-k	1043.33e-k	36.39b-i	34.01b-i	35.20b-i	27.60ab	25.79ab	26.69ab
SN ₃ LM ₄	1119.96b-h	1098.00b-h	1108.98b-h	37.43a-g	34.98a-g	36.20a-g	27.94ab	26.11ab	27.02ab
SN ₃ LM ₅	829.26op	813.00op	821.13op	32.69g-i	30.55g-i	31.62g-i	25.80ab	24.11ab	24.95ab
SN ₄ LM ₁	1017.96g-m	998.00g-m	1007.98g-m	35.82b-i	33.48b-i	34.65b-i	27.33ab	25.54ab	26.43ab
SN ₄ LM ₂	992.h-n46	973.00h-n	982.73h-n	35.43c-i	33.11c-i	34.27c-i	27.17ab	25.39ab	26.28ab
SN ₄ LM ₃	983.2h-n8	964.00h-n	973.64h-n	34.98d-i	32.69d-i	33.83d-i	27.04ab	25.27ab	26.15ab
SN ₄ LM ₄	1031.22f-l	1011.00f-l	1021.11f-l	36.23b-i	33.86b-i	35.05b-i	27.42ab	25.63ab	26.53ab
SN ₄ LM ₅	813.96op	798.00op	805.98op	32.23hi	30.12hi	31.17hi	23.25ab	22.48ab	22.87ab
SN ₅ LM ₁	945.54j-o	927.00j-o	936.27j-o	34.23e-i	31.99e-i	33.11e-i	26.81ab	25.06ab	25.94ab
SN ₅ LM ₂	934.32k-o	916.00k-o	925.16k-o	33.56f-i	31.36f-i	32.46f-i	26.69ab	24.94ab	25.81ab
SN ₅ LM ₃	907.80l-p	890.00l-p	898.90l-p	34.33e-i	32.08e-i	33.20e-i	26.36ab	24.64ab	25.50ab
SN ₅ LM ₄	970.02i-n	951.00i-n	960.51i-n	34.64d-i	32.37d-i	33.50e-i	26.89ab	25.13ab	26.01ab
SN ₅ LM ₅	784.38p	769.00p	776.69p	31.86i	29.78i	30.82i	19.45c	20.07c	19.76c
S.Em±	41.47	40.65	41.06	1.46	1.37	1.42	1.49	1.25	1.35

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75% RDN through IF +25% RDN through VC and PM in equal proportion
 SN₃-50% RDN through IF + 50% RDN through VC and PM in equal proportion
 SN₄-25% RDN through IF +75% RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100%) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20%) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10%) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20%) and CU (10%) at 30 and 60 DAS
 LM₅- Control (no spray)

compared to other sources of nitrogen in both years and on pooled basis. The treatments which received 75 per cent RDN through inorganic fertilizer (IF) +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par tuber weight (1107.52, 1085.80 and 1096.66 g plant⁻¹, respectively) as that of SN₁. Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN₅) recorded significantly lower tuber weight (908.41, 890.60 and 899.51 g plant⁻¹, respectively).

Among the liquid manures treatments, foliar spray of vermiwash (VW) (20 %) and cow urine (CU) (10 %) at 30 and 60 DAS (LM₄) recorded significantly higher tuber weight (1116.70, 1094.80 and 1105.75 g plant⁻¹, respectively) in both years and on pooled basis. However, the treatments which received soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS (LM₁) and foliar spray of VW (20 %) at 30 and 60 DAS (LM₂) were found to be on par with LM₄. The lowest tuber weight was recorded in treatment LM₅ in both years and on pooled basis (837.22, 820.80 and 829.01 g plant⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher tuber weight in both years and on pooled basis (1263.78, 1239.00 and 1251.39 g plant⁻¹, respectively). Whereas, significantly lower tuber weight was recorded in SN₅LM₅ in both years and on pooled basis (784.38, 769.00 and 776.69 g plant⁻¹, respectively) as compared to other treatments.

4.8.2 Tuber length (cm)

Sources of nitrogen, liquid manures and their interactions influenced the tuber length of sugar beet significantly during 2010-11 and 2011-12 and in pooled analysis (Table 48).

Among the sources of nitrogen, treatment which received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher tuber length (39.30, 36.73 and 38.01 cm, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment receiving 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par tuber length (37.40, 34.96 and 36.18 cm, respectively) as that of SN₁. While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN₅) recorded significantly lower tuber length (33.72, 31.52 and 32.62 cm, respectively) as compared to rest of the treatments.

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher tuber length (36.60 to 37.80, 34.21 to 35.33 and 35.41 to 36.56 cm, respectively) in both years and on pooled basis. The lowest tuber length was recorded in treatment LM₅ (32.84, 30.69 and 31.76 cm, respectively).

Among the treatment combinations, SN₁LM₄ recorded significantly higher tuber length in both years and on pooled basis than application of 100 per cent through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) treatment.

4.8.3 Tuber girth (cm)

The tuber girth of sugar beet was significantly influenced by the application of sources of nitrogen and liquid manures and their interaction during 2010-11, 2011-12 and on pooled basis (Table 48).

All the sources of nitrogen recorded significantly higher tuber girth except application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN₅) in both years and on pooled basis. Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN₅) recorded significantly lower tuber girth in both years and on pooled basis (25.24, 23.97 and 24.60 cm, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher tuber girth when compared to control (LM₅) in both years and on pooled basis. The latter treatment (LM₅) recorded lowest tuber girth in both years and on pooled basis (23.99, 23.07 and 23.53 cm, respectively).

The tuber girth of sugar beet differed significantly due to interaction of sources of nitrogen and liquid manures. Among the treatment combinations, SN₁LM₄ recorded significantly higher tuber girth in both years and on pooled basis (28.85, 26.96 and 27.90 cm, respectively). However, rest of the treatments were found on par with SN₁LM₄ except SN₅LM₅ which recorded significantly lower tuber girth (19.45, 20.07 and 19.76 cm, respectively).

4.8.4 Green foliage yield (t ha^{-1})

Sources of nitrogen, liquid manures and their interactions influenced the green foliage yield of sugar beet significantly during 2010-11 and 2011-12 and on pooled basis (Table 49).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher green foliage yield in both years and on pooled basis (8.33, 7.86 and 8.10 t ha^{-1} , respectively) when compared to other sources of nitrogen. However, SN_2 and SN_3 treatments were found to be on par with SN_1 . While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN_5) recorded significantly lower green foliage yield (SN_5) in both years and on pooled basis (7.38, 6.96 and 7.17 t ha^{-1} , respectively).

All the liquid manures treatments (LM_1 to LM_4) recorded significantly higher green foliage yield in both years and on pooled basis (7.89 to 8.15, 7.45 to 7.69 and 7.67 to 7.92 t ha^{-1} , respectively) when compared to control (LM_5). Whereas significantly lowest green foliage yield was recorded in treatment LM_5 (7.07, 6.67 and 6.87 t ha^{-1} , respectively).

The interaction effect due to sources of nitrogen (SN) and liquid manures (LM) on green foliage yield of sugar beet was found to be significant. Among the treatment combinations, SN_1LM_4 recorded significantly higher green foliage yield in both years and on pooled basis (8.70, 8.21 and 8.46 t ha^{-1} , respectively). Significantly lower green foliage yield was recorded in SN_5LM_5 (6.90, 6.51 and 6.71 t ha^{-1} , respectively).

4.8.5 Tuber yield (t ha^{-1})

Sources of nitrogen and liquid manures and their combinations showed significant influence on tuber yield of sugar beet during 2010-11, 2011-12 and on pooled basis (Table 49).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher tuber yield (79.40, 74.91 and 77.16 t ha^{-1} , respectively) compared to SN_5 in both years and on pooled basis. However, treatments which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN_2) and 50 per cent RDN through IF + 50 per cent RDN through VC and PM in equal proportion (SN_3) were on par with SN_1 . Significantly lower tuber yield was recorded in SN_5 (application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion) in both years and on pooled basis (72.31, 68.22 and 70.27 t ha^{-1} , respectively).

All the liquid manures treatments (LM_1 to LM_4) recorded significantly higher tuber yield when compared to control (LM_5) in both years and on pooled basis. The lowest tuber yield was recorded in treatment LM_5 (70.45, 66.46 and 68.45 t ha^{-1} , respectively).

The tuber yield of sugar beet differed significantly due to interaction of sources of nitrogen and liquid manures. Among the treatment combinations, application of 100 per cent RDN (120 kg ha^{-1}) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher tuber yield in both years and on pooled basis (82.47, 77.80 and 80.13 t ha^{-1} , respectively). However, rest of the treatments were found on par with SN_1LM_4 except SN_3LM_5 and SN_4LM_5 . Significantly lower tuber yield was recorded with application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN_5LM_5) (69.12, 65.21 and 67.16 t ha^{-1} , respectively).

4.8.6 Harvest index

Sources of nitrogen and liquid manures and interaction effects of sources of nitrogen and liquid manures did not show any significant influence on harvest index in both years and on pooled basis (Table 49).

4.9 Quality parameters of sugar beet

4.9.1 Brix (%)

Sources of nitrogen, liquid manures and their interactions influenced the brix percentage in both years and on pooled basis (Table 50).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher brix value (22.34, 22.32 and 22.33 %, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, the treatments SN_2 and SN_3

Table 49: Green foliage yield, tuber yield (t ha⁻¹) and harvest index of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Green foliage yield (t ha ⁻¹)			Tuber yield (t ha ⁻¹)			Harvest index		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	8.33a	7.86a	8.10a	79.40a	74.91a	77.16a	0.90a	0.91a	0.90a
SN ₂	8.06ab	7.60ab	7.83ab	77.78ab	73.38ab	75.58ab	0.91a	0.91a	0.91a
SN ₃	7.83a-c	7.38a-c	7.61a-c	75.64a-c	71.36a-c	73.50a-c	0.91a	0.91a	0.91a
SN ₄	7.58bc	7.15bc	7.37bc	73.58bc	69.42bc	71.50bc	0.91a	0.91a	0.91a
SN ₅	7.38c	6.96c	7.17c	72.31c	68.22c	70.27c	0.91a	0.91a	0.91a
S.Em±	0.18	0.17	0.11	1.48	1.39	1.28	0.003	0.001	0.001
CV (%)	8.67	9.02	6.38	7.59	7.54	6.72	4.95	5.03	4.89
Liquid manures (LM)									
LM ₁	8.06a	7.60a	7.83a	77.31a	72.94a	75.12a	0.91a	0.91a	0.91a
LM ₂	8.00a	7.55a	7.77a	76.77a	72.43a	74.60a	0.91a	0.91a	0.91a
LM ₃	7.89a	7.45a	7.67a	76.31a	71.99a	74.15a	0.91a	0.91a	0.91a
LM ₄	8.15a	7.69a	7.92a	77.88a	73.47a	75.68a	0.91a	0.91a	0.91a
LM ₅	7.07b	6.67b	6.87b	70.45b	66.46b	68.45b	0.91a	0.91a	0.91a
S.Em±	0.14	0.13	0.10	1.54	1.41	1.38	0.003	0.001	0.001
CV (%)	6.99	6.97	5.74	7.90	7.66	7.24	4.78	4.97	4.79
Interactions (SN x LM)									
SN ₁ LM ₁	8.64ab	8.15ab	8.39a	81.51ab	76.90ab	79.21ab	0.90a	0.90a	0.90a
SN ₁ LM ₂	8.58a-c	8.09a-c	8.33ab	80.67a-c	76.10a-c	78.38a-c	0.90a	0.90a	0.90a
SN ₁ LM ₃	8.49a-d	8.01a-c	8.25a-c	80.43a-c	75.88a-c	78.16a-c	0.90a	0.90a	0.90a
SN ₁ LM ₄	8.70a	8.21a	8.46a	82.47a	77.80a	80.13a	0.90a	0.90a	0.90a
SN ₁ LM ₅	7.26f-j	6.85e-i	7.06i-m	71.94a-c	67.87a-c	69.91a-d	0.91a	0.91a	0.91a
SN ₂ LM ₁	8.34a-f	7.87a-e	8.11a-e	79.50a-c	75.00a-c	77.25a-d	0.90a	0.91a	0.90a
SN ₂ LM ₂	8.28a-f	7.81a-e	8.04a-f	79.45a-c	74.95a-c	77.20a-d	0.91a	0.91a	0.91a
SN ₂ LM ₃	8.10a-h	7.64a-g	7.87a-h	79.11a-c	74.63a-c	76.87a-d	0.91a	0.91a	0.91a
SN ₂ LM ₄	8.42a-e	7.94a-d	8.18a-d	79.85a-c	75.33a-c	77.59a-d	0.90a	0.90a	0.90a
SN ₂ LM ₅	7.14g-j	6.74f-i	6.94g-j	71.02a-c	67.00a-c	69.01b-d	0.91a	0.91a	0.91a
SN ₃ LM ₁	8.02a-i	7.57a-h	7.80a-h	77.50a-c	73.11a-c	75.30a-d	0.91a	0.91a	0.91a
SN ₃ LM ₂	7.96a-j	7.51a-i	7.74a-i	76.53a-c	72.20a-c	74.37a-d	0.91a	0.91a	0.91a
SN ₃ LM ₃	7.88a-j	7.43a-i	7.65a-i	75.64a-c	71.36a-c	73.50a-d	0.91a	0.91a	0.91a
SN ₃ LM ₄	8.22a-g	7.75a-f	7.98a-g	78.21a-c	73.78a-c	75.99a-d	0.90a	0.90a	0.90a
SN ₃ LM ₅	7.06h-j	6.66g-i	6.86h-j	70.33bc	66.35bc	68.34cd	0.91a	0.91a	0.91a
SN ₄ LM ₁	7.76a-j	7.32a-i	7.54a-j	74.67a-c	70.44a-c	72.55a-d	0.91a	0.91a	0.91a
SN ₄ LM ₂	7.71a-j	7.27a-i	7.49a-i	74.31a-c	70.10a-c	72.20a-d	0.91a	0.91a	0.91a
SN ₄ LM ₃	7.65a-j	7.22a-i	7.44a-i	73.97a-c	69.78a-c	71.87a-d	0.91a	0.91a	0.91a
SN ₄ LM ₄	7.80a-j	7.36a-i	7.58a-j	75.14a-c	70.89a-c	73.02a-d	0.91a	0.91a	0.91a
SN ₄ LM ₅	6.99ij	6.59hi	6.79ij	69.83bc	65.88c	67.85cd	0.91a	0.91a	0.91a
SN ₅ LM ₁	7.54c-j	7.11c-i	7.32c-i	73.38a-c	69.23a-c	71.31a-d	0.91a	0.91a	0.91a
SN ₅ LM ₂	7.48d-j	7.06c-i	7.27d-j	72.92a-c	68.79a-c	70.85a-d	0.91a	0.91a	0.91a
SN ₅ LM ₃	7.36e-j	6.94d-i	7.15d-i	72.41a-c	68.31a-c	70.36a-d	0.91a	0.91a	0.91a
SN ₅ LM ₄	7.60b-j	7.17b-i	7.39b-j	73.73a-c	69.56a-c	71.65a-d	0.91a	0.91a	0.91a
SN ₅ LM ₅	6.90j	6.51i	6.71j	69.12c	65.21c	67.16d	0.91a	0.91a	0.91a
S.Em±	0.32	0.30	0.22	3.45	3.16	3.08	0.03	0.01	0.01

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermiwash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

Table 50: Brix and sucrose (%) of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Brix (%)			Sucrose (%)		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	22.34a	22.32a	22.33a	17.12a	17.10a	17.11a
SN ₂	22.07ab	22.05ab	22.06ab	16.57ab	16.55ab	16.56ab
SN ₃	21.73a-c	21.71a-c	21.72a-c	16.03bc	16.02bc	16.02bc
SN ₄	21.30bc	21.28bc	21.29bc	15.54cd	15.52cd	15.53cd
SN ₅	20.85c	20.83c	20.84c	15.02d	15.01d	15.01d
S.Em±	0.28	0.29	0.28	0.24	0.24	0.23
CV (%)	5.21	5.11	4.94	5.73	5.16	5.21
Liquid manures (LM)						
LM ₁	22.07a	22.05a	22.06a	16.51ab	16.50ab	16.50ab
LM ₂	21.98a	21.95a	21.96a	16.37ab	16.35ab	16.36ab
LM ₃	21.85a	21.83a	21.84a	16.22b	16.21b	16.21b
LM ₄	22.16a	22.14a	22.15a	16.65a	16.63a	16.64a
LM ₅	20.23b	20.21b	20.22b	14.53c	14.51c	14.52c
S.Em±	0.12	0.12	0.10	0.11	0.09	0.08
CV (%)	4.87	4.86	4.78	5.01	4.98	5.02
Interactions (SN x LM)						
SN ₁ LM ₁	22.78ab	22.76ab	22.77ab	17.78ab	17.76ab	17.77ab
SN ₁ LM ₂	22.72a-c	22.69a-c	22.70ab	17.60a-c	17.58a-c	17.59a-c
SN ₁ LM ₃	22.62a-d	22.60a-c	22.61a-c	17.41a-d	17.39a-d	17.40a-d
SN ₁ LM ₄	22.87a	22.85a	22.86a	17.88a	17.86a	17.87a
SN ₁ LM ₅	20.74k-n	20.72k-m	20.73l-n	14.92o-r	14.91n-q	14.92m-o
SN ₂ LM ₁	22.50a-d	22.48a-d	22.49a-d	17.05b-f	17.03b-f	17.04c-e
SN ₂ LM ₂	22.39a-e	22.37a-e	22.38a-e	16.99b-f	16.97c-f	16.98c-e
SN ₂ LM ₃	22.31a-f	22.29a-f	22.30a-f	16.84c-g	16.82c-g	16.83d-f
SN ₂ LM ₄	22.53a-d	22.51a-d	22.52a-d	17.19a-e	17.17a-e	17.18a-e
SN ₂ LM ₅	20.60l-n	20.58l-n	20.59mn	14.77p-r	14.76o-r	14.77m-p
SN ₃ LM ₁	22.15a-g	22.12a-g	22.13a-g	16.52e-i	16.50e-i	16.51e-h
SN ₃ LM ₂	22.09a-h	22.06a-h	22.07a-h	16.31f-j	16.29f-j	16.30f-i
SN ₃ LM ₃	21.95b-i	21.93b-i	21.94c-i	16.13g-k	16.11g-k	16.12g-i
SN ₃ LM ₄	22.22a-g	22.20a-g	22.21a-f	16.71d-h	16.69d-h	16.70e-g
SN ₃ LM ₅	20.24m-o	20.22m-o	20.23no	14.50qr	14.49p-r	14.50n-p
SN ₄ LM ₁	21.71d-j	21.69d-j	21.70e-j	15.95h-m	15.93h-l	15.94h-j
SN ₄ LM ₂	21.58e-k	21.56e-k	21.57f-k	15.79i-n	15.77i-m	15.78i-k
SN ₄ LM ₃	21.45f-l	21.43f-l	21.44g-l	15.65j-o	15.63j-n	15.64i-l
SN ₄ LM ₄	21.84c-i	21.81c-i	21.82d-j	16.03g-l	16.01h-l	16.02h-j
SN ₄ LM ₅	19.91no	19.89no	19.90o	14.29r	14.28qr	14.29op
SN ₅ LM ₁	21.23h-l	21.20h-l	21.22i-m	15.28l-q	15.26l-p	15.27k-m
SN ₅ LM ₂	21.11i-l	21.09i-l	21.10j-m	15.16n-q	15.14m-p	15.15k-n
SN ₅ LM ₃	20.92j-m	20.90j-m	20.91k-n	15.10n-q	15.08m-p	15.09l-n
SN ₅ LM ₄	21.37g-l	21.35g-l	21.36h-l	15.44k-p	15.42k-p	15.43j-m
SN ₅ LM ₅	19.65o	19.63o	19.64o	14.14r	14.13r	14.14p
S.Em±	0.27	0.26	0.22	0.25	0.25	0.21

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermicompost and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75% RDN through IF +25% RDN through VC and PM in equal proportion
 SN₃-50% RDN through IF + 50% RDN through VC and PM in equal proportion
 SN₄-25% RDN through IF +75% RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100%) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20%) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10%) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20%) and CU (10%) at 30 and 60 DAS
 LM₅- Control (no spray)

were on par with SN₁. Significantly lower brix value was recorded in SN₅ in both years and on pooled basis (20.85, 20.83 and 20.84 %, respectively) compared to SN₁.

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher brix value when compared to control (LM₅) in both years and on pooled basis. The lowest brix value was recorded in treatment LM₅ (20.23, 20.21 and 20.22, respectively).

The brix percentage of sugar beet differed significantly due to interaction of sources of nitrogen (SN) and liquid manures (LM). Among the treatment combinations, SN₁LM₄ recorded significantly higher brix content (22.87, 22.85 and 22.86%, respectively) in both years and on pooled basis. Significantly lower brix content was recorded in SN₅LM₅ (19.65, 19.63 and 19.64 %, respectively) compared to SN₁LM₄.

4.9.2 Sucrose (%)

Sources of nitrogen, liquid manures and their interactions influenced the sucrose percentage of sugar beet significantly during 2010-11 and 2011-12 and in their pooled analysis (Table 50).

Among the sources of nitrogen, treatment which received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher sucrose content (17.12, 17.10 and 17.11 %, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments receiving 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par sucrose content (16.57, 16.55 and 16.56 %, respectively) as that of SN₁. While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN₅) recorded significantly lower sucrose content (15.02, 15.01 and 15.01 %, respectively).

Among the liquid manures treatments, foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (LM₄) recorded significantly higher sucrose content (16.65, 16.63 and 16.64 %, respectively). However, the treatment LM₁ and LM₂ were on par with LM₄. The lowest sucrose content was recorded in treatment LM₅ in both years and on pooled basis (14.53, 14.51 and 14.52 %, respectively).

The sucrose content of sugar beet differed significantly due to interaction of sources of nitrogen (SN) and liquid manures (LM). Among the treatment combinations, SN₁LM₄ recorded significantly higher sucrose content in both years and on pooled basis (17.88, 17.86 and 17.87 %, respectively). Significantly lower sucrose content (14.14, 14.13 and 14.14 %, respectively) was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) as compared to SN₁LM₄.

4.9.3 Commercial beet sugar content (%)

Commercial beet sugar content showed significant variations due to sources of nitrogen, liquid manures and their interactions during 2010-11, 2011-12 and on pooled basis (Table 51).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher commercial beet sugar content (10.97, 10.96 and 10.96 %, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) which recorded on par commercial beet sugar content (10.49, 10.48 and 10.48%, respectively) as that of SN₁. Significantly lower commercial beet sugar content was recorded in SN₅ (9.26, 9.25 and 9.26 %, respectively).

Among the liquid manures treatments LM₄ recorded significantly higher commercial beet sugar content (10.54, 10.53 and 10.54 %, respectively) in both years and on pooled basis. However, the treatment LM₁ and LM₂ were on par with LM₄. The lowest commercial beet sugar content was recorded in treatment LM₅ (8.94, 8.93 and 8.94%, respectively).

The commercial beet sugar content (%) of sugar beet differed significantly due to interaction of sources of nitrogen (SN) and liquid manures (LM). Among the treatment combinations, SN₁LM₄ recorded significantly higher commercial beet sugar content (11.59, 11.58 and 11.59%, respectively) in both years and on pooled basis. Significantly lower commercial beet sugar content was recorded in SN₅LM₅ (8.72, 8.71 and 8.71 %, respectively) as compared to SN₁LM₄.

Table 51: Quality parameters of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Commercial beet sugar content (%)			Sugar yield (t ha ⁻¹)		
	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)						
SN ₁	10.97a	10.96a	10.96a	8.75a	8.25a	8.50a
SN ₂	10.49ab	10.48ab	10.48ab	8.18ab	7.71ab	7.94ab
SN ₃	10.04bc	10.03bc	10.04bc	7.61bc	7.17bc	7.39bc
SN ₄	9.66cd	9.65cd	9.66cd	7.12cd	6.71cd	6.92cd
SN ₅	9.26d	9.25d	9.26d	6.70d	6.31d	6.50d
S.Em±	0.18	0.15	0.15	0.21	0.21	0.20
CV (%)	7.08	6.87	5.98	10.51	11.34	10.22
Liquid manures (LM)						
LM ₁	10.43ab	10.42ab	10.43ab	8.09a	7.62a	7.85a
LM ₂	10.31ab	10.30ab	10.30ab	7.93a	7.48a	7.71a
LM ₃	10.20b	10.19b	10.19b	7.80a	7.35a	7.58a
LM ₄	10.54a	10.53a	10.54a	8.23a	7.76a	7.99a
LM ₅	8.94c	8.93c	8.94c	6.30b	5.95b	6.12b
S.Em±	0.11	0.11	0.09	0.17	0.16	0.15
CV (%)	5.18	5.64	5.36	8.45	8.63	7.85
Interactions (SN x LM)						
SN ₁ LM ₁	11.52a	11.51a	11.51a	9.40ab	8.86a	9.13ab
SN ₁ LM ₂	11.35ab	11.34ab	11.35ab	9.17a-c	8.64ab	8.90a-c
SN ₁ LM ₃	11.19a-c	11.17a-c	11.18a-c	9.00a-d	8.48a-c	8.74a-c
SN ₁ LM ₄	11.59a	11.58a	11.59a	9.55a	9.00a	9.28a
SN ₁ LM ₅	9.20k-n	9.19k-n	9.19k-n	6.61j-n	6.26h-l	6.44j-l
SN ₂ LM ₁	10.85a-e	10.84a-d	10.85a-d	8.62a-f	8.12a-e	8.37a-e
SN ₂ LM ₂	10.82a-e	10.81a-e	10.82a-e	8.59a-f	8.10a-e	8.34a-e
SN ₂ LM ₃	10.69b-f	10.68b-f	10.69b-f	8.45a-g	7.96a-f	8.21a-f
SN ₂ LM ₄	10.99a-d	10.98a-d	10.98a-d	8.78a-e	8.28a-d	8.53a-d
SN ₂ LM ₅	9.08l-n	9.07l-n	9.08l-n	6.46k-n	6.09i-l	6.27j-l
SN ₃ LM ₁	10.41c-h	10.40c-h	10.41c-h	8.07c-i	7.61b-g	7.84c-h
SN ₃ LM ₂	10.22d-i	10.21d-i	10.21d-i	7.82d-j	7.37c-h	7.59d-i
SN ₃ LM ₃	10.07e-j	10.06e-j	10.07e-j	7.62e-k	7.17d-i	7.40e-j
SN ₃ LM ₄	10.59b-g	10.58b-g	10.58b-g	8.29b-h	7.81b-g	8.05b-g
SN ₃ LM ₅	8.91mn	8.91mn	8.91mn	6.26l-n	5.90j-l	6.08kl
SN ₄ LM ₁	9.96f-k	9.95f-k	9.95f-k	7.43f-l	7.00e-k	7.22f-j
SN ₄ LM ₂	9.83g-l	9.82g-l	9.83g-l	7.30g-m	6.88f-l	7.09g-k
SN ₄ LM ₃	9.73h-l	9.72h-l	9.72h-l	7.20h-n	6.79f-l	7.00g-k
SN ₄ LM ₄	10.00f-k	9.99g-j	10.00g-j	7.53f-k	7.09d-j	7.31e-j
SN ₄ LM ₅	8.80mn	8.79mn	8.79mn	6.13mn	5.80kl	5.97kl
SN ₅ LM ₁	9.41j-n	9.40j-n	9.41j-n	6.92i-n	6.51g-l	6.71i-l
SN ₅ LM ₂	9.33j-n	9.32j-n	9.32j-n	6.79j-n	6.40g-l	6.60i-l
SN ₅ LM ₃	9.32j-n	9.31j-n	9.31j-n	6.74j-n	6.35h-l	6.55i-l
SN ₅ LM ₄	9.54i-m	9.53i-n	9.54i-m	7.01j-n	6.60g-l	6.80h-l
SN ₅ LM ₅	8.72n	8.71n	8.71n	6.02n	5.69l	5.85l
S.Em±	0.24	0.24	0.21	0.37	0.36	0.34

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

4.9.4 Sugar yield ($t\ ha^{-1}$)

The sugar yield of sugar beet was significantly influenced by the application of sources of nitrogen, liquid manures and their interaction during 2010-11, 2011-12 and on pooled basis (Table 51).

Among the sources of nitrogen, treatment which received 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher sugar yield (8.75 , 8.25 and $8.50\ t\ ha^{-1}$, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments which received 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN_2) which recorded on par sugar yield (8.18 , 7.71 and $7.94\ t\ ha^{-1}$, respectively) as that of SN_1 . While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN_5) recorded significantly lower sugar yield of 6.70 , 6.31 and $6.50\ t\ ha^{-1}$, respectively.

All the liquid manures treatments, (LM1 to LM4) recorded significantly higher sugar yield compared to control (LM_5). The latter treatment recorded the lowest sugar yield (6.30 , 5.95 and $6.12\ t\ ha^{-1}$, respectively).

The interaction effect due to sources of nitrogen (SN) and liquid manures (LM) on sugar yield was found significant. Among the treatment combinations, application of 100 per cent RDN ($120\ kg\ ha^{-1}$) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher sugar yield in both years and on pooled basis (9.55 , 9.00 and $9.28\ t\ ha^{-1}$, respectively). Significantly lower sugar yield was recorded in SN_5LM_5 (6.02 , 5.69 and $5.85\ t\ ha^{-1}$, respectively).

4.10 Economics

4.10.1 Gross returns ($Rs.\ ha^{-1}$)

Sources of nitrogen, liquid manures and their interactions influenced the gross returns significantly during 2010-11 and 2011-12 and in their pooled analysis (Table 52).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher gross returns ($Rs.\ 95286$, 112365 and $103825\ ha^{-1}$, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, the treatment SN_2 and SN_3 were on par with SN_1 . Significantly lower gross returns was recorded in SN_5 ($Rs.\ 86775$, 102331 and $94553\ ha^{-1}$, respectively).

All the liquid manures treatments (LM_1 to LM_4) recorded significantly higher gross returns when compared to control (LM_5) in both years and on pooled basis. The lower gross returns was recorded in treatment LM_5 ($Rs.\ 84537$, 99693 and $92115\ ha^{-1}$, respectively).

The gross returns of sugar beet differed significantly due to interaction of sources of nitrogen (SN) and liquid manures (LM). Among the treatment combinations, SN_1LM_4 recorded significantly higher gross returns ($Rs.\ 98962$, 116700 and $107831\ ha^{-1}$, respectively) in both years and on pooled basis. However, rest of the treatments were found on par with SN_1LM_4 except SN_3LM_5 and SN_4LM_5 . While, significantly lower gross returns was recorded in SN_5LM_5 ($Rs.\ 82941$, 97815 and $90378\ ha^{-1}$, respectively).

4.10.2 Net returns ($Rs.\ ha^{-1}$)

Net returns was significantly influenced by the application of sources of nitrogen, liquid manures and their interaction during 2010-11, 2011-12 and on pooled basis (Table 52).

Among the sources of nitrogen, treatment which received 100 per cent RDN through inorganic fertilizer (SN_1) recorded significantly higher net returns ($Rs.\ 54105$, 67485 and $60795\ ha^{-1}$, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatment receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN_2) recorded on par net returns ($Rs.\ 48478$, 61535 and $55007\ ha^{-1}$, respectively) as that of SN_1 . While, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportion (SN_5) recorded significantly lower net returns ($Rs.\ 35805$, 47766 and $41785\ ha^{-1}$, respectively).

All the liquid manures treatments, (LM1 to LM4) recorded significantly higher net returns ($Rs.\ 44312$ to 45595 , 57093 to 58712 and 50703 to $52154\ ha^{-1}$, respectively) compared to control (LM_5). The lowest net returns was recorded in treatment LM_5 ($Rs.\ 37350$, 48874 and $43112\ ha^{-1}$, respectively).

Table 52: Economics of sugar beet as influenced by sources of nitrogen and liquid manures

Treatment	Gross returns (Rs. ha ⁻¹)			Net returns (Rs. ha ⁻¹)			B:C ratio		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	95286a	112365a	103825a	54105a	67485a	60795a	2.31a	2.50a	2.41a
SN ₂	93342ab	110072ab	101707ab	48478ab	61535ab	55007ab	2.08b	2.27b	2.17b
SN ₃	90770a-c	107038a-c	98904a-c	42170bc	54791bc	48480bc	1.87c	2.05c	1.96c
SN ₄	88298bc	104127bc	96213bc	36005c	48213c	42109c	1.69d	1.86d	1.78d
SN ₅	86775c	102331c	94553c	35805c	47766c	41785d	1.70d	1.88d	1.79d
S.Em±	1780	2087	1719	1780	2087	1719	0.04	0.04	0.04
CV (%)	7.59	7.54	6.72	17.37	15.53	14.51	7.94	7.63	7.01
Liquid manures (LM)									
LM ₁	92775a	109405a	101090a	44963a	57886a	51424a	1.96a	2.14a	2.05a
LM ₂	92128a	108642a	100385a	44342a	57224a	50783a	1.95a	2.13a	2.04a
LM ₃	91574a	107987a	99780a	44312a	57093a	50703a	1.96a	2.14a	2.05a
LM ₄	93456a	110206a	101831a	45595a	58712a	52154a	1.97a	2.16a	2.07a
LM ₅	84537b	99693b	92115b	37350b	48874b	43112b	1.81b	1.98b	1.89b
S.Em±	1853	2120	1849	1853	2120	1849	0.04	0.04	0.04
CV (%)	7.90	7.66	7.23	18.08	15.77	15.61	7.79	7.73	7.25
Interactions (SN x LM)									
SN ₁ LM ₁	97817ab	115350ab	106583ab	56406ab	70180ab	63293ab	2.36a	2.55ab	2.46a
SN ₁ LM ₂	96799a-c	114150a-c	105475a-c	55413ab	69080ab	62247a-c	2.34a	2.53ab	2.44a
SN ₁ LM ₃	96519a-c	113820a-c	105170a-c	55659ab	69275ab	62467a-c	2.36a	2.56ab	2.46a
SN ₁ LM ₄	98962a	116700a	107831a	57501a	71555a	64528a	2.39a	2.59a	2.49a
SN ₁ LM ₅	86331a-c	101804a-c	94067a-d	45545a-e	57334a-e	51439a-f	2.12ab	2.29a-c	2.20ab
SN ₂ LM ₁	95400a-c	112500a-c	103950a-d	50306a-d	63673a-d	56990a-e	2.12ab	2.30a-c	2.21ab
SN ₂ LM ₂	95336a-c	112425a-c	103881a-d	50268a-d	63698a-d	56983a-e	2.12ab	2.31a-c	2.21ab
SN ₂ LM ₃	94929a-c	111945a-c	103437a-d	50386a-d	63743a-d	57065a-e	2.13ab	2.32a-c	2.23ab
SN ₂ LM ₄	95820a-c	112990a-c	104405a-d	50676a-c	64188a-c	57432a-d	2.12ab	2.32a-c	2.22ab
SN ₂ LM ₅	85224a-c	100500a-c	92862a-c	40755c-e	52373c-e	46564d-f	1.92bc	2.09c-e	2.00bc
SN ₃ LM ₁	92996a-c	109665a-c	101330a-d	44166a-e	57128a-e	50647a-f	1.90bc	2.09c-e	2.00bc
SN ₃ LM ₂	91838a-c	108300a-c	100069a-d	43033b-e	55863b-e	49448b-f	1.88bc	2.07c-e	1.97bc
SN ₃ LM ₃	90770a-c	107035a-c	98902a-d	42490b-e	55123b-e	48806c-f	1.88bc	2.06c-e	1.97bc
SN ₃ LM ₄	93848a-c	110665a-c	102257a-d	44968a-e	58153a-e	51560a-f	1.92bc	2.11cd	2.01bc
SN ₃ LM ₅	84397bc	99525bc	91961cd	36192de	47688de	41940f	1.75bc	1.92de	1.84c
SN ₄ LM ₁	89600a-c	105660a-c	97630 a-d	37077c-e	49456c-e	43266ef	1.71c	1.88de	1.79c
SN ₄ LM ₂	89167a-c	105152a-c	97160a-d	36669c-e	49048c-e	42858f	1.70c	1.87de	1.79c
SN ₄ LM ₃	88760a-c	104670a-c	96715a-d	36787c-e	49091c-e	42939f	1.71c	1.88de	1.80c
SN ₄ LM ₄	90172a-c	106335a-c	98254a-d	37599c-e	50156c-e	43877d-f	1.72c	1.89de	1.80c
SN ₄ LM ₅	83792bc	98820c	91306cd	31894e	43316e	37605f	1.61c	1.78e	1.70c
SN ₅ LM ₁	88061a-c	103848a-c	95954 a-d	36861c-e	48993c-e	42927f	1.72c	1.89de	1.81c
SN ₅ LM ₂	87501a-c	103185a-c	95343a-d	36326de	48430c-e	42378f	1.71c	1.88de	1.80c
SN ₅ LM ₃	86890a-c	102465a-c	94678a-d	36240de	48235c-e	42238f	1.72c	1.89de	1.80c
SN ₅ LM ₄	88480a-c	104340a-c	96410a-d	37230c-e	49510c-e	43370f	1.73c	1.90de	1.81c
SN ₅ LM ₅	82941c	97815c	90378d	32366e	43660e	38013f	1.64c	1.81de	1.72c
S.Em±	4143	4740	4135	4143	4740	4740	0.09	0.09	0.08

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

2010-11 2011-12
Market price Rs. 1200/tonne Rs. 1500/tonne

The interaction effect due to sources of nitrogen (SN) and liquid manures (LM) on net returns was found significant. Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher net returns in both years and on pooled basis (Rs. 57501, 71555 and 64528 ha⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₁LM₅, SN₂LM₁, SN₂LM₂, SN₂LM₃, SN₂LM₄, SN₃LM₁ and SN₃LM₄ remained on par with former treatment combination. Significantly lower net returns were recorded in SN₅LM₅ (Rs. 32366, 43660 and 38013 ha⁻¹, respectively).

4.10.3 B:C ratio

B:C ratio of sugar beet as influenced by the application of sources of nitrogen, liquid manures and their interaction was significant during 2010-11, 2011-12 and on pooled basis (Table 52).

Among the sources of nitrogen, application of 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher B:C ratio (2.31, 2.50 and 2.41, respectively) followed by SN₂ (2.08, 2.27 and 2.17, respectively) and SN₃ (1.87, 2.05 and 1.96, respectively) in both years and on pooled basis. Significantly lower B:C ratio was recorded in SN₅ (1.70, 1.88 and 1.79, respectively) and SN₄ (1.69, 1.86 and 1.78, respectively).

All the liquid manures treatments (LM₁ to LM₄) recorded significantly higher B:C ratio when compared to control (LM₅) in both years and on pooled basis. The lowest B:C ratio was recorded in treatment LM₅ (1.81, 1.98 and 1.89, respectively).

The B:C ratio of sugar beet differed significantly due to interactions of sources of nitrogen and liquid manures. Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher B:C ratio in both years and on pooled basis (2.39, 2.59 and 2.49, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₁LM₅, SN₂LM₁, SN₂LM₂, SN₂LM₃ and SN₂LM₄ remained on par with former treatment combination. While significantly lower B:C ratio of 1.64, 1.81 and 1.72, respectively was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅).

4.11 Nutrient uptake by sugar beet

4.11.1 Nitrogen uptake (kg ha⁻¹)

The nitrogen uptake by sugar beet varied significantly due to sources of nitrogen, liquid manures and their interaction at harvest during 2010-11, 2011-12 and on pooled basis (Table 53).

Among the sources of nitrogen, treatment received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher nitrogen uptake (178.30, 171.30 and 175.10 kg ha⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. The treatments receiving 75 per cent RDN through IF +25 per cent RDN through VC and PM in equal proportion (SN₂) recorded on par nitrogen uptake (172.77, 166.40 and 169.59 kg ha⁻¹, respectively) as that of SN₁. Significantly lower nitrogen uptake was recorded in SN₅ (156.13, 149.89 and 153.01 kg ha⁻¹, respectively).

Among the liquid manures treatments LM₄ recorded significantly higher nitrogen uptake (173.02, 166.67 and 169.84 kg ha⁻¹, respectively) in both years and on pooled basis. However, the treatment LM₁ and LM₂ were on par with LM₄. The lowest nitrogen uptake was recorded in treatment LM₅ (154.35, 148.04 and 151.20 kg ha⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher nitrogen uptake in both years and on pooled basis (185.69, 179.27 and 182.48 kg ha⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower nitrogen uptake was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (150.92, 144.70 and 147.81 kg ha⁻¹, respectively).

4.11.2 Phosphorus uptake (kg ha⁻¹)

Significant differences in phosphorus uptake by sugar beet crop was observed due to sources of nitrogen, liquid manures and their interaction at harvest during 2010-11, 2011-12 and on pooled basis (Table 53).

Table 53: Nutrient uptake (kg ha⁻¹) by sugar beet at harvest as influenced by sources of nitrogen and liquid manures

Treatment	Nitrogen			Phosphorous			Potassium		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	178.30a	171.90a	175.10a	30.56a	29.51a	30.03a	117.94a	113.97a	115.95a
SN ₂	172.77ab	166.40ab	169.59ab	29.84ab	28.79ab	29.32ab	115.18ab	111.24ab	113.21ab
SN ₃	167.67bc	161.33bc	164.50bc	29.03ab	27.99ab	28.51ab	112.49a-c	108.57a-c	110.53a-c
SN ₄	161.82cd	155.52cd	158.67cd	28.11bc	27.07bc	27.59bc	109.48bc	105.58bc	107.53bc
SN ₅	156.13d	149.89d	153.01d	27.12c	26.09c	26.61c	106.59c	102.72c	104.66c
S.Em±	3.09	3.01	3.05	0.52	0.50	0.51	1.97	1.92	1.94
CV (%)	7.14	7.23	7.38	6.91	7.34	6.95	7.79	6.95	7.28
Liquid manures (LM)									
LM ₁	171.24ab	164.90ab	168.07ab	29.51ab	28.47ab	28.99ab	114.39ab	110.46ab	112.43ab
LM ₂	169.89ab	163.56ab	166.72ab	29.34ab	28.30ab	28.82ab	113.66ab	109.74ab	111.70ab
LM ₃	168.19b	161.87b	165.03b	29.09b	28.05b	28.57b	112.86b	108.95b	110.91b
LM ₄	173.02a	166.67a	169.84a	29.74a	28.70a	29.22a	115.28a	111.35a	113.32a
LM ₅	154.35c	148.04c	151.20c	26.97c	25.93c	26.45c	105.49c	101.58c	103.53c
S.Em±	1.13	1.12	1.13	0.18	0.17	0.18	0.64	0.63	0.64
CV (%)	5.62	5.70	5.66	5.36	6.05	5.48	6.18	6.17	6.19
Interactions (SN x LM)									
SN ₁ LM ₁	184.02ab	177.61ab	180.82ab	31.37ab	30.32ab	30.84ab	120.91ab	116.94ab	118.93ab
SN ₁ LM ₂	182.73a-c	176.32a-c	179.52a-c	31.23ab	30.18ab	30.70ab	120.24ab	116.28ab	118.26ab
SN ₁ LM ₃	180.99a-d	174.59a-d	177.79a-d	31.00a-c	29.95a-c	30.47a-c	119.41a-c	115.45a-c	117.43a-c
SN ₁ LM ₄	185.69a	179.27a	182.48a	31.60a	30.55a	31.08a	121.80a	117.83a	119.82a
SN ₁ LM ₅	158.08k-o	151.69k-o	154.88k-o	27.60j-m	26.55j-m	27.07j-m	107.31l-o	103.36l-o	105.34l-o
SN ₂ LM ₁	177.62a-f	171.24a-f	174.43a-f	30.58a-d	29.52a-d	30.05a-d	117.65a-d	113.70a-d	115.68a-d
SN ₂ LM ₂	176.39b-f	170.02b-f	173.20b-f	30.42a-e	29.37a-e	29.89a-e	117.10b-e	113.15b-e	115.12b-e
SN ₂ LM ₃	174.86c-g	168.50c-g	171.68c-g	30.24b-e	29.19b-e	29.71b-e	116.44b-f	112.50b-f	114.47b-f
SN ₂ LM ₄	179.04a-e	172.65a-e	175.84a-e	30.73a-d	29.67a-d	30.20a-d	118.36a-d	114.41a-d	116.38a-d
SN ₂ LM ₅	155.96l-o	149.61l-o	152.79l-o	27.26k-m	26.21k-m	26.73k-m	106.36m-o	102.42m-o	104.39m-o
SN ₃ LM ₁	171.85e-h	165.51e-h	168.68e-h	29.67d-f	28.63d-f	29.15d-f	114.68d-h	110.76d-h	112.72d-h
SN ₃ LM ₂	170.66f-i	164.32f-i	167.49f-i	29.50d-g	28.45d-g	28.97d-g	114.02d-i	110.10d-i	112.06d-i
SN ₃ LM ₃	168.15g-j	161.83g-j	164.99g-j	29.17e-h	28.12e-h	28.64e-h	112.74e-j	108.83e-j	110.78e-j
SN ₃ LM ₄	173.30d-g	166.95d-g	170.12d-g	29.86c-f	28.81c-f	29.34c-f	115.53c-g	111.59c-g	113.56c-g
SN ₃ LM ₅	154.38m-o	148.06m-o	151.22m-o	26.96lm	25.92lm	26.44lm	105.49m-o	101.58m-o	103.54m-o
SN ₄ LM ₁	164.95h-k	158.65h-k	161.80h-k	28.61f-i	27.57f-j	28.09f-j	111.17g-l	107.27g-l	109.22g-l
SN ₄ LM ₂	163.05i-l	156.76i-l	159.91i-l	28.36g-k	27.33g-k	27.84g-k	110.13h-m	106.23h-m	108.18h-m
SN ₄ LM ₃	161.74j-m	155.46j-m	158.60j-m	28.04h-l	27.01h-l	27.53h-l	109.59i-m	105.70i-m	107.65i-m
SN ₄ LM ₄	166.92g-j	160.60g-j	163.76g-j	28.87f-i	27.83f-i	28.35f-i	112.05f-j	108.15f-k	110.10f-k
SN ₄ LM ₅	152.43no	146.15no	149.29no	26.64m	25.61m	26.13m	104.46no	100.57no	102.51no
SN ₅ LM ₁	157.75k-o	151.50k-o	154.62k-o	27.34k-m	26.32j-m	26.83j-m	107.52k-o	103.65k-o	105.58k-o
SN ₅ LM ₂	156.62l-o	150.37l-o	153.49l-o	27.19k-m	26.17k-m	26.68k-m	106.82l-o	102.95l-o	104.88l-o
SN ₅ LM ₃	155.21l-o	148.97n-o	152.09l-o	27.00lm	25.97lm	26.49lm	106.13m-o	102.26m-o	104.20m-o
SN ₅ LM ₄	160.16j-n	153.89j-n	157.02j-n	27.67i-m	26.64i-m	27.15i-m	108.67j-n	104.79j-n	106.73j-n
SN ₅ LM ₅	150.92o	144.70o	147.81	26.40m	25.37m	25.88m	103.81o	99.95o	101.88o
S.Em±	2.53	2.51	2.52	0.39	0.39	0.39	1.43	1.42	1.43

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

SN₁-100% RDN (120 kg ha⁻¹) through IF
 SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
 SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
 SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
 SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
 LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
 LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
 LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
 LM₅- Control (no spray)

Among the sources of nitrogen, treatment received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher phosphorus uptake (30.56, 29.51 and 30.03 kg ha⁻¹, respectively) during 2010-11, 2011-12 and on pooled basis compared to other sources of nitrogen in both years and on pooled basis. However, the treatments SN₂ and SN₃ were found on par with SN₁. Significantly lower phosphorus uptake was recorded in SN₅ (27.12, 26.09 and 26.61 kg ha⁻¹, respectively)

Among the liquid manures treatments LM₄ recorded significantly higher phosphorus uptake (29.74, 28.70 and 29.22 kg ha⁻¹, respectively) in both years and on pooled basis. However, the treatment LM₁ and LM₂ were on par with LM₄. The lowest phosphorus uptake was recorded in treatment LM₅ (26.97, 25.93 and 26.45 kg ha⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher phosphorus uptake in both years and on pooled basis (31.60, 30.55 and 31.08 kg ha⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower phosphorus uptake was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (26.40, 25.37 and 25.88 kg ha⁻¹, respectively).

4.11.3 Potassium uptake (kg ha⁻¹)

The potassium uptake by sugar beet varied significantly due to sources of nitrogen, liquid manures and their interaction at harvest during 2010-11, 2011-12 and on pooled basis (Table 53).

Among the sources of nitrogen, treatment received 100 per cent RDN through inorganic fertilizer (SN₁) recorded significantly higher potassium uptake (117.94, 113.97 and 115.95 kg ha⁻¹, respectively) compared to other sources of nitrogen in both years and on pooled basis. However, the treatments SN₂ and SN₃ were found on par with SN₁. Significantly lower potassium uptake was recorded in SN₅ (106.59, 102.72 and 104.66 kg ha⁻¹, respectively)

Among the liquid manures treatments LM₄ recorded significantly higher potassium uptake (115.28, 111.35 and 113.32 kg ha⁻¹, respectively) in both years and on pooled basis. However, the treatment LM₁ and LM₂ were on par with LM₄. The lowest potassium uptake was recorded in treatment LM₅ (105.49, 101.58 and 103.53 kg ha⁻¹, respectively).

Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher potassium uptake in both years and on pooled basis (121.80, 117.83 and 119.82 kg ha⁻¹, respectively). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁ and SN₂LM₄ treatments were found on par with SN₁LM₄. Significantly lower potassium uptake was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (103.81, 99.95 and 101.88 kg ha⁻¹, respectively) as compared to SN₁LM₄.

4.11.4 Available nutrients status of soil after harvest of crop

The available nutrients (N, P and K) status of soil after harvest of crop varied significantly due to sources of nitrogen, liquid manures and their interaction at harvest during 2010-11, 2011-12 and on pooled basis (Table 54).

Among the sources of nitrogen, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) (SN₅) recorded significantly higher available nitrogen (282.97, 286.95 and 284.96 kg N ha⁻¹, respectively), available phosphorous (43.60, 45.06 and 44.33 kg ha⁻¹, respectively) and available potassium (382.21, 386.47 and 384.34 kg ha⁻¹, respectively) after harvest of sugar beet during 2010-11, 2011-12 and on pooled basis, respectively. Significantly lower available nitrogen (263.44, 267.43 and 265.43 kg N ha⁻¹, respectively), available phosphorous (38.41, 39.87 and 39.14 kg ha⁻¹, respectively) and available potassium (362.69, 366.94 and 364.81 kg ha⁻¹, respectively) after harvest of sugar beet was recorded with application of 100 per cent RDN (120 kg ha⁻¹) through IF (SN₁). The available nutrients (N, P and K) status in the rest of the treatments was intermediate.

Among the liquid manures treatments LM₅ recorded significantly higher available nitrogen (279.49, 283.48 and 281.48 kg N ha⁻¹, respectively), available phosphorous (42.85, 44.30 and 43.58 kg ha⁻¹, respectively) and available potassium (378.74, 382.99 and 380.86 kg ha⁻¹, respectively) after harvest of sugar beet during 2010-11, 2011-12 and on pooled basis, respectively. The treatment LM₄ recorded significantly lower available nitrogen (264.28, 268.27 and 266.27 kg N ha⁻¹, respectively),

Table 54: Available nitrogen, phosphorous and potassium (kg ha⁻¹) of sugar beet after harvest as influenced by sources of nitrogen and liquid manures

Treatment	Available nitrogen (kg ha ⁻¹)			Available phosphorous (kg ha ⁻¹)			Available potassium (kg ha ⁻¹)		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Sources of nitrogen (SN)									
SN ₁	263.44e	267.43e	265.43e	38.41e	39.87e	39.14e	362.69e	366.94e	364.81e
SN ₂	267.95d	271.94d	269.95d	39.66d	41.12d	40.39d	367.20d	371.45d	369.33d
SN ₃	272.85c	276.84c	274.84c	40.98c	42.44c	41.71c	372.10c	376.35c	374.22c
SN ₄	278.09b	282.08b	280.09b	42.25b	43.71b	42.98b	377.34b	381.59b	379.46b
SN ₅	282.97a	286.95a	284.96a	43.60a	45.06a	44.33a	382.21a	386.47a	384.34a
S.Em±	0.32	0.32	0.32	0.09	0.09	0.09	0.32	0.32	0.32
CV (%)	7.46	7.37	7.51	7.81	7.78	7.52	8.24	7.69	7.34
Liquid manures (LM)									
LM ₁	271.16d	275.15d	273.15d	40.46d	41.91d	41.19d	370.41d	374.66d	372.53d
LM ₂	274.17c	278.16c	276.16c	40.78c	42.23c	41.51c	373.42c	377.67c	375.54c
LM ₃	276.20d	280.19d	278.19d	41.81b	43.26b	42.54b	375.45b	379.70b	377.57b
LM ₄	264.28e	268.27e	266.27e	39.02e	40.47e	39.75e	363.53e	367.78e	365.65e
LM ₅	279.49a	283.48a	281.48a	42.85a	44.30a	43.58a	378.74a	382.99a	380.86a
S.Em±	0.11	0.11	0.11	0.03	0.03	0.03	0.11	0.11	0.11
CV (%)	6.15	6.03	6.54	6.25	6.39	5.97	6.34	5.93	6.15
Interactions (S x LM)									
SN ₁ LM ₁	261.54m	265.53m	263.53m	37.89q	39.35q	38.62q	360.79m	365.04m	362.91m
SN ₁ LM ₂	264.55l	268.54l	266.54l	38.21p	39.67p	38.94p	363.80l	368.05l	365.92l
SN ₁ LM ₃	266.58k	270.57k	268.57k	39.24n	40.70n	39.97n	365.83k	370.08k	367.95k
SN ₁ LM ₄	254.66o	258.65o	256.65o	36.45s	37.91s	37.18s	353.91o	358.16o	356.03o
SN ₁ LM ₅	269.87i	273.86i	271.86i	40.28l	41.74l	41.01l	369.12i	373.37i	371.24i
SN ₂ LM ₁	266.05k	270.04k	268.05k	39.14no	40.59no	39.86no	365.30k	369.55k	367.43k
SN ₂ LM ₂	269.06j	273.05j	271.06j	39.46m	40.91m	40.18m	368.31j	372.56j	370.44j
SN ₂ LM ₃	271.09h	275.08h	273.09h	40.49k	41.94k	41.21k	370.34h	374.59h	372.47h
SN ₂ LM ₄	259.17n	263.16n	261.17n	37.70r	39.15r	38.42r	358.42n	362.67n	360.55n
SN ₂ LM ₅	274.38g	278.37g	276.38g	41.53i	42.98i	42.25i	373.63g	377.88g	375.76g
SN ₃ LM ₁	270.95h	274.94h	272.94h	40.46k	41.92k	41.19k	370.20h	374.45h	372.32h
SN ₃ LM ₂	273.96g	277.95g	275.95g	40.78j	42.24j	41.51j	373.21g	377.46g	375.33g
SN ₃ LM ₃	275.99f	279.98f	277.98f	41.81h	43.27h	42.54h	375.24f	379.49f	377.36f
SN ₃ LM ₄	264.07l	268.06l	266.06l	39.02o	40.48o	39.75o	363.32l	367.57l	365.44l
SN ₃ LM ₅	279.28e	283.27e	281.27e	42.85f	44.31f	43.58f	378.53e	382.78e	380.65e
SN ₄ LM ₁	276.19f	280.18f	278.19f	41.72h	43.18h	42.45h	375.44f	379.69f	377.56f
SN ₄ LM ₂	279.20e	283.19e	281.20e	42.04g	43.50g	42.77g	378.45e	382.70e	380.57e
SN ₄ LM ₃	281.23d	285.22d	283.23d	43.07e	44.53e	43.80e	380.48d	384.73d	382.60d
SN ₄ LM ₄	269.31ij	273.30ij	271.31ij	40.28l	41.74l	41.01l	368.56ij	372.81ij	370.68ij
SN ₄ LM ₅	284.52c	288.51c	286.52c	44.11c	45.57c	44.84c	383.77c	388.02c	385.89c
SN ₅ LM ₁	281.07d	285.05d	283.06d	43.08e	44.54e	43.81e	380.31d	384.57d	382.44d
SN ₅ LM ₂	284.08c	288.06c	286.07c	43.40d	44.86d	44.13d	383.32c	387.58c	385.45c
SN ₅ LM ₃	286.11b	290.09b	288.10b	44.43b	45.89b	45.16b	385.35b	389.61b	387.48b
SN ₅ LM ₄	274.19g	278.17g	276.18g	41.64hi	43.10hi	42.37i	373.43g	377.69g	375.56g
SN ₅ LM ₅	289.40a	293.38a	291.39a	45.47a	46.93a	46.20a	388.64a	392.90a	390.77a
S.Em±	0.24	0.24	0.24	0.06	0.06	0.06	0.24	0.24	0.24

Means followed by common letter do not differ significantly by DMRT @ p=0.05

Note: RDN: Recommended dose of nitrogen, IF: inorganic fertilizer, VC: vermicompost, PM: poultry manure, GM: green manuring, VW: vermivash and CU: cowurine and DAS: Days after sowing

Sources of nitrogen (SN)

- SN₁-100% RDN (120 kg ha⁻¹) through IF
- SN₂-75 % RDN through IF +25 % RDN through VC and PM in equal proportion
- SN₃-50 % RDN through IF + 50 % RDN through VC and PM in equal proportion
- SN₄-25 % RDN through IF +75 % RDN through VC and PM in equal proportion
- SN₅-100% RDN through VC (33%), PM (33%) and GM (33%)

Liquid manures (LM)

- LM₁- Soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS
- LM₂- Foliar spray of VW (20 %) at 30 and 60 DAS
- LM₃- Foliar spray of CU (10 %) at 30 and 60 DAS
- LM₄- Foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS
- LM₅- Control (no spray)

available phosphorous (39.02, 40.47 and 39.75 kg ha⁻¹, respectively) and available potassium (363.53, 367.78 and 365.65 kg ha⁻¹, respectively) over other treatments. The available nutrients (N, P and K) status in the rest of the treatments was intermediate.

Among the treatment combinations, application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) recorded significantly higher available nitrogen (289.40, 293.38 and 291.39 N ha⁻¹, respectively), available phosphorous (45.47, 46.93 and 46.20 kg ha⁻¹, respectively) and available potassium (388.64, 392.90 and 390.77 kg ha⁻¹, respectively) after harvest of sugar beet during 2010-11, 2011-12 and on pooled basis, respectively. Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly lower available nitrogen (254.66, 258.65 and 256.65 kg N ha⁻¹, respectively), available phosphorous (36.45, 37.91 and 37.18 kg ha⁻¹, respectively) and available potassium (353.91, 358.16 and 356.03 kg ha⁻¹, respectively). The available nutrients (N, P and K) status in the rest of the treatments was intermediate.

4.12 Correlation studies

Tuber yield showed significant and positive correlation with yield components such as tuber weight ($r=0.99$), tuber length ($r=0.99$) and tuber girth ($r=0.95$). Similarly, growth parameters like LAI ($r=0.99$), LAD ($r=0.99$), TDMP ($r=0.99$) and its accumulation in tuber ($r=0.99$) and leaves (green foliage) ($r=0.99$) were positively and significantly correlated with tuber yield (Table 55).

Table 55: Correlation of tuber yield (t ha⁻¹) with yield and growth parameters of sugar beet

SI. No	Parameters	'r' value*
I	Yield characters	
1.	Tuber weight	r = 0.99
2.	Tuber length	r = 0.99
3.	Tuber girth	r = 0.95
II	Growth characters	
1.	LAI	r = 0.99
2.	LAD	r = 0.99
3.	Total dry matter production	r = 0.99
4.	Dry matter accumulation in tuber	r = 0.99
5.	Dry matter accumulation in leaves	r = 0.99

Note: * Indicates significance level at 5 %

DISCUSSION

Two field experiments namely 1) Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2) Performance of sugar beet to sources of nitrogen and liquid manures was carried out during 2010-11 and 2011-12 at Agricultural Research Station (ARS), Madhurakhandi (Dist. Bagalkot), University of Agricultural Sciences, Dharwad which is located in Northern Dry Zone (Zone-3) of Karnataka.

The first experiment consisted of evaluation of sugar beet cultivars (Cauvery, Shubhra, Magnolia and Calixta) with different row proportions (1:1, 1:2 and 1:3) in sugarcane. There were seventeen treatment combinations laid out in randomised complete block design with three replications.

The second experiment consisted of five sources of nitrogen as main plot *i.e.* 100 per cent RDN through inorganic fertilizer (SN₁), 75 per cent RDN through inorganic fertilizer +25 per cent RDN through vermicompost and poultry manure in equal proportions (SN₂), 50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost and poultry manure in equal proportions (SN₃), 25 per cent RDN through inorganic fertilizer +75 per cent RDN through vermicompost and poultry manure in equal proportions (SN₄) and 100 per cent RDN through vermicompost (33%), poultry manure (33%) and green manuring (33%) (SN₅). The subplot treatments consisted of five liquid manures soil application of Jeevamrutha (100 %) at sowing, 30 and 60 DAS (LM₁), foliar spray of vermiwash (20 %) at 30 and 60 DAS (LM₂), foliar spray of cow urine (10 %) at 30 and 60 DAS (LM₃), foliar spray of vermiwash (20 %) and cow urine (10 %) at 30 and 60 DAS (LM₄) and control (no spray) (LM₅). The treatments were laid out in split plot design with three replications.

In this chapter, an attempt has been made to discuss critically the important causes and effects emerging out of investigation on growth, yield parameters and yield of sugarcane as influenced by different cultivars and row proportions of sugar beet in intercropping system. The study was also aimed to investigate the effect of sources of nitrogen and liquid manures on growth, yield parameters and yield of sugar beet. As the trend in most of the parameters was similar during both years, the salient results are discussed on pooled data basis.

5.1 Seasonal condition during crop growth

Crop growth is mainly dependent on the weather conditions. Variations in weather conditions during cropping season greatly influences on growth, development and yielding ability of the crops. Among the weather conditions during the cropping period, rainfall deviated from the normal than temperature and relative humidity. The yearly rainfall variations are discussed as under.

During the first year (2010-11) of the experimentation the total rainfall received was 512.8 mm which was lower by 13.54 mm than the normal rainfall (526.34 mm). Sugar beet crop was sown with the onset of monsoon during June (26-06-2010). The germination, emergence and growth of sugar beet were satisfactory. The subsequent rains received in the month of July, August, September, October and November ensured better crop growth and yield. In addition, sugar beet was irrigated based on crop need at an interval of 15 days. Sugarcane was planted in the month of September (7-09-2010) and irrigated immediately after planting and crop was irrigated at monthly interval as no rains were received from December-2010 to April-2011. As a result sugarcane crop growth was normal.

During the second year (2011-12), the total rainfall received was 301.9 mm which was lower by 224.44 mm than the normal rainfall (526.34 mm). Sugar beet crop was sown in the beginning of July month (14-07-2011). As the rainfall received was lower than the normal the crop was irrigated at 15 days interval. This ensured proper germination, emergence and further growth and development of sugar beet. The rains received in the month of August, September and October was supplemented with irrigation. Sugarcane was planted in the month of September (23-09-2011) and irrigated immediately after planting. Since there was no rainfall from November-2011 to April-2012 the crop was grown under canal irrigation with irrigation at monthly interval.

Other meteorological parameters such as temperature (minimum and maximum), relative humidity did not deviate much from the normal to influence the crop performance to a great extent in both the years.

In general, the rainfall during the first year was near normal while, in the second year was below normal. As a result, the performance of both crops (sugarcane and sugar beet) in terms of growth and yield was better in the first year than second year.

5.2 Experiment-1: Intercropping of sugar beet cultivars at different row proportions in sugarcane

5.2.1 Performance of sugarcane

When two or more crops are grown together in an intercropping system, the intercrop yield may be low compared to their sole crop yield due to competition for growth resources *viz.*, space, light, moisture and nutrients as a result of increased population pressure per unit land area or demand exceeding supply or both. However, the competition between component crops may be minimized by selecting crops of different rooting pattern, growth habit and maturity groups having complementary effect, and by adjusting plant geometry, planting time, population levels and other agronomic practices (Willey *et al.*, 1986). Sugarcane and sugar beet are two such crops which are morphologically and physiologically different in their growth habit.

Sugarcane yield differed significantly due to intercropping of sugar beet cultivars in different row proportions (RP) (Table 17 and Fig. 5). Sole sugarcane recorded significantly higher cane yield during 2010-11, 2011-12 and on pooled basis (103.56, 99.21 and 101.39 t ha⁻¹, respectively) compared to intercropped treatments (85.15 to 97.65 t ha⁻¹). However, growing of sugarcane (SC) and sugar beet (SB) in 1:1 RP (irrespective of sugar beet cultivars) remained on par with sole sugarcane during both the years and on pooled basis. The sugarcane yield reduced gradually and significantly as the row ratio of sugar beet increased from 1:2 to 1:3. Significantly lower sugarcane yield was recorded under 1:3 RP. The extent of reduction in sugarcane yield (Average over sugar beet cultivars) over sole sugarcane was 4.66, 9.95 and 14.99 per cent in 1:1, 1:2 and 1:3 RP, respectively (Fig. 6). Results are in concurrence with the findings of El-Gergawi and Abdalla (2000) in Sugarcane + sweet potato/ cowpea, Mahadevaswamy (2002) in sugarcane + onion, Singh and Vashist (2004) in sugarcane + onion and Bahadar *et al.* (2007) in sugarcane + sugar beet.

Significantly higher cane yield in sole sugarcane was mainly due to absence of competition for growth resources compared to intercropping treatments involving 1:2 and 1:3 RP. However, cane yield recorded in 1:1 RP was comparable to that of sole sugarcane due to lesser competition exerted by sugar beet. The per cent population of sugar beet in 1:1 RP was 33. On the contrary, significantly lower cane yield was observed in 1:2 and 1:3 RP on account of greater competition exerted by higher population of sugar beet for various growth resources. The population of sugar beet was 66 and 100 per cent in 1:2 and 1:3 RP, respectively. The results are in conformity with the findings of Mahadevaswamy (2002) and Singh and Vashist (2004), wherein they reported that cane yield obtained in sugarcane + onion in 1:1 RP was on par with sole sugarcane. Further, they reported that as the row proportions of onion increased from 1:2 to 1:4, there was significant reduction in yield of sugarcane. Similarly, Bahadar *et al.* (2007) reported highest cane yield when single row of sugar beet was sown in 90 cm spaced sugarcane compared to sole sugarcane. The variations in cane yield could be related to variations in nutrient uptake by the crop (Table 19). Significantly higher cane yield in sole sugarcane was due to higher N, P and K uptake by crop compared to intercropped sugarcane. The SC + SB in 1:1 RP was next in order in nutrient uptake.

Cane yield per unit area is a function of yield contributing characters. In other words, the higher cane yield in sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP (irrespective of sugar beet cultivars) was due to yield attributes namely number of millable canes (NMC) and single cane weight (Table 16 and Fig. 7). Significantly higher values of NMC (83190 and 79040 ha⁻¹, respectively) and single cane weight (1420 and 1340 g plant⁻¹, respectively) was observed in sole sugarcane and SC + SB in 1:1 RP compared to other intercropped treatments (SC + SB in 1:2 and 1:3 RP). The simple correlation study also showed positive and significant correlation between cane yield and number of millable canes ($r = 0.99$) and single cane weight ($r = 0.95$) (Table 20). Findings are in line with observations made by Patil (1978) and Mahadevaswamy (2002). Tiller production per unit area and transformation into the millable canes was higher in sole sugarcane and SC + SB in 1:1 RP compared to other intercropped treatments (SC + SB in 1:2 and 1:3 RP). Higher tiller conversion ratio coupled with better growth of the individual stalk (cane) was due to less competition for sunlight, water and nutrients which might have contributed towards the development of thicker and heavier canes. The yield levels were highest due to not only higher single cane weight but also the reasonable stand



Sole Sugarcane



Sugarcane + sugar beet in 1:1 row proportion
(sugar beet was harvested when sugarcane was 100 days old)

Plate 6 : Performance of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions



Sole sugarcane



Sugarcane + Sugar beet in 1:1 RP

Plate 7 : Comparative view of millable canes under sole and intercropping (1:1 RP) with sugar beet

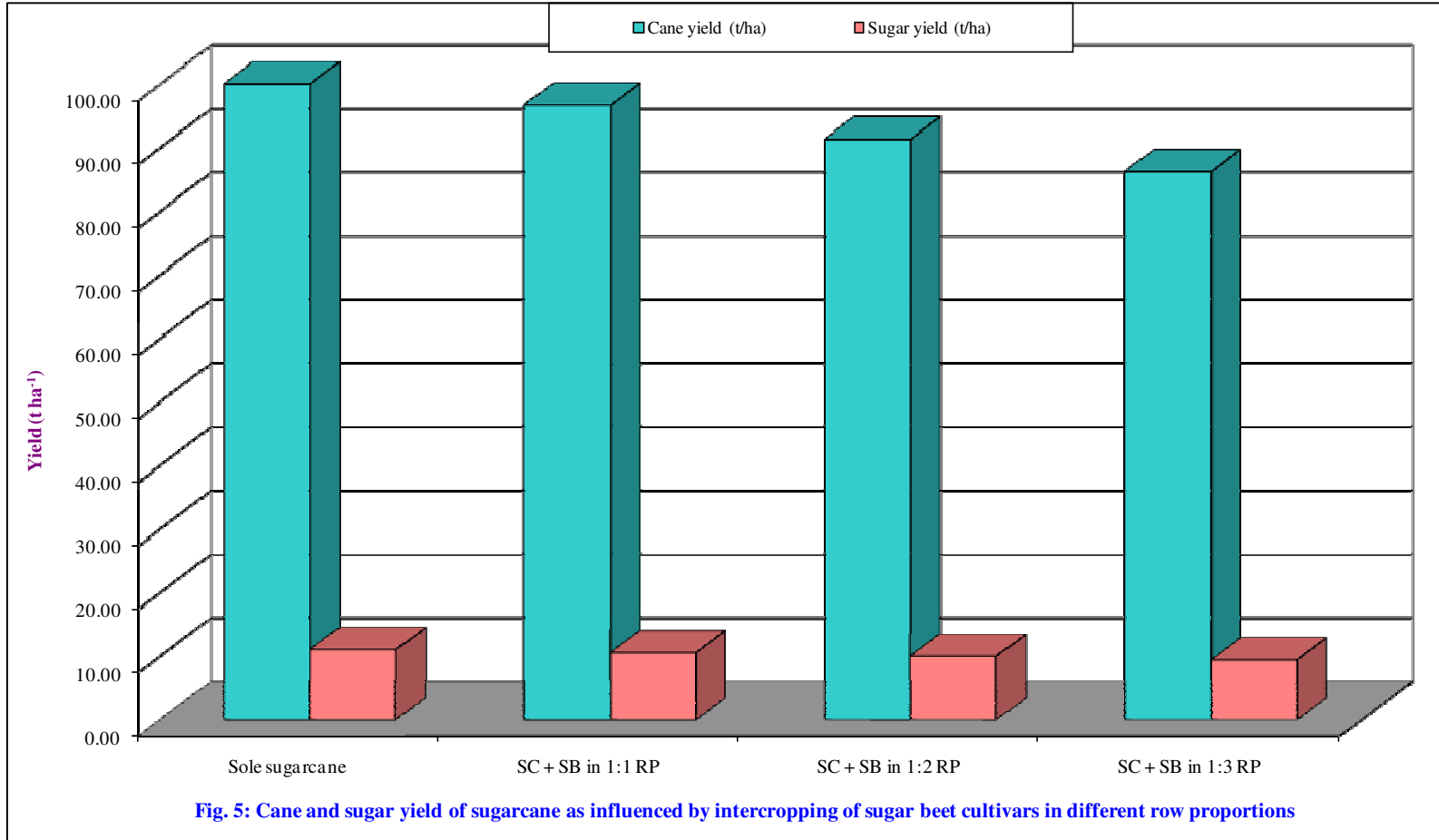


Fig 5 : Cane and sugar yield of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

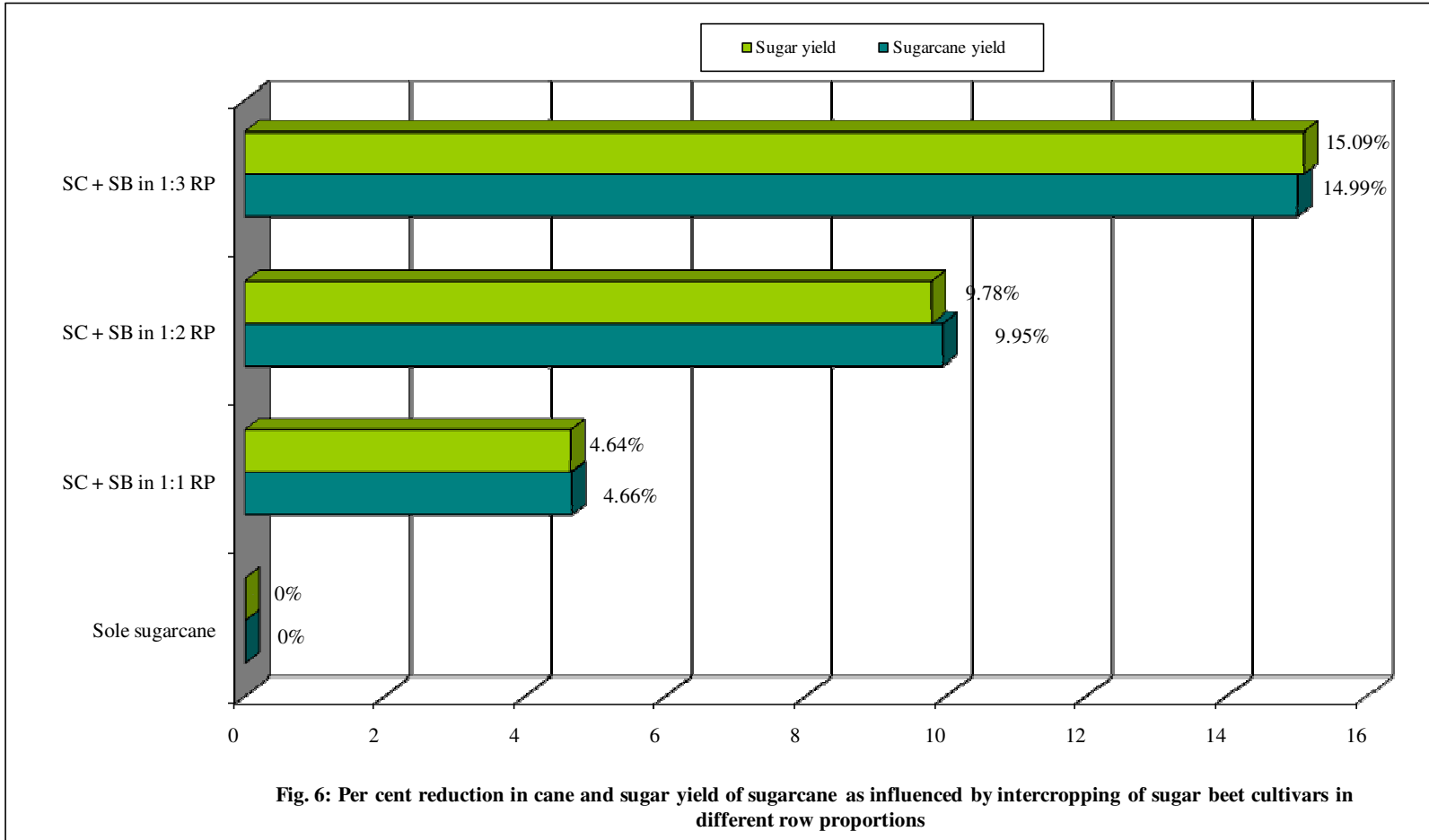


Fig 6 : Per cent reduction in cane and sugar yield of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

of millable cane population made it possible to record significantly higher yield in sole sugarcane and SC + SB in 1:1 RP. The results are in line with findings of Mahadevaswamy and Martin (2002).

The NMC per unit area is an important factor in determining the final yield of sugarcane (James, 1971) and is dependent mainly on the tiller production and its survival. In intercropping the tiller mortality rate was higher compared to sole sugarcane. Bose and Thakur (1980) and Narwal and Malik (1981) observed that mortality of tillers was associated positively with number of tillers. High mortality of tillers could only be expected under close row spacing and high population pressure lead to severe competition for nutrient and light. Nagendran and Palaniswamy (1997) reported 30 per cent increase in single cane weight under wider row spacing of 150 cm compared to closer spacing of 75 cm. Single cane weight was more in the wide rows (150 cm) than in the normal row spacing of 90 cm mainly due to more availability of solar radiation (Anon., 2000).

The higher NMC and single cane weight in sole sugarcane and SC + SB in 1:1 RP are the reflections of other yield attributing characters like length of internode (10.62 and 9.97 cm, respectively), diameter of cane (2.59 and 2.54 cm, respectively) and number of internodes (22.41 and 21.23, respectively) at harvest. The simple correlation study also showed positive and significant correlation between cane yield and length of internode ($r = 0.94$), diameter of cane ($r = 0.96$) and number of internodes ($r = 0.94$) (Table 20). According to Mali and Singh (1989) individual cane weight is a function of leaf area production, number of internode, length of internode and girth of cane. In the present study there was significant improvement in length of internode (Table 16 and Fig. 7), girth of cane (Table 15 and Fig. 7) and number of internode (Table 14 and Fig. 7), which finally contributed to higher individual cane weight in sole sugarcane as well as in SC + SB in 1:1 RP. Mahadevaswamy and Martin (2002) also observed that the sole sugarcane and SC + onion in 1:1 RP recorded the maximum cane diameter, number of internodes and length of internode. Similarly, Singh and Vashist (2004) also reported similar findings in SC + onion intercropping system. The length of internode, girth of cane and number of internodes were significantly lower in treatments involving higher row ratio (1:2 and 1:3 RP) of sugar beet than sole sugarcane and SC + SB in 1:1 RP. The significant reduction in these values could be attributed to intense competition for light, moisture, nutrient and space exerted by higher population of sugar beet. Mahadevaswamy (2002) opined that the length of internode, girth of cane and number of internodes were significantly lower in sugarcane + onion with 1:4 RP.

The differences in yield components in sole sugarcane and SC + SB in 1:1 RP could be traced back to significant differences with regard to total dry matter production (TDMP) (Table 13 and Fig. 8). The TDMP was significantly higher in sole sugarcane and SC + SB in 1:1 RP (average of all sugar beet cultivars) (438.74 and 430.78 g plant⁻¹, respectively) than 1:2 (424.28 g plant⁻¹) and 1:3 RP (419.28 g plant⁻¹). The TDMP produced under sole sugarcane and SC + SB in 1:1 RP was higher by 3.41 and 1.53 per cent, respectively over 1:2 RP and by 5.10 and 2.74 per cent over 1:3 RP, respectively. Simple correlation study also showed positive and significant correlation between cane yield and TDMP ($r = 0.99$) (Table 20). The higher TDMP in sole sugarcane and SC + SB in 1:1 RP was the cumulative effect of higher growth characters such as plant height (165.42 and 159.36 cm, respectively) at harvest (Table 6), number of leaves (19.82 and 18.60 , respectively) (Table 7) and leaf area (77.24 and 70.79 dm² plant⁻¹, respectively) (Table 8) at peak stage of crop (270 DAP) on pooled basis. On the contrary these values were significantly lower in SC + SB intercropping involving 1:2 and 1:3 RP.

The higher cane yield and yield attributing characters of sole sugarcane and SC + SB in 1:1 RP are the reflections of dry matter accumulation (DMA) in stem (Table 12). At harvest, sole sugarcane and SC + SB in 1:1 RP accounted significantly higher DMA in stem (333.79 and 330.96 g plant⁻¹, respectively) on pooled basis compared to 1:2 and 1:3 RP (329.62 and 327.78 g plant⁻¹, respectively). Partitioning of dry matter in stem is a single most important factor contributing to the final cane yield. The higher DMA in stem may be due to higher photosynthetic ability of the crop as reflected through higher DMA in leaves (Table 11) and higher translocation of metabolites from leaf to stem during formative phases of crop growth. The simple correlation study also showed positive and significant correlation between cane yield and DMA in stem ($r=0.97$) (Table 20).

Leaf area index (LAI) and leaf area duration (LAD) which indicates the photosynthetic ability and persistence of the crop depends largely on leaf area (Table 9, 10 and Fig. 8). Sole sugarcane and SC + SB in 1:1 RP recorded significantly higher LAI (1.72 and 1.57 , respectively) at formative phase (270 DAP) and (1.60 and 1.47 , respectively) at maturity stage. Similarly, higher LAD was recorded with sole sugarcane and SC + SB in 1:1 RP (101.21 and 93.38 days, respectively) at formative phase (99.56 and 82.02 days, respectively) and at maturity stage. Higher LAI and LAD obtained with sole sugarcane and SC + SB in 1:1 RP might have helped in producing higher TDMP and its accumulation

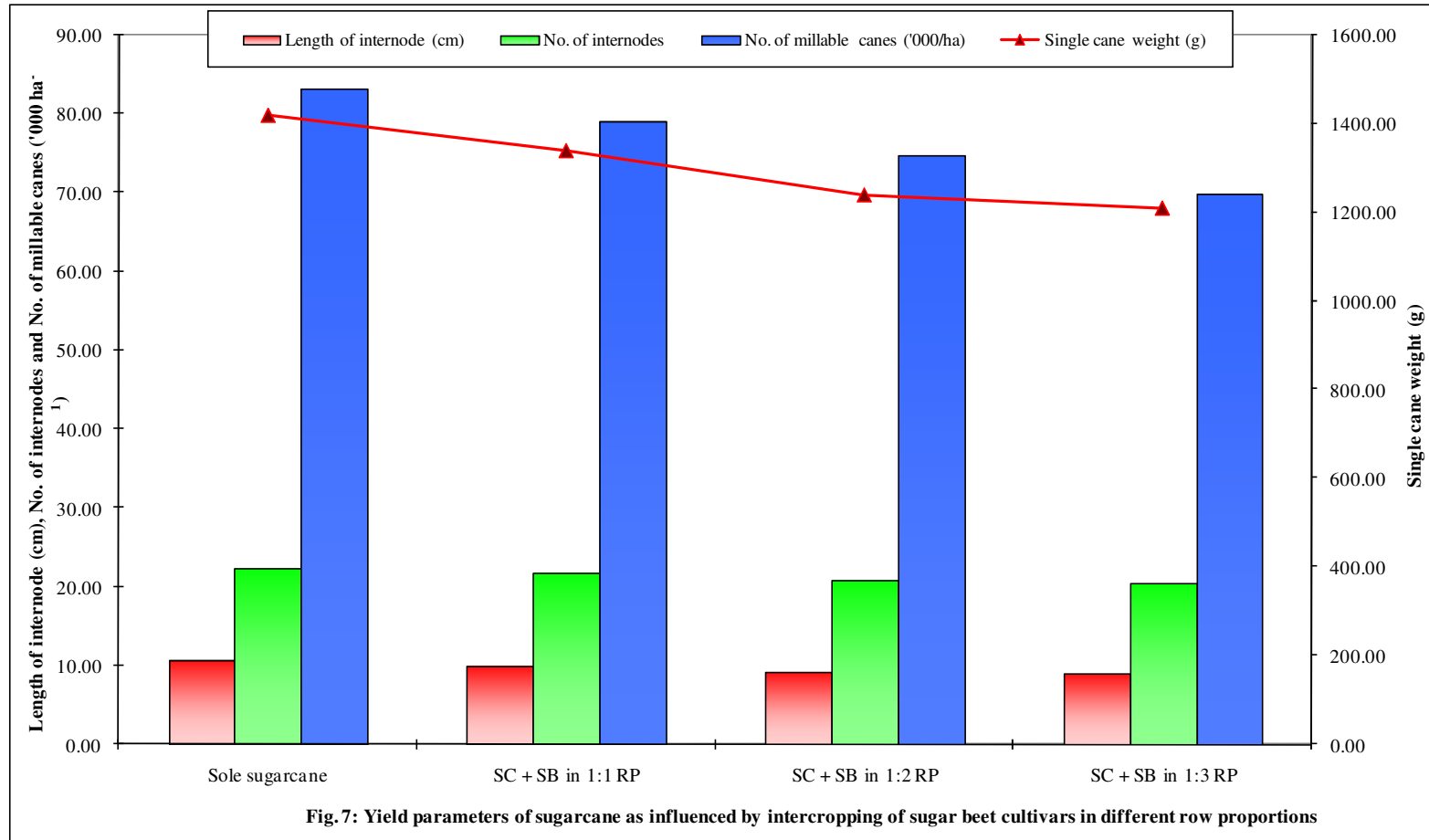


Fig 7 : Yield parameters of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

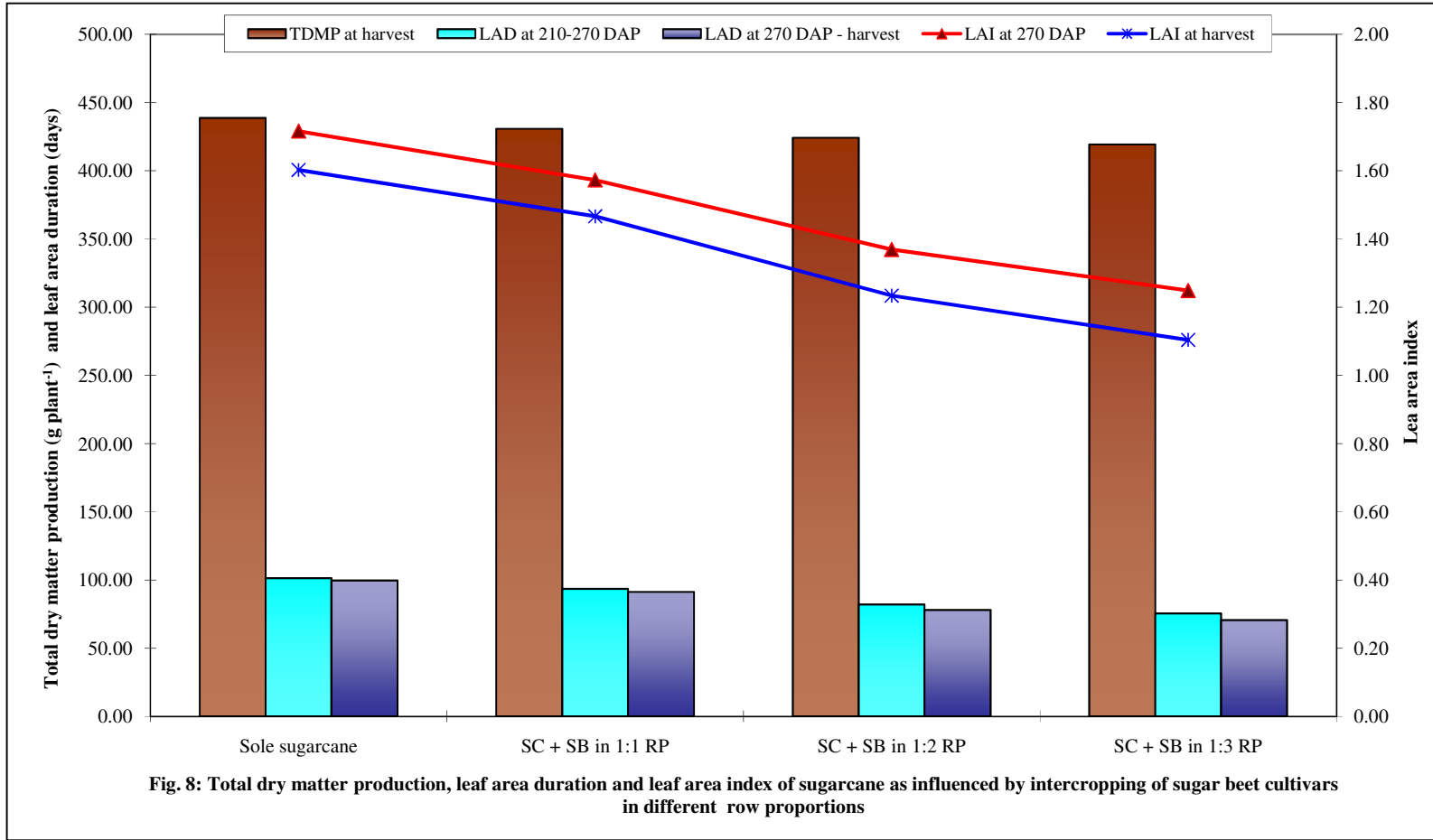


Fig 8 : Total dry matter production, leaf area duration and leaf area index of sugarcane as influenced by intercropping of sugar beet cultivars in different row proportions

in stem which lead to higher cane yield of sugarcane. The importance of LAI and LAD as a determinant of TDMP, DMA in stem and cane yield has been widely accepted (Mahadevaswamy, 2002). The simple correlation study also showed significant and positive correlation between cane yield and LAI ($r=0.93$) and LAD ($r=0.94$) (Table 20).

Among the different quality parameters (brix, sucrose, commercial cane sugar per cent and sugar yield) studied, significant variations were observed only in sugar yield due to intercropping of sugar beet cultivars in different row proportions (Table 18 and Fig. 5). Sole sugarcane recorded higher sugar yield (11.07 t ha^{-1}) compared to intercropped treatments. However, intercropping of SC + SB in 1:1 (10.55 t ha^{-1}) and 1:2 RP (9.98 t ha^{-1}) recorded at par sugar yield to that of sole sugarcane. Significantly lower sugar yield was recorded in 1:3 RP (9.40 t ha^{-1}). The per cent reduction in sugar yield of 1:3 RP over sole sugarcane, SC + SB in 1:1 and 1:2 RP was 17.76, 12.23 and 6.17, respectively

Sugar yield is a function of cane yield and quality characters of cane. In the present investigation, the quality parameters such as brix, sucrose and commercial cane sugar per cent did not show any significant variations. Hence, the variation in sugar yield was mainly due to variations in cane yield. In other words the trend of variations observed in sugar yield was similar to that of cane yield. The higher sugar yield in sole sugarcane, SC + SB in 1:1 and 1:2 RP was due to higher cane yield compared to SC + SB 1:3 RP. Intercropping of sugar beet in 1:1 RP with sugarcane did not reduce the cane or sugar yield as compared to sole sugarcane. This was mainly because the NMC as well as single cane weight were not reduced significantly. The results are in line with the findings of Mahadevaswamy (2002) wherein, the sugar yield was higher in sole sugarcane and SC + onion in 1:1 RP compared with SC + onion in 1:4 RP. Similarly, Bahadar *et al.* (2007) also reported higher sugar yield in SC + SB in 1:1 RP. The significant reduction in sugar yield in SC + SB in 1:3 RP was related to significant reduction in cane yield as well as yield parameters.

5.2.2 Performance of sugar beet

5.2.2.1 Performance of sugar beet in sole cropping

Tuber yield of sugar beet differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 30 and Fig. 9a). Sole cultivars Cauvery and Shubhra recorded significantly higher tuber yield (85.58 and 79.84 t ha^{-1} , respectively) than cultivar Calixta (74.82 t ha^{-1}) and Magnolia. Significantly the lower tuber yield was recorded in cultivar Magnolia (72.06 t ha^{-1}). The increase in tuber yield with sole cultivars Cauvery and Shubhra over sole cultivar Magnolia was to an extent of 14.60 and 6.92 per cent, respectively. Balakrishnan and Selvakumar (2008b) reported that cultivar Cauvery performed better in terms of yield (76 and 94 t ha^{-1} during 2005 and 2006 respectively) as compared to cultivars Shubhra and Indus. Similar results were also reported by Rajashekar (2007), Balakrishnan and Selvakumar (2009), Salimath and Lamani (2010) and Yekkeli (2010).

The economic yield is a function of dry matter production, efficiency to translocate photosynthates from assimilatory area of the source (leaf) and accumulate in tuber (sink). The higher yield with sole Cauvery and Shubhra cultivars compared to other two cultivars of sugar beet was due to improvement in yield attributing characters such as tuber weight (1181.07 and $1126.62 \text{ g plant}^{-1}$, respectively), tuber length (39.65 and 38.60 cm , respectively) and tuber girth (28.99 and 28.25 cm , respectively) (Table 29 and Fig. 10a, 10b). On the contrary, significantly lower tuber weight ($1083.06 \text{ g plant}^{-1}$), tuber length (37.30 cm) and tuber girth (27.08 cm) was recorded with sole cultivar Magnolia followed by sole cultivar Calixta. The simple correlation study also showed positive and significant correlation between tuber yield and yield attributes *viz.*, tuber weight ($r=0.99$), tuber length ($r=0.99$) and tuber girth ($r=0.99$) (Table 34). Rajashekar (2007) reported that the yield attributes such as tuber length, tuber girth and tuber weight was superior in cultivars Indus and Cauvery than Shubhra. Similar results were also reported by Balakrishnan and Selvakumar (2009).

The differences in yield components of sugar beet could be traced back to the differences in the total dry matter production (TDMP) (Table 28 and Fig. 11a). Significantly higher TDMP was recorded in sole cultivars Cauvery ($225.18 \text{ g plant}^{-1}$) and Shubhra ($223.05 \text{ g plant}^{-1}$) than cultivars Calixta and Magnolia. The latter cultivar recorded lower TDMP ($219.65 \text{ g plant}^{-1}$). Simple correlation study also showed positive and significant correlation between tuber yield and TDMP ($r=0.99$) (Table 34). The results obtained are in line with the work of Rajashekar (2007), Shewate *et al.* (2008a) and Balakrishnan and Selvakumar (2008b), Refay (2010) and Khogali *et al.* (2011).



Sole Cauvery



Sole Shubhra



Sole Magnolia



Sole Calixta

Plate 8 : Comparative view of sugar beet cultivars in sole cropping



Plate 9 : Comparative view of tubers of sugar beet cultivars in sole cropping

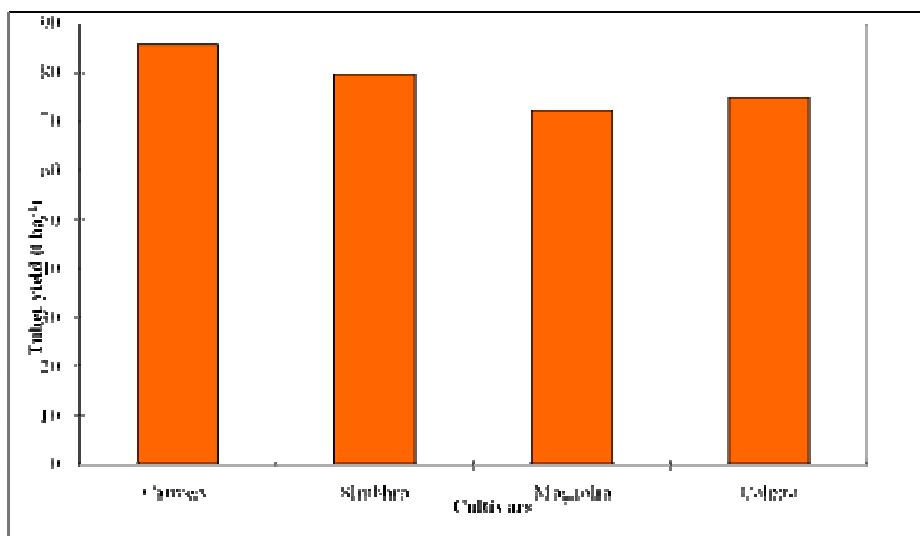


Fig 9a : Tuber yield of sole sugar beet cultivars

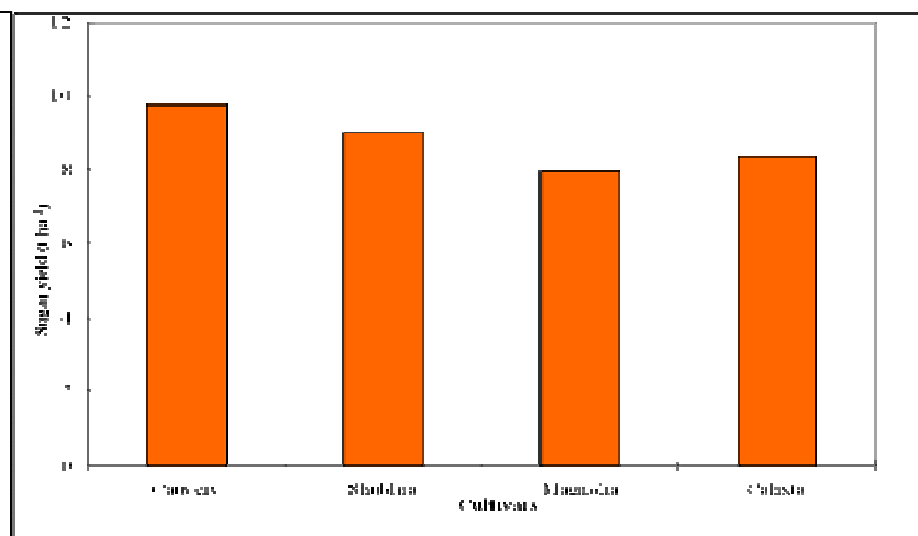


Fig 9b : Tuber yield of sole sugar beet cultivars

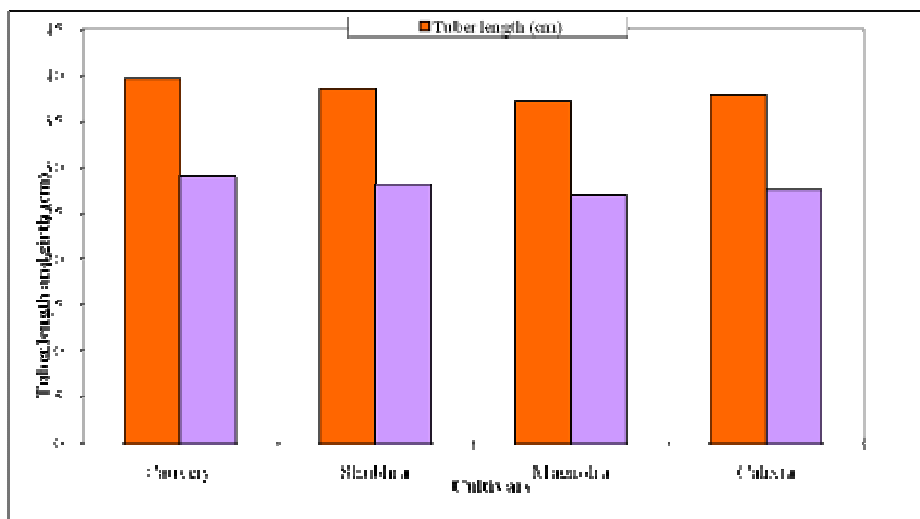


Fig 10 a : Tuber length and girth of sole sugar beet cultivars

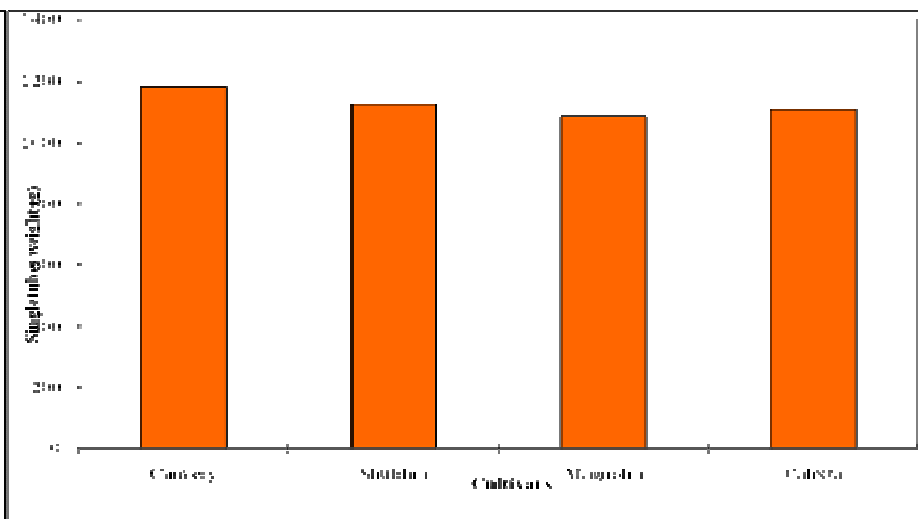


Fig 10b : Single tuber weight of sole sugar beet cultivars

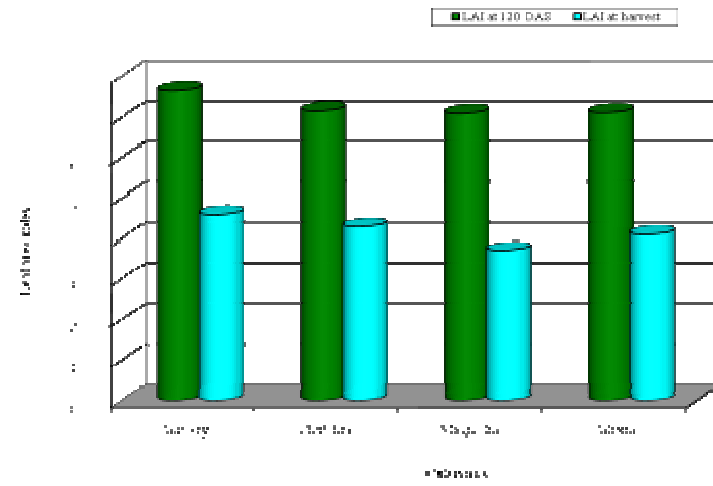
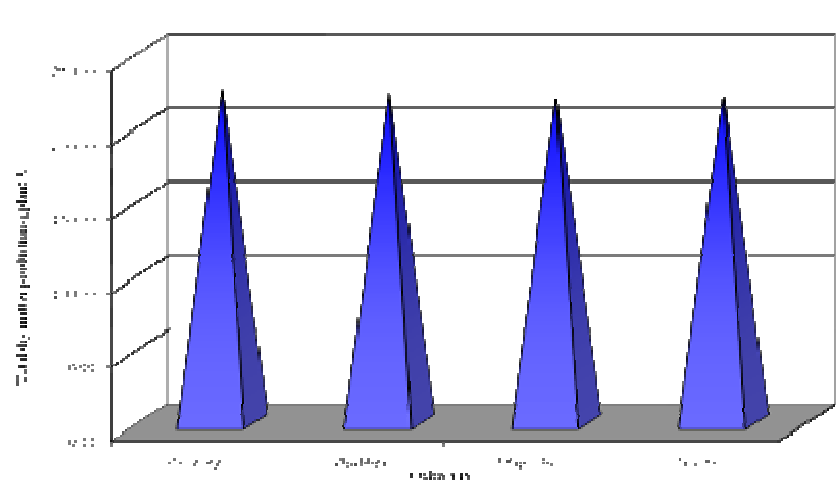


Fig 11a : Total dry matter production of sole sugar beet cultivars Fig 11b : Leaf area index of sole sugar beet cultivars

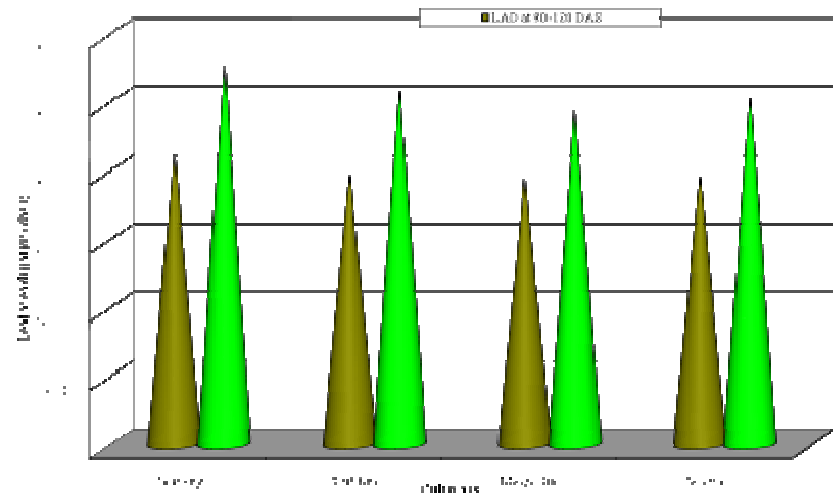


Fig 11c : Leaf area duration of sole sugar beet cultivars

The higher TDMP in sole cultivars Cauvery and Shubhra could also be related to higher photosynthetically active assimilatory surface area. Photosynthetic capacity of a plant depends upon plant height (Table 21), number of leaves per plant (Table 22), leaf area (Table 23) and dry matter accumulation in leaves (Table 26) at peak stage of crop growth (120 DAS). These growth parameters enabled the plant to trap higher quantity of solar energy with higher leaf surface area to convert into chemical energy. This helps in accumulation of higher dry matter in the economic parts which in turn might have led to the higher tuber yield. Further, at 120 DAS, significantly higher LAI was recorded in Cauvery and Shubhra (7.63 and 7.16 for LAI, respectively) than other cultivars (Table 24 and Fig. 11b). Similar trend was observed in LAD between 120 - harvest (274.84 and 257.24 days for LAD, respectively) (Table 25 and Fig. 11c). Simple correlation study also showed positive and significant correlation between tuber yield and LAI ($r=0.97$) and LAD ($r=0.99$) (Table 34). The significance of LAI and LAD as a determinant of TDMP, dry matter accumulation in tuber and tuber yield has been broadly accepted (Anon., 2004, Dhananjaya, 2007, Rajashekar, 2007, Balakrishnan and Selvakumar, 2008b and Praveen Kumar, 2010 and Ahmad *et al.*, 2010).

Tuber yield is a function of TDMP and its accumulation in economic part (tuber). In the present investigation sole cultivars Cauvery and Shubhra recorded significantly higher dry matter accumulation (DMA) in tuber (208.43 and 207.48 g plant⁻¹, respectively) than other cultivars (Table 27). The higher DMA in tuber may be due to higher photosynthetic ability of the crop as reflected through higher DMA in leaves and higher translocation of metabolites from leaf to tuber during reproductive phase of crop growth. Simple correlation study also showed positive and significant correlation between tuber yield and DMA in tuber ($r=0.99$) (Table 34). Rajashekar (2002) attributed that higher tuber yield in cultivars Indus and Cauvery was due to significantly higher DMA in tuber than Shubhra. The variations in tuber yield of sugar beet can also be attributed to variations in nutrient uptake. Sole Cauvery and Shubhra recorded higher nutrient uptake than other cultivars (Table 33).

With regard to quality parameters of sugar beet, brix, sucrose and commercial beet sugar percentage did not differ significantly, but significant variations were observed in sugar yield due to intercropping of sugar beet cultivars in different row proportions (Table 32 and Fig. 9b). Sole cultivars Cauvery and Shubhra recorded significantly higher sugar yield (9.76 and 9.00 t ha⁻¹, respectively) on pooled basis when compared to cultivars Magnolia (7.98 t ha⁻¹) and Calixta (8.37 t ha⁻¹). Significantly lower sugar yield was recorded in sole cultivar Magnolia. The increase in sugar yield with sole cultivars Cauvery and Shubhra over sole cultivar Magnolia was to an extent of 22.30 and 12.78 per cent, respectively.

Sugar yield is a function of tuber yield and quality characters *viz.*, brix and sucrose. In the present investigation, the quality parameters such as brix, sucrose and commercial beet sugar per cent did not show any significant variations. Hence, the variation in sugar yield could be attributed to variations in tuber yield of cultivars. The simple correlation study also showed positive and significant correlation between sugar yield and tuber yield ($r=0.99$), quality characters like Brix ($r=0.97$) and sucrose ($r=0.98$). Balakrishnan and Selvakumar (2009) reported that cultivar Shubhra recorded higher brix (20 %) followed by cultivars Cauvery (18%) and Indus (16%).

5.2.2.2 Performance of sugar beet in intercropping system

The performance of sugar beet cultivars at different row proportions (RP) was quite contrasting in relation to sole sugar beet. In general, tuber yield of sugar beet in intercropping system was significantly lower than sole sugar beet (Table 30 and 30a). The extent of reduction in tuber yield in 1:1, 1:2 and 1:3 RP (average of all sugar beet cultivars) was 54.90, 24.91 and 19.94 per cent, respectively (Fig. 12). Further, among the intercropped treatments tuber yield increased significantly with increase in the rows of sugar beet from 1:1 to 1:3 in all the cultivars. Accordingly, significantly higher tuber yield was recorded in 1:3 RP (57.72 to 68.46 t ha⁻¹, Av. 62.51 t ha⁻¹) followed by 1:2 RP (54.16 to 64.21 t ha⁻¹, Av. 58.62 t ha⁻¹). The lowest tuber yield was recorded in 1:1 RP (32.62 to 38.54 t ha⁻¹, Av. 35.21 t ha⁻¹) (Fig. 13a).

The higher tuber yield of sugar beet in 1:3 RP was mainly due to higher plant population of sugar beet than 1:1 and 1:2 RP. The population of sugar beet in 1:3 RP was same as that of sole sugar beet (100 %) while the population of sugar beet in 1:1 and 1:2 RP was 33 and 66 %, respectively. The higher yield of any crop is mainly due to higher growth and yield attributing characters. In the present investigation, sugar beet in 1:3 RP recorded higher tuber yield although the various growth and yield attributes were significantly lower compared with sugar beet in 1:1 and 1:2 RP (Fig. 13b and 14a, 14b). The growth (plant height, number of leaves, leaf area, LAI, LAD, DMA in leaves, DMA in stem and TDMP) and yield (tuber weight, tuber length and tuber girth) parameters



Cauvery at 60 DAS before sugarcane planting
in 1:1 RP



Cauvery at 150 DAS with sugarcane
in 1:1 RP

Sugarcane+sugar beet (cv. Cauvery) in 1:1 RP



Cauvery at 60 DAS before sugarcane planting
in 1:2RP



Cauvery at 150 DAS with sugarcane
in 1:2 RP

Sugarcane+sugar beet (cv. Cauvery) in 1:2 RP



Cauvery at 60 DAS before sugarcane planting
in 1:3 RP



Cauvery at 150 DAS with sugarcane
in 1:3 RP

Sugarcane+sugar beet (cv. Cauvery) in 1:3 RP

Plate 10 : Performance of sugar beet (cv. Cauvery) in intercropping with sugarcane at different row proportions



Shubhra at 60 DAS before sugarcane planting
in 1:1 RP



Shubhra at 150 DAS with sugarcane
in 1:1 RP

Sugarcane+sugar beet (cv. Shubhra) in 1:1 RP



Shubhra at 60 DAS before sugarcane planting
in 1:2RP



Shubhra at 150 DAS with sugarcane
in 1:2 RP

Sugarcane+sugar beet (cv. Shubhra) in 1:2 RP



Shubhra at 60 DAS before sugarcane planting
in 1:3 RP



Shubhra at 150 DAS with sugarcane
in 1:3 RP

Sugarcane+sugar beet (cv. Shubhra) in 1:3 RP

Plate 11 : Performance of sugar beet (cv. Shubhra) in intercropping with sugarcane at different row proportions



Magnolia at 60 DAS before sugarcane planting in 1:1 RP



Magnolia at 150 DAS with sugarcane in 1:1 RP

Sugarcane+sugar beet (cv. Magnolia) in 1:1 RP



Magnolia at 60 DAS before sugarcane planting in 1:2RP



Magnolia at 150 DAS with sugarcane in 1:2 RP

Sugarcane+sugar beet (cv. Magnolia) in 1:2 RP



Magnolia at 60 DAS before sugarcane planting in 1:3 RP



Magnolia at 150 DAS with sugarcane in 1:3 RP

Sugarcane+sugar beet (cv. Magnolia) in 1:3 RP

Plate 12 : Performance of sugar beet (cv. Magnolia) in intercropping with sugarcane at different row proportions



Calixta at 60 DAS before sugarcane planting
in 1:1 RP



Calixta at 150 DAS with sugarcane
in 1:1 RP

Sugarcane+sugar beet (cv. Calixta) in 1:1 RP



Calixta at 60 DAS before sugarcane planting
in 1:2RP



Calixta at 150 DAS with sugarcane
in 1:2 RP

Sugarcane+sugar beet (cv. Calixta) in 1:2 RP



Calixta at 60 DAS before sugarcane planting
in 1:3 RP



Calixta at 150 DAS with sugarcane
in 1:3 RP

Sugarcane+sugar beet (cv. Calixta) in 1:3 RP

Plate 13 : Performance of sugar beet (cv. Calixta) in intercropping with sugarcane at different row proportions

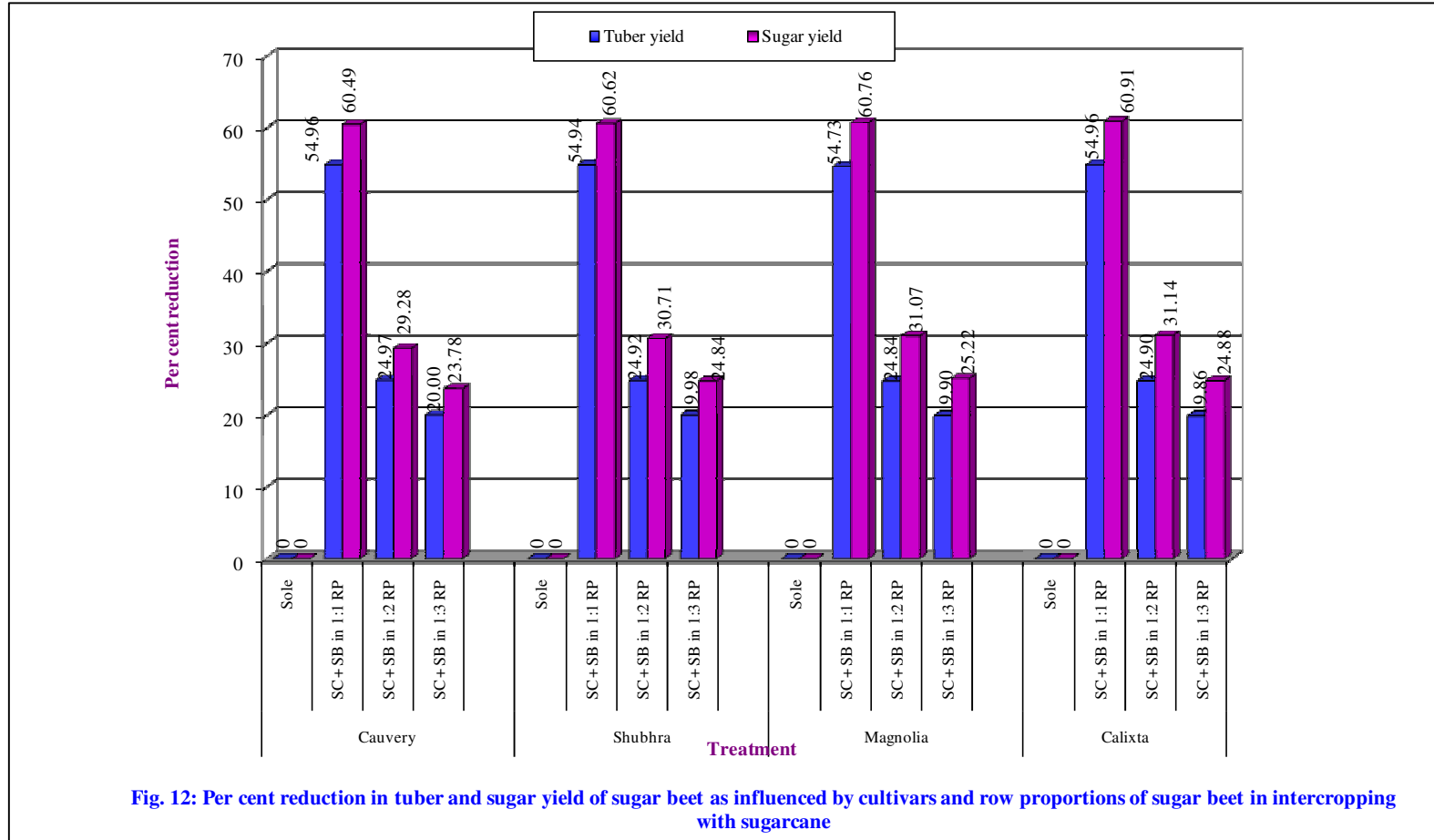


Fig. 12: Per cent reduction in tuber and sugar yield of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

Fig 12 : Per cent reduction in tuber and sugar yield of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

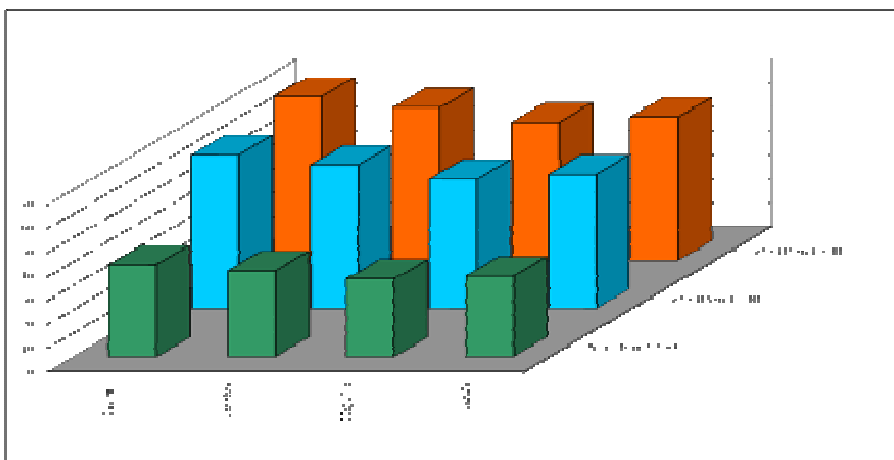


Fig 13a : Tuber yield (t ha⁻¹) of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

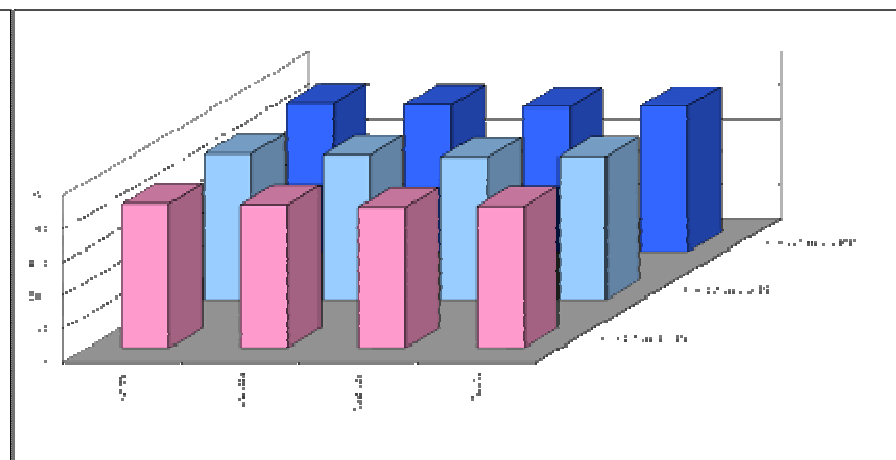


Fig 13b : Total dry matter production (g plant⁻¹) of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

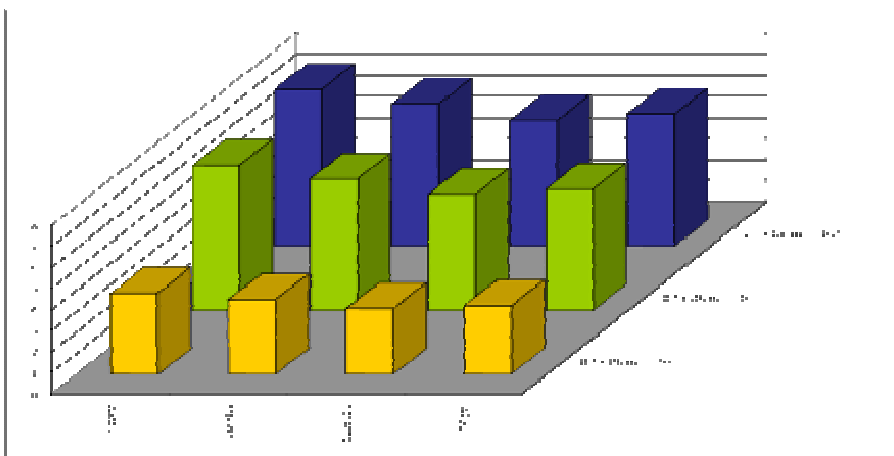


Fig 13c : Sugar yield (t ha⁻¹) of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

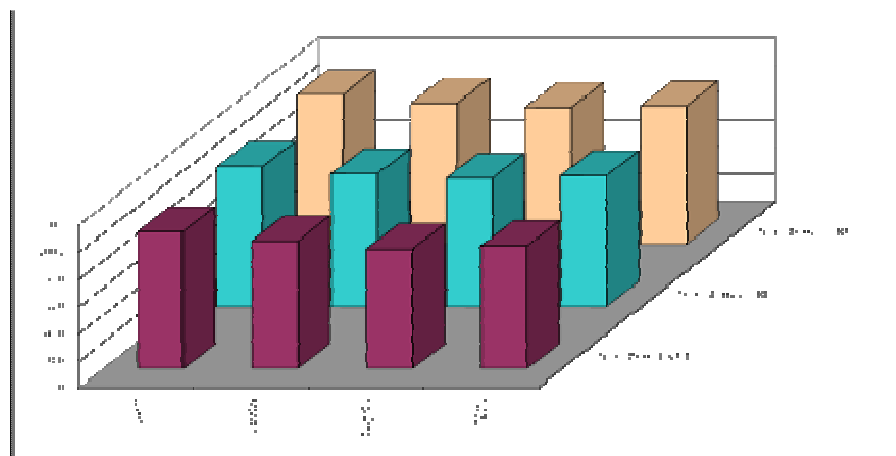


Fig 13d : Single tuber weight (g) of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

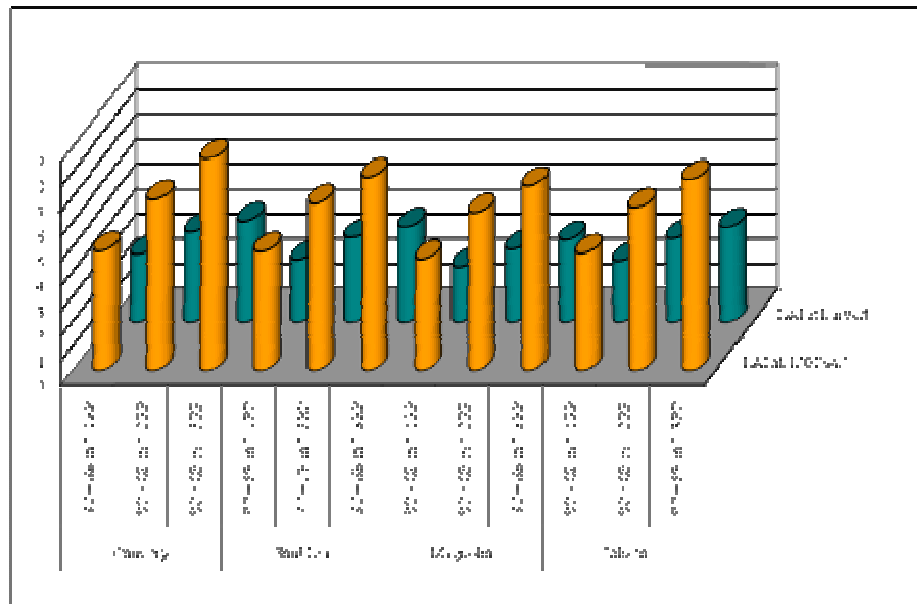


Fig 14a : Leaf area index of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane

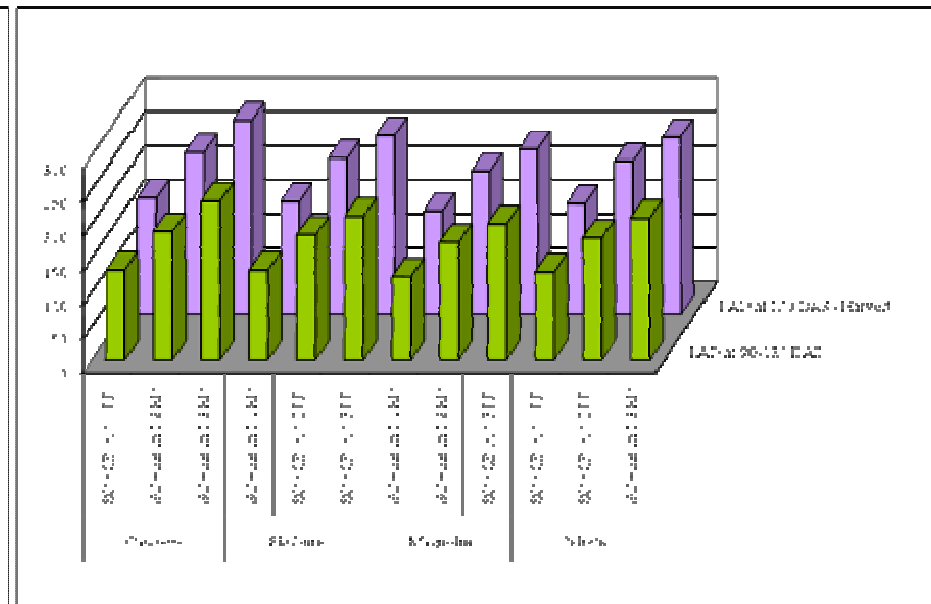


Fig 14b : Leaf area duration of sugar beet as influenced by cultivars and row proportions of sugar beet in intercropping with sugarcane



Plate 14 : Comparative view of tubers of sugar beet cultivars (cv. Cauvery and Shubhra) in intercropping system



Plate 15 : Comparative view of tubers of sugar beet cultivars (cv. Magnolia and Calixta) in intercropping system

were significantly lower in 1:3 RP than 1:2 and 1:1 RP. On the contrary these components were significantly higher in 1:1 RP followed by 1:2 RP, but, these components failed to compensate the tuber yield due to reduced plant population in intercropping system. Hence the tuber yield obtained in 1:1 and 1:2 RP was significantly lower than 1:3 RP (Fig. 13a). Results are in concurrence with the findings of Mahadevaswamy (2002) and Khan *et al* (2002).

Among the intercropping systems, the performance of cultivars Cauvery and Shubhra in terms of tuber yield was higher in 1:3 and 1:2 RP than 1:1 RP than cultivars Magnolia and Calixta (Fig. 13a, 13c). The higher tuber yield in cultivars Cauvery and Shubhra in 1:3 and 1:2 RP could be related to higher values of various growth (plant height, number of leaves, leaf area, LAI, LAD, DMA in leaves, DMA in stem and TDMP) and yield (tuber weight, tuber length and tuber girth) parameters observed. On the contrary, the poor performance of Magnolia and Calixta was due to lower values of various growth and yield components (Yekkeli, 2010).

Similar to tuber yield, the sugar yield also showed significant variations among the intercropped treatments but was significantly lower compared to sole crop. Among the intercropped treatments, irrespective of sugar beet cultivars sugar yield increased significantly with increase in the rows of sugar beet from 1:1 to 1:3. Accordingly, significantly higher sugar yield was recorded in 1:3 RP (5.97 to 7.44 t ha⁻¹, Av. 6.62 t ha⁻¹) followed by 1:2 RP (5.50 to 6.90 t ha⁻¹ Av. 6.10 t ha⁻¹). The lowest tuber yield was recorded in 1:1 RP (3.13 to 3.86 t ha⁻¹ Av. 3.45 t ha⁻¹). The higher sugar yield of sugar beet in 1:3 RP was mainly due to higher tuber yield than 1:2 and 1:1 RP.

5.2.3 Performance of sugarcane + sugar beet intercropping system

The productivity of a system is mainly determined by the efficiency of the system in utilization of resources. This depends not only on the individual main and component crops of the system but also on how much of these crops complement with each other in space and time (Palaniappan, 1985). Therefore, the overall productivity of intercropping of sugarcane and sugar beet depends on the main crop as well as its compatibility with component crop. A system to be productive it has to ensure complementary resource use pattern among the main and component crops.

Sugarcane equivalent yield (SEY) differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 35). All the intercropping treatments recorded significantly higher SEY (116.02 to 128.03 t of SEY ha⁻¹) compared to sole stands (101.39 t ha⁻¹ in sugarcane and 41.20 to 48.93 t ha⁻¹ in sugar beet). Irrespective of sugar beet cultivars, intercropping treatments namely SC + SB in 1:2 and 1:3 RP recorded significantly higher SEY than SC + SB in 1:1 RP due to better resource utilization by both the crops (Fig. 15a). The higher SEY in SC + SB in 1:2 and 1:3 RP was due to higher yield and market price of both the crops. Significantly lower SEY was recorded in sole sugarcane and sugar beet on account of lower yield. These findings are in line with observations made by Kapur and Kanwar (1989), Porwal *et al.* (1994) and Sanjay Kumar *et al.* (2011).

Land equivalent ratio (LER) differed significantly due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 35). All the intercropping treatments recorded significantly higher LER over sole crops. Among cropping systems, intercropping of sugarcane + sugar beet in 1:2 and 1:3 RP recorded significantly higher LER when compared to sugarcane + sugar beet in 1:1 row proportion (Irrespective of sugar beet cultivars). The higher LER values in the above intercropped treatments were due to higher yield of component crops in relation to their sole crops. This was evident by higher combined yield of both the crops per unit area. The higher combined yield in turn could be related to the fact that component crops differed in utilization of growth resources and converting them more efficiently into economic part leading to higher yield per unit area. Results are in concurrence with the findings of Abou Salama *et al.* (2000) and Mahadevaswamy and Martin (2002).

Similar to LER, the area time equivalent ratio (ATER) also showed significant variations among the treatments (Table 35). All the intercropped treatments recorded higher ATER values than sole crops except SC + SB (Cauvery/Shubra) in 1:1 RP. Intercropping of SC + SB in 1:2 and 1:3 RP recorded significantly higher ATER when compared to SC + SB in 1:1 RP (Irrespective of sugar beet cultivars). The higher ATER values in the above treatments indicate that both sugarcane as well as sugar beet were not only efficient in use of land but also efficient in use of time. The variations in ATER values in intercropping treatments could be attributed to higher productivity per unit area per unit time. Findings are in line with observations of Mahadevaswamy and Martin (2002).

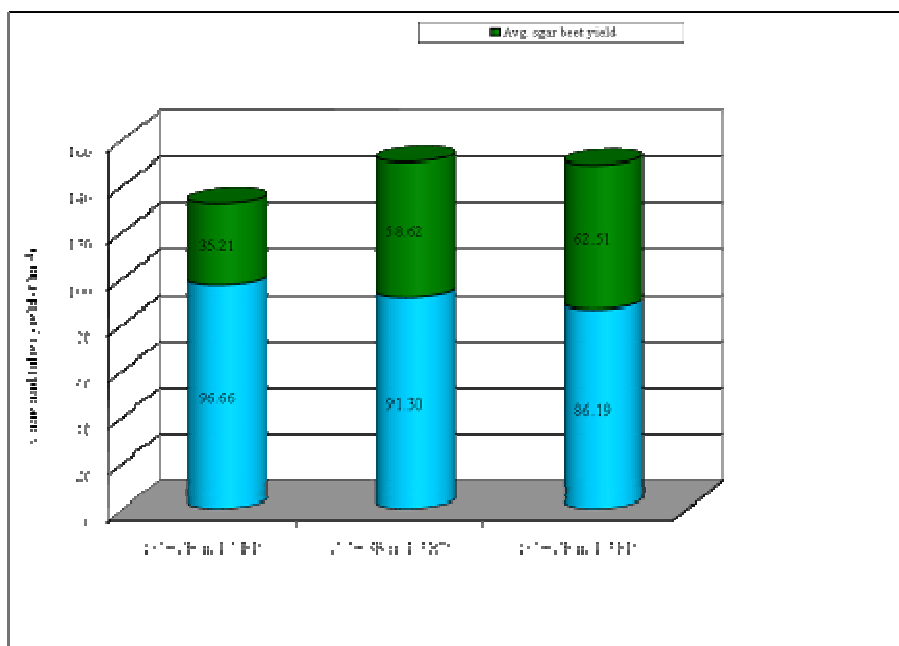


Fig 15a : Total productivity of sugarcane and sugar beet intercropping system in different row proportions

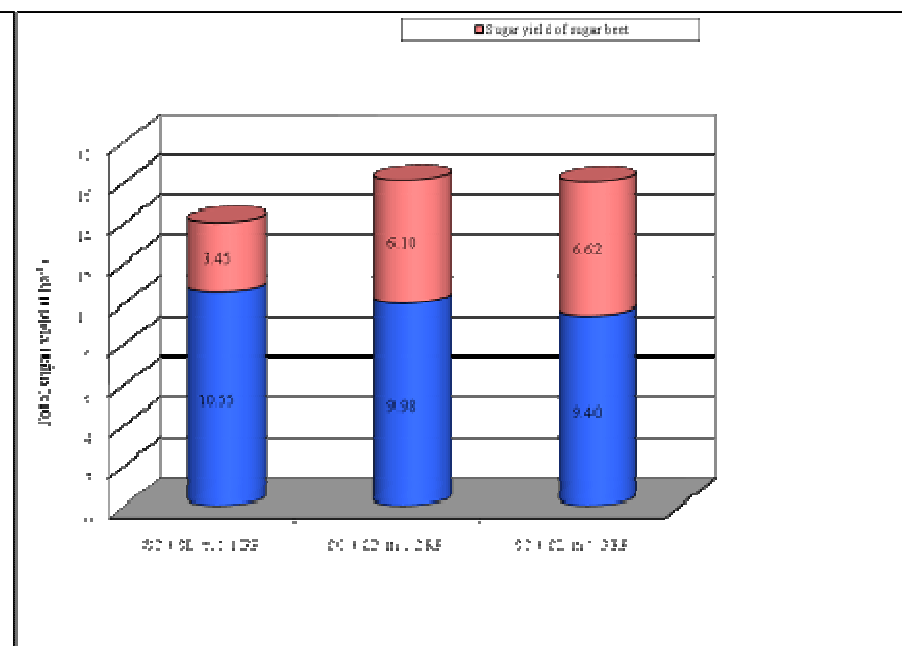


Fig 15b : Total sugar yield of sugarcane and sugar beet intercropping system in different row proportions

The system productivity index (SPI) differed significantly due to intercropping of sugar beet cultivars with sugarcane at different row ratios during 2010-11, 2011-12 and on pooled basis (Table 35). Irrespective of sugar beet cultivars, intercropping treatments namely SC + SB in 1:2 and 1:3 RP recorded significantly higher SPI than SC + SB in 1:1 RP. This clearly indicates that growing of sugar beet as an intercrop in sugarcane in 1:2 and 1:3 RP helped to increase the total productivity of the system although the component crops were affected in intercropping system compared to sole stands. This was evident from the SEY data.

The total sugar yield obtained from sugarcane and sugar beet in intercropping system was significantly higher in 1:2 and 1:3 RP compared to 1:1 RP (Table 36 and Fig. 15b). On the contrary, sole stand of both the crops recorded significantly lower total sugar yield. Significantly higher total sugar yield in 1:2 and 1:3 RP was mainly due to relatively higher sugar yield from sugar beet and relatively lower reduction from sugar beet. The lower total sugar yield in 1:1 RP was due to significantly lower sugar yield from sugar beet although sugar yield from sugarcane was relatively higher.

5.2.4 Economic analysis of sugarcane + sugar beet intercropping system

The economics of intercropping of sugar beet with sugarcane depends upon the various factors such as any reduction in cane yield, yield of intercrop, cost of production and its market price. In the present study significant differences were observed with respect to gross returns, net returns and B:C due to intercropping of sugar beet cultivars with sugarcane in different row proportions during 2010-11, 2011-12 and on pooled basis (Table 37). Irrespective of sugar beet cultivars, SC + SB in 1:2 and 1:3 RP recorded significantly higher gross returns except SC + SB (Magnolia) in 1:3 RP compared to SC + SB in 1:1 RP (Fig. 16). Significantly lower gross returns were recorded in sole stands of both the crops. Significantly higher gross returns in the above treatments were due to higher yield and price of both crops.

In contrast to gross returns, all the intercropping treatments (except SC + Calixta/ Magnolia in 1:3 RP) recorded significantly higher net returns than sole crops (Table 37 and Fig. 16). The net returns recorded under 1:1 RP was comparable to that of 1:2 and 1:3 RP, though the tuber yield of sugar beet was significantly lower in former treatment which was compensated by the higher cane yield. On the other hand in 1:2 and 1:3 RP sugarcane yield was significantly lower as that of sole sugarcane and 1:1 RP but was compensated by higher tuber yield of sugar beet. Thus, the comparable net returns in above intercropped treatments could be attributed to variations in yield and cost of cultivation of component crops. The results corroborate the findings of Singh and Mehra (1995), Singh and Vashist (2004) and Sanjay Kumar *et al.* (2011).

The B:C of sugarcane and sugar beet intercropping system showed significant variations (Table 37). Intercropping of sugarcane + sugar beet in 1:1 and 1:2 RP recorded significantly higher B:C compared to 1:3 RP and sole crops. The variations in B:C was due to variations in gross returns and cost of cultivation. The higher B:C in 1:1 and 1:2 RP was mainly due to higher gross returns obtained by both the crops in relation to the cost involved. The results obtained are in line with the work of Patil *et al.* (1991) and Porwal *et al.* (1994).

5.3 Experiment-II: Performance of sugar beet to sources of nitrogen and liquid manures

Sugar beet is a highly input intensive crop and heavy feeder of all the major plant nutrients and more particularly nitrogen from the beginning of the crop growth. Fertilization with higher amount of inorganic sources of nitrogen may results in increased cost. Integrated nitrogen management by using biodegraded wastes (vermicompost, poultry manure, organic liquid manures *etc.*) along with chemical nitrogen is need of the day in sustaining crop productivity besides improving sugar yield. The information on integrated nitrogen management through combination of organic and inorganic for sustainable sugar beet production is meagre and hence study was conducted to find out integrated nitrogen management practices for sugar beet during 2010-11 and 2011-12 at Agricultural Research Station (ARS), Madhurakhandi, University of Agricultural Sciences, Dharwad which is located at Northern dry zone (Zone-3) of Karnataka. Results obtained from field experiments on different aspects are discussed in this chapter in detail establishing cause and effect relationship. Pooled data of the two years are mainly discussed.

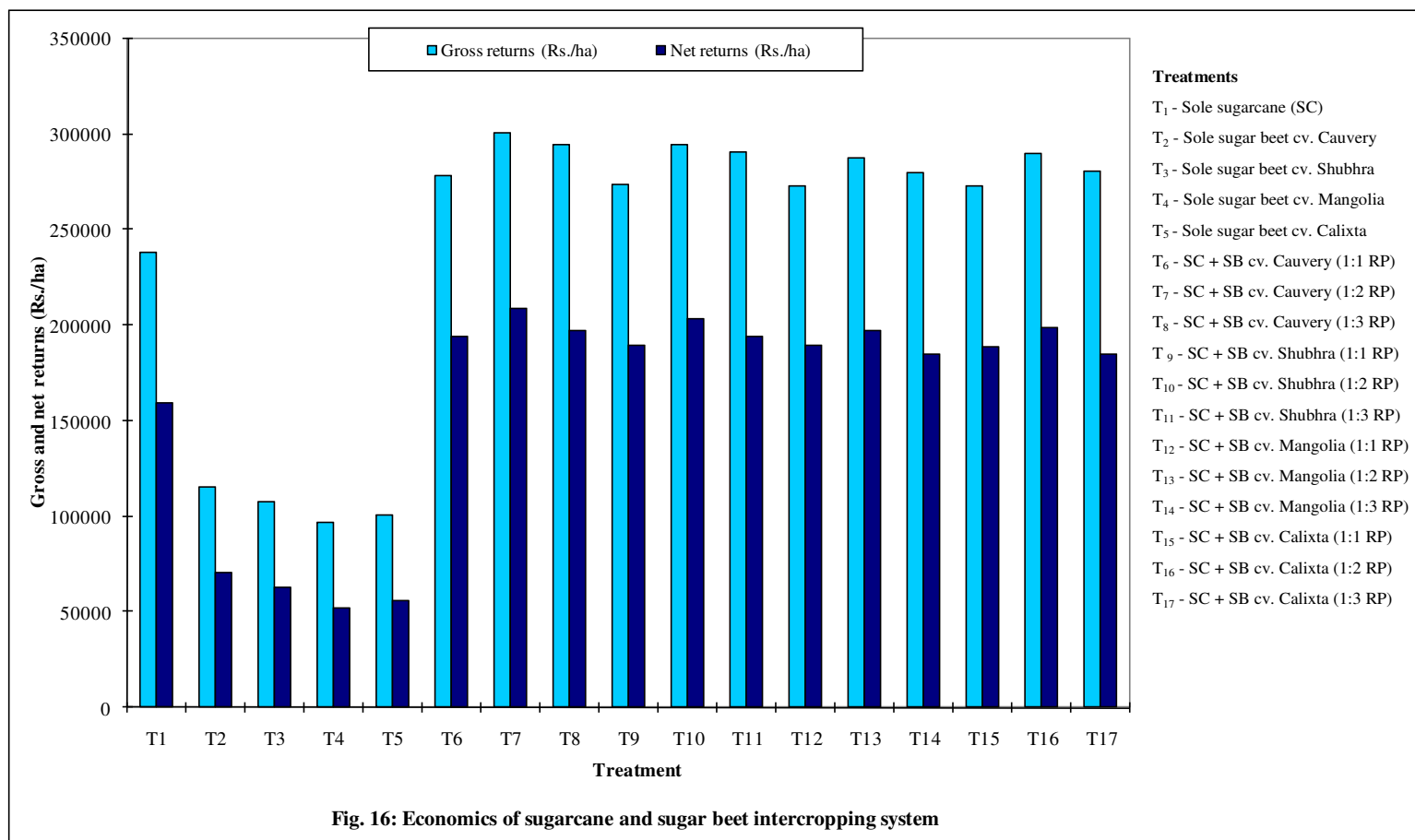


Fig 16 : Economics of sugarcane and sugar beet intercropping system

5.3.1 Effect of sources of nitrogen on performance of sugar beet

Sources of nitrogen showed significant influence on tuber yield of sugar beet during 2010-11, 2011-12 and on pooled basis (Table 49 and Fig. 17). Application of 100 per cent RDN through inorganic fertilizer (IF) (SN₁) recorded significantly higher tuber yield (77.16 t ha⁻¹) compared to other sources of nitrogen on pooled basis. However, treatment which received 75 per cent RDN through IF + 25 per cent RDN through vermicompost (VC) and poultry manure (PM) in equal proportions (SN₂) (75.58 t ha⁻¹) was on par with SN₁. Significantly lower tuber yield was recorded with application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) (SN₅) (70.27 t ha⁻¹). The magnitude of yield increase with SN₁ and SN₂ treatments was to the tune of 9.80 and 7.56 per cent, respectively over SN₅. Wojcik (1993) reported that tuber yield of 63.1 t ha⁻¹ was recorded with application of 140 kg N ha⁻¹ using urea as nitrogen source. Similarly in onion, Singh *et al.* (2001) opined that the average weight of bulb and bulb yield increased significantly with application of farmyard manure at 10 t ha⁻¹ and N at 120 kg ha⁻¹. Similar results were also reported by Noruzi *et al.* (2003), Dhananjaya (2007), Balakrishnan and Selvakumar (2008a), Shewate *et al.* (2008b) and Praveen Kumar (2010).

The variations in tuber yield of sugar beet could also be attributed to variations in nutrient uptake by the crop (Table 53 and Fig. 18). Significantly higher nitrogen uptake by sugar beet was recorded in SN₁ and SN₂. This could be attributed to higher quantity of inorganic N added to the crop than other sources of nitrogen. The similar trend was also observed in P and K nutrients. Shanmugasundaram and Savithri (2004) noticed that application of nitrogen at 120 kg ha⁻¹ along with FYM (10 t ha⁻¹) recorded higher amount of nitrogen content and uptake of nitrogen in foliage as well as in carrot root. Similar results were also reported by Rajashekaran (2007).

The economic yield is a function of dry matter production, efficiency to translocate photosynthates from assimilatory area of the source (leaf) and accumulate in different plant parts and ultimately on yield attributing traits. Significantly higher tuber yield in SN₁ and SN₂ was mainly attributed to significantly superior yield attributes *viz.*, tuber weight (1153.82 and 1096.66 g plant⁻¹, respectively), tuber length (38.01 and 36.18 cm, respectively) and tuber girth (27.11 and 26.75 cm, respectively). On the contrary, significantly lower tuber weight (899.51 g plant⁻¹), tuber length (32.62 cm) and tuber girth (24.60 cm) recorded in SN₅ (Table 48 and Fig. 19). The simple correlation study also showed positive and significant correlation between tuber yield and yield attributes *viz.*, tuber weight ($r=0.99$), tuber length ($r=0.99$) and tuber girth ($r=0.95$) (Table 55). The results are in line with findings of Zimny *et al.* (2007) wherein they reported significant increase of root length, mass and thickness of sugar beet with application of 100 kg N ha⁻¹. Similarly, Balakrishnan and Selvakumar (2008) reported that application of 100 per cent RDF + bio fertilizers along with FYM recorded significantly higher root length and root girth. The higher in tuber yield with SN₁ and SN₂ might be attributed to higher and readily available nitrogen for longer period since major quantity of nitrogen was in inorganic form which promoted growth of sugar beet and hence resulted in increased tuber yield.

The differences in yield components of sugar beet could be traced back to the favourable improvement in total dry matter production (TDMP) (Table 47 and Fig. 20). Significantly higher TDMP was noticed in application of 100 per cent RDN through IF (SN₁) (219.14 g plant⁻¹). Application of 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportions (SN₂) (214.47 g plant⁻¹) was on par with former treatment. Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportions recorded lower TDMP (199.80 g plant⁻¹). Simple correlation study also showed positive and significant correlation between tuber yield and TDMP ($r = 0.99$) (Table 55). The higher TDMP in SN₁ and SN₂ was cumulative effect of higher growth characters such as plant height (58.17 and 56.73 cm, respectively), number of leaves (24.25 and 23.95, respectively) and leaf area (78.65 and 74.34 dm² plant⁻¹, respectively) at 120DAS (Table 40, 41 and 42, respectively). Rajashekaran (2007) reported that the growth parameters such as plant height, leaf area and dry matter production of the tropical sugar beet were significantly higher with application 150 kg N along with recommended dose of P, K and FYM. Similar results also reported by Balakrishnan and Selvakumar (2008).

Higher TDMP in the SN₁ and SN₂ could be related to higher photosynthetically active assimilatory surface area as observed by higher leaf area index (LAI) and leaf area duration (LAD) (Table 47). Application of 100 per cent RDN through IF (SN₁) and application of 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportions (SN₂) recorded significantly higher LAI (7.87 and 7.43, respectively) (Table 43 and Fig. 21) at 120 DAS and LAD (285.55 and 265.54 days, respectively) between 121 to harvest over application of 100 per cent RDN through VC



Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN,LM,)



Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN,LM,)

Plate 16 : Performance of sugar beet as influenced by sources of nitrogen (SN) and liquid manures (LM)



Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10%) at 30 and 60 DAS (SN,LM₂)



Application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN,LM₂)

Plate 17 : Performance of sugar beet as influenced by sources of nitrogen (SN) and liquid manures (LM)

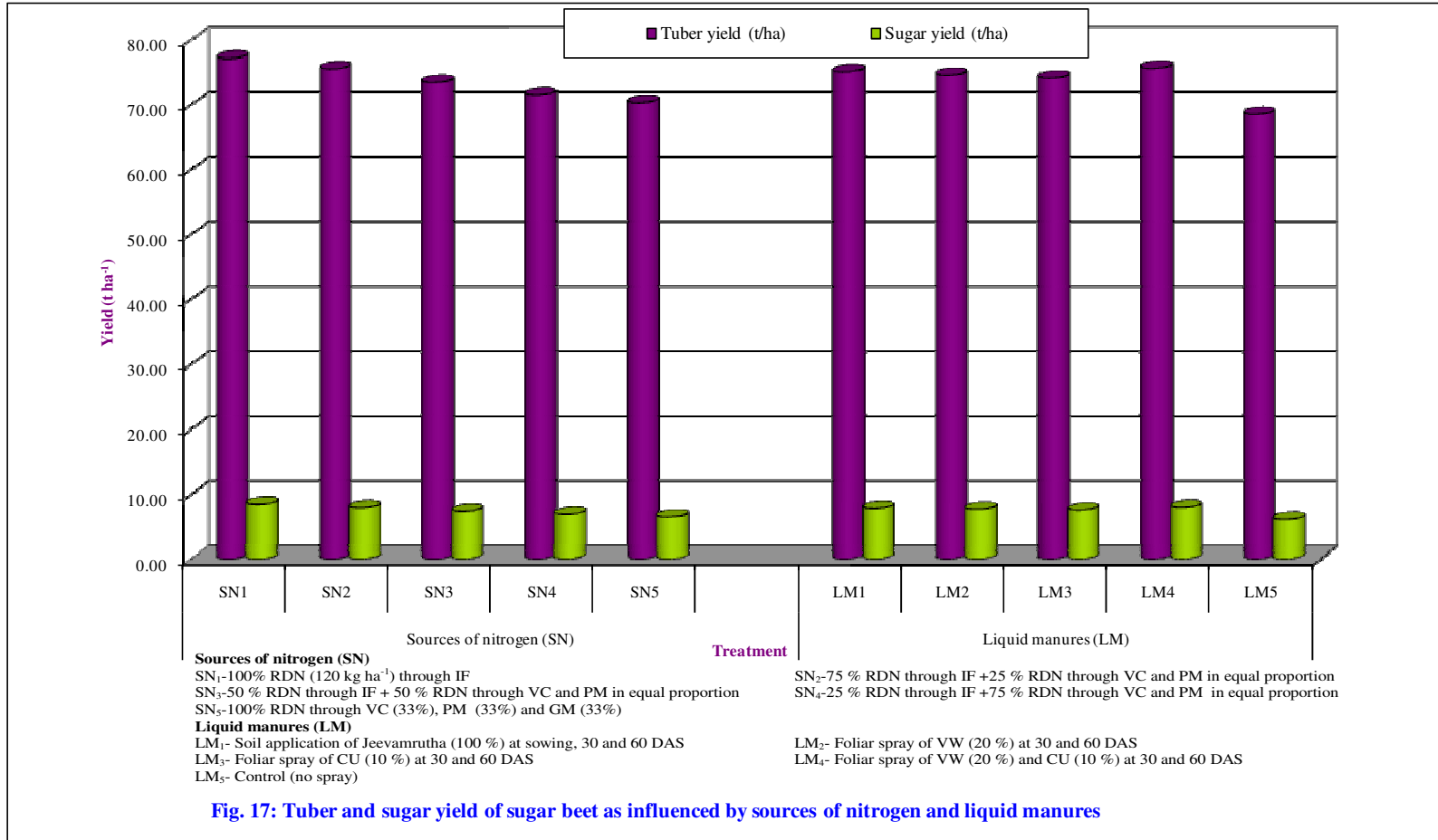


Fig 17 : Tuber and sugar yield of sugar beet as influenced by sources of nitrogen and liquid manures

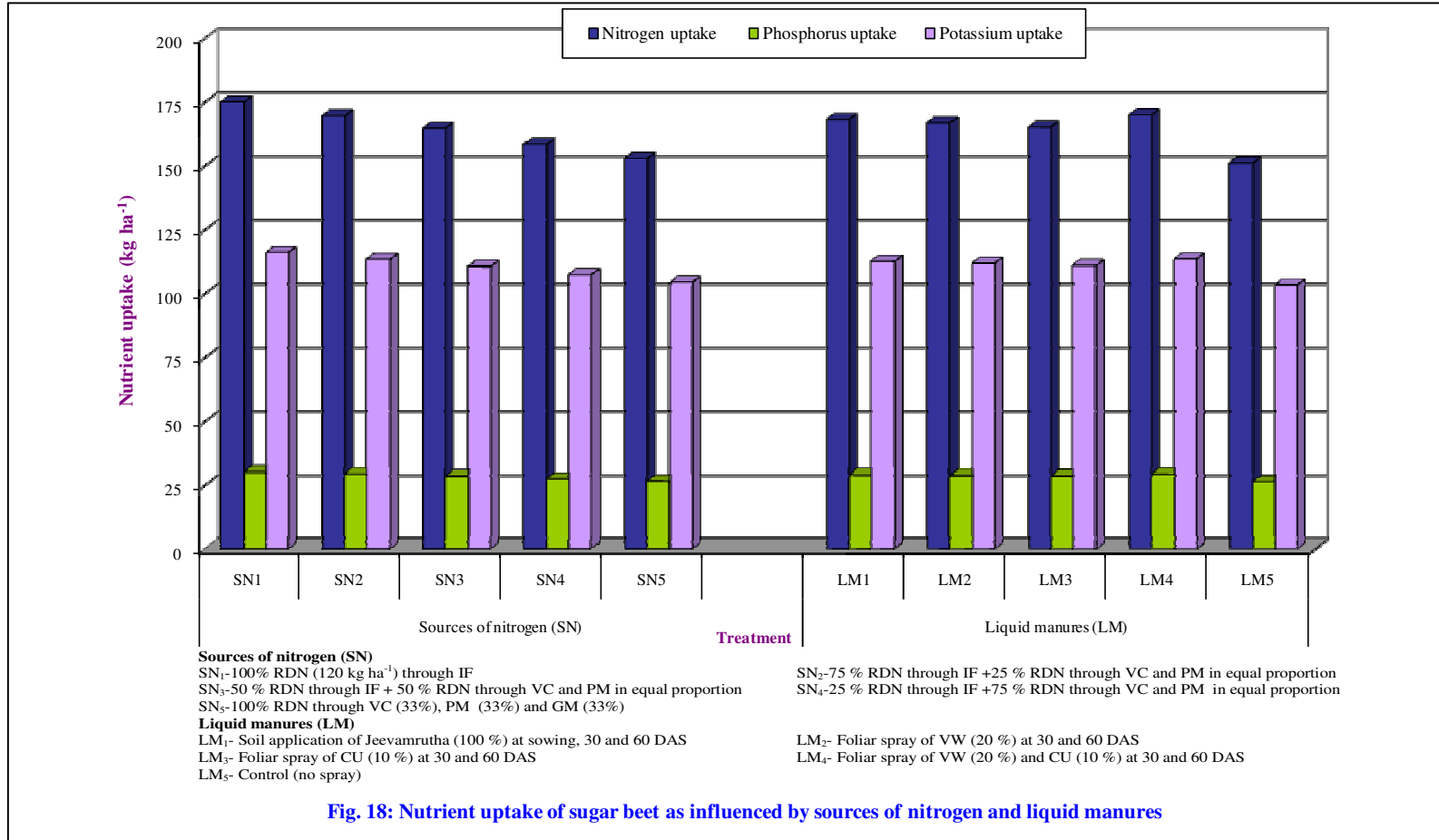


Fig 18 : Nutrient uptake of sugar beet as influenced by sources of nitrogen and liquid manures

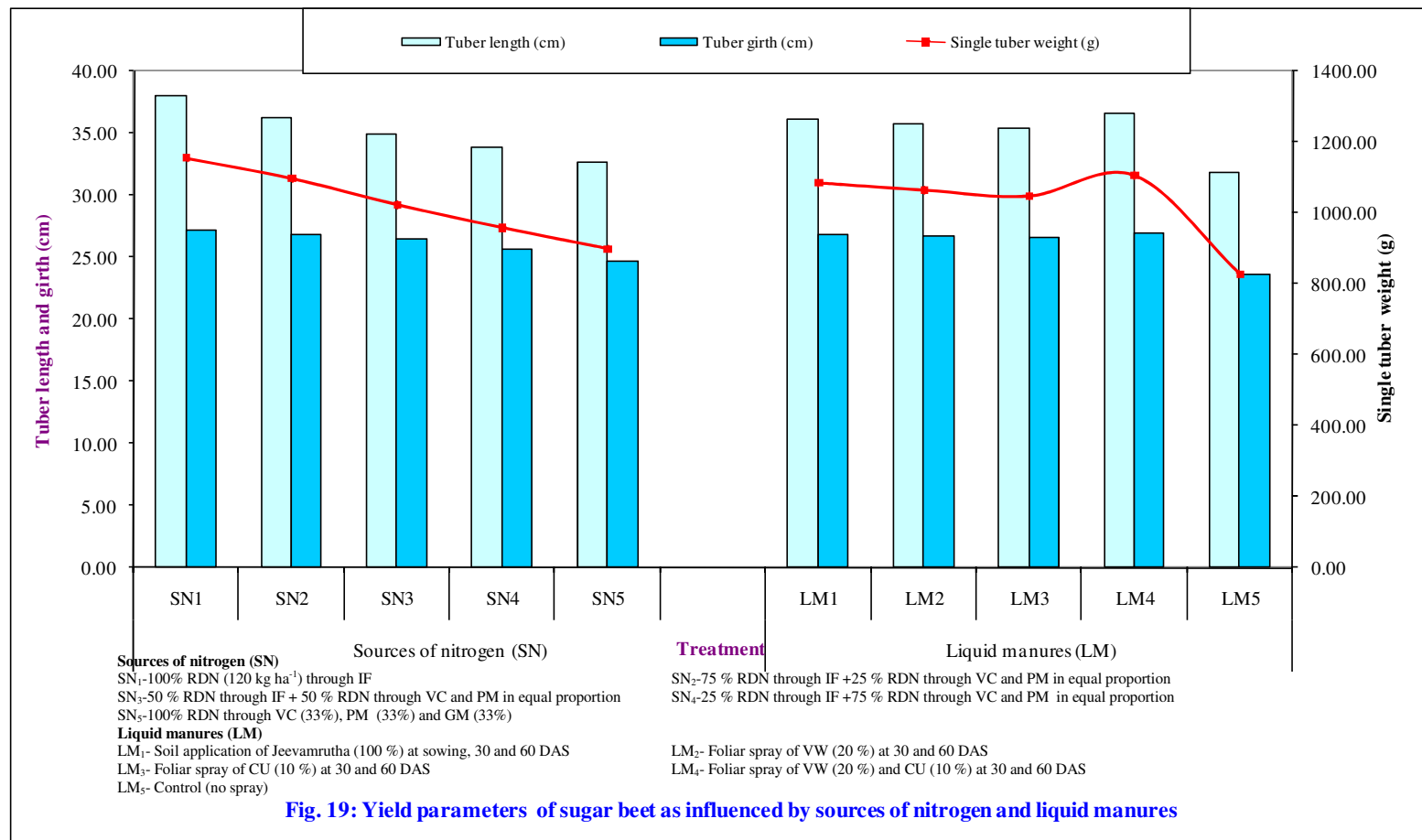


Fig 19 : Yield parameters of sugar beet as influenced by sources of nitrogen and liquid manures

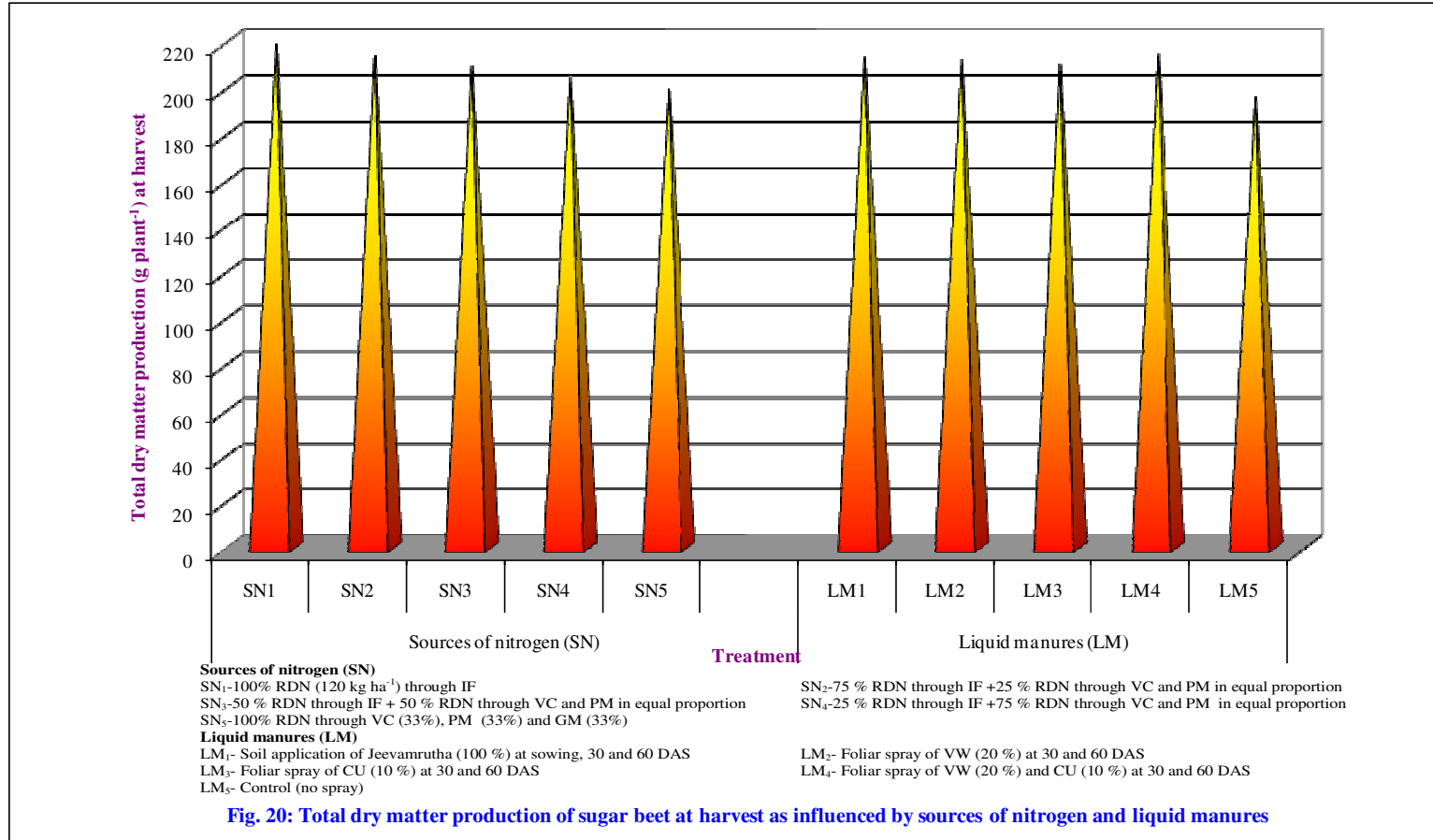


Fig 20 : Total dry matter production of sugar beet at harvest as influenced by sources of nitrogen and liquid manures

(33%), PM (33%) and GM (33%) in equal proportions (6.26 for LAI and 211.71 days for LAD) (Table 44 and Fig. 22). Higher LAI and LAD recorded in SN₁ and SN₂ might have helped in producing higher TDMP and its accumulation in tuber which leading to higher tuber yield of sugar beet. Simple correlation study also showed positive and significant correlation between tuber yield and LAI ($r=0.99$) and LAD ($r=0.99$) (Table 55). Sharief *et al.* (1997) reported that application of nitrogen fertilizer rate at 80 kg N ha^{-1} to sugar beet recorded significantly higher LAI. The findings are in line with observations of Dhananjaya (2007) and Rajashekar (2007).

Tuber yield and yield attributing characters of sugar beet are the reflections of dry matter accumulation (DMA) in tuber (Table 46). Significantly higher DMA in tuber was observed with SN₁ and SN₂ (196.61 and 195.28 g plant^{-1} , respectively) at harvest over SN₅ (190.03 g plant^{-1}). Results are in concurrence with the findings of Rajashekar (2007). The higher DMA in tuber may be due to higher photosynthetic ability of the crop as reflected through higher DMA in green foliage (Table 45) and higher translocation of metabolites from leaves to tuber during reproductive phase of crop growth (Table 46).

Among the sources of nitrogen, treatment which received 100 per cent RDN through IF (SN₁) recorded significantly higher sugar yield (8.50 t ha^{-1}) when compared to application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportions (SN₅) (6.50 t ha^{-1}). However, the treatments which received 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportions (SN₂) which recorded on par sugar yield (7.94 t ha^{-1}) as that of SN₁ (Table 51 and Fig. 17). Hassaneina and Hassouna (2000) reported that combination of biofertilizer (HALEX) and mineral nitrogen fertilization (144 kg N ha^{-1}) treatments, recorded highest sugar yields of 54.49 t ha^{-1} . Similarly, Panhwar *et al.* (2007) observed that N @ 120 kg ha^{-1} recorded maximum sugar yield of 12.11 t ha^{-1} as compared to control.

Sugar yield is a function of tuber yield and quality characters. In other words, the improvement in sugar yield of SN₁ and SN₂ was due to increase in tuber yield (77.16 and 75.58 t ha^{-1} , respectively) and quality characters *viz.*, brix (22.33 and 22.06 %, respectively), Sucrose (17.11 and 16.56 %, respectively) and commercial beet sugar (CBS) (10.96 and 10.48 %, respectively). Simple correlation study also showed positive and significant correlation between sugar yield and tuber yield ($r=0.99$), quality characters like Brix ($r=0.96$), sucrose ($r=0.99$) and CBS ($r=0.99$). Findings are in line with observations of EL-Moursy *et al.* (1998), Praveen Kumar (2010) and Kale (2010).

Among the sources of nitrogen, application of 100 per cent RDN through IF (SN₁) and application of 75 per cent RDN through IF + 25 per cent RDN through VC and PM in equal proportions (SN₂) recorded significantly higher gross (Rs. 103825 and 101707 ha^{-1} , respectively) and net (Rs. 60795 and 55007 ha^{-1} , respectively) returns compared to other sources of nitrogen (Table 52). While, SN₅ recorded significantly lower gross and net returns (Rs. 94553 and 41785 ha^{-1} , respectively). SN₁ recorded significantly higher B:C ratio (2.41) followed by SN₂ (2.17) compared to SN₅ (1.79) (Table 52 and Fig. 23). The variations in net returns and B:C ratio in these treatments was mainly due to variations in gross returns and cost of cultivation. Singh *et al.* (2001) recorded maximum net returns and B:C in onion with the application of nitrogen @ 120 kg ha^{-1} along with 10 t ha^{-1} of FYM. Similarly, Praveen Kumar (2010) observed that application of recommended dose of NPK + FYM resulted in highest B:C of 4.59.

5.3.2 Effect of liquid manures on performance of sugar beet

The tuber yield of sugar beet was significantly influenced by liquid manures (LM) during both years and on pooled basis (Table 49 and Fig. 17). All the liquid manures (LM₁ to LM₄) recorded significantly higher tuber yield (74.15 to 75.68 t ha^{-1}) compared to control (LM₅) (68.45 t ha^{-1}) on pooled basis. The increase in tuber yield by all the liquid manures (LM₁ to LM₄) was 8.32 to 10.56 per cent over control (LM₅). The increase in tuber yield was mainly due to beneficial effect of liquid manures which act as growth regulator and enhanced the availability of nutrients to crop. The beneficial effect of liquid organic manures was mainly attributed to the presence of large quantities of IAA and GA which are physiologically active in photosynthesis and other processes (Somasundaram *et al.*, 2003). Similarly, Nekar *et al.* (2009) observed that application of panchagavya and cow urine recorded significantly superior pod yield of ground nut compared to control.

The higher tuber yield with liquid manures (LM₁ to LM₄) might be due to yield contributing characters like tuber weight (1047.57 to 1105.75 g plant^{-1}), tuber length (35.41 to 36.56 cm) and tuber girth (26.56 to 26.96 cm). Significantly lower tuber weight (829.01 g plant^{-1}), tuber length (31.76 cm) and tuber girth (23.53 cm) was recorded with control (LM₅) (Table 48 and Fig. 19). Higher yield

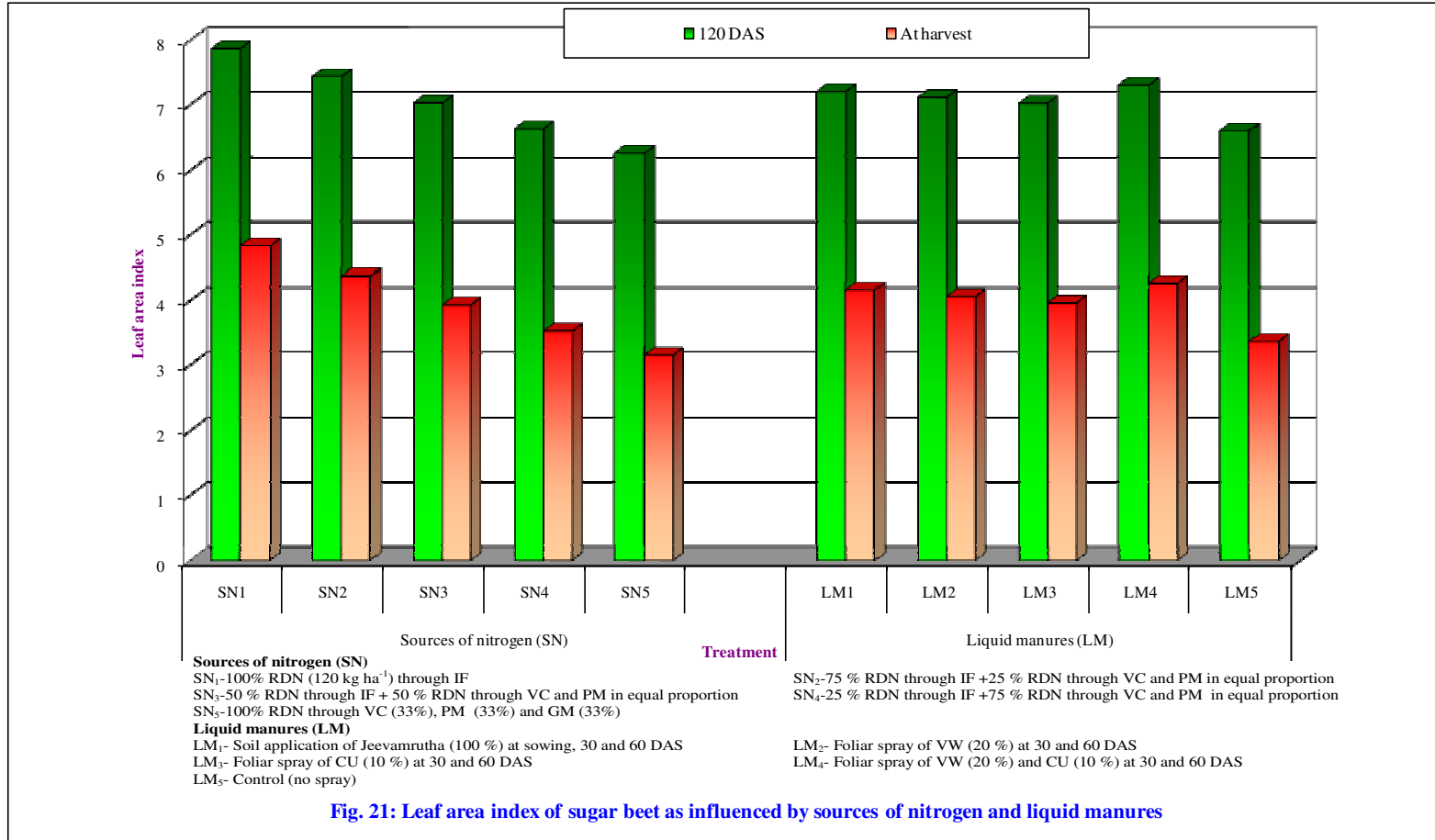


Fig 21 : Leaf area index of sugar beet as influenced by sources of nitrogen and liquid manures

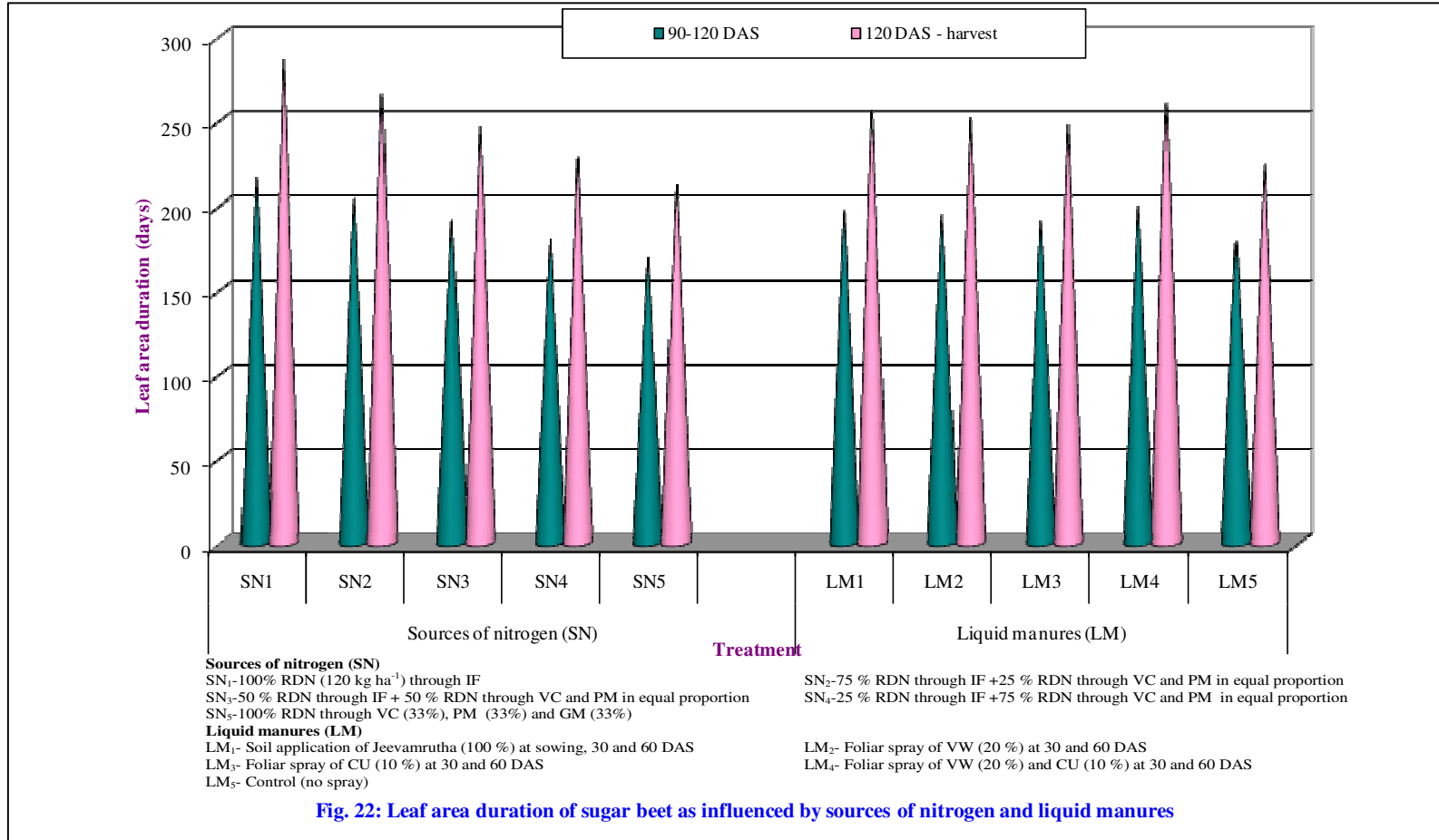


Fig 22 : Leaf area duration of sugar beet as influenced by sources of nitrogen and liquid manures

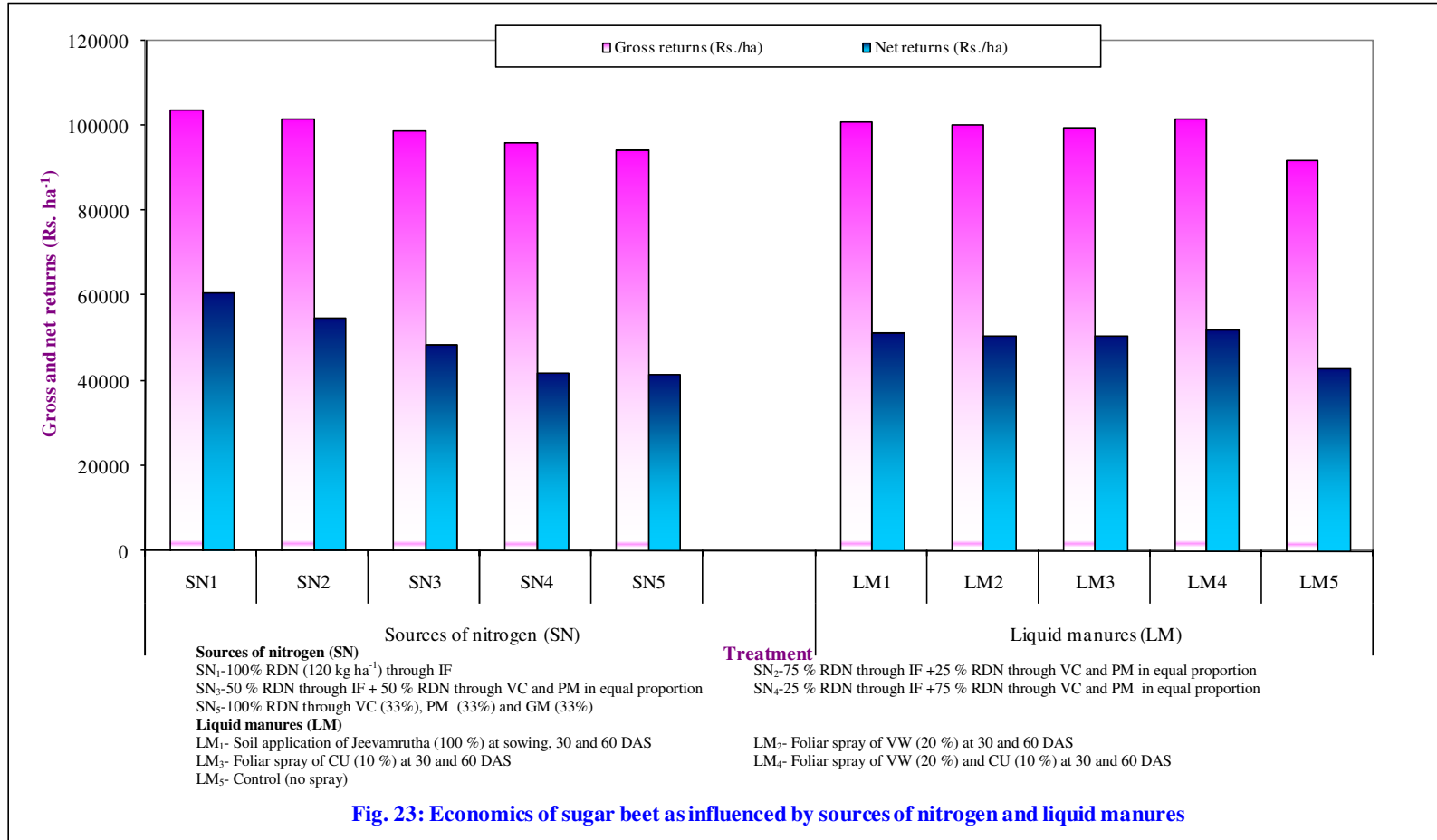


Fig 23 : Economics of sugar beet as influenced by sources of nitrogen and liquid manures

attributing characters in aforesaid treatments was a consequence of increased rate of photosynthesis coupled with efficient translocation of photosynthates from source (leaf) to sink (tuber). Simple correlation study also showed positive and significant correlation between tuber yield and yield attributes such as tuber weight ($r=0.99$), tuber length ($r=0.99$) and tuber girth ($r=0.95$) (Table 55). Cynthia (2003) observed that spraying four per cent panchagavya increased the number of tubers per plant in *Withania somnifera*. Similar results reported by Yadav and Lourduraj (2006b).

In the present investigation, the differences in various yield components could be traced back to differences in dry matter production and its accumulation in various plant parts viz., leaves (green foliage) and tuber (Table 47, 46 & 45 and Fig. 20). Foliar spray of vermiwash (VW) (20%) and cow urine (CU) (10%) at 30 and 60 DAS (LM_4) recorded significantly higher TDMP ($215.20 \text{ g plant}^{-1}$) than control (LM_5) ($196.23 \text{ g plant}^{-1}$). However, soil application of Jeevamrutha (100%) at sowing, 30 and 60 DAS (LM_1) ($213.38 \text{ g plant}^{-1}$) and foliar spray of VW (20%) at 30 and 60 DAS (LM_2) ($212.38 \text{ g plant}^{-1}$) recorded on par TDMP as that of LM_4 . The results are in line with findings of Kanimozhi (2003) wherein spraying of four per cent Panchagavya increased the dry matter production in coleus. Findings are in line with observations of Cynthia (2003) and Nekar *et al.* (2009).

The higher TDMP and its accumulation in different parts of plant are the manifestation of the magnitude and persistence of photosynthetic capacity of the plant and its translocation to different parts. Photosynthetic capacity of plants is a function of photosynthetically active leaf area and its persistence which is indicated by LAI and LAD (Table 43 and 44; Fig. 21 and 22). LAI and their effectiveness over a period of time (LAD) are most important for dry matter production. LAI which is indicative of leaf surface (source) available for photosynthesis was significantly higher at 120 DAS. All the liquid manures treatments (LM_1 to LM_4) recorded significantly higher LAI (7.01 to 7.30) compared to control (LM_5) (6.58). The similar trend was also noticed with respect to LAD (Table 44). Further, the higher TDMP in LM_4 was also the cumulative effect of higher growth characters such as plant height and number of leaves (Table 40 and 41). De Britto and Girija (2006) reported that use of panchagavya improved growth and yield parameters in black gram and green gram. They also reported that cow dung in Panchagavya acts as a medium for the growth of beneficial microbes and cow urine provides nitrogen which is essential for crop growth. The present findings are in line with observations of Cynthia (2003) and Kanimozhi (2003).

All the liquid manures (LM_1 to LM_4) recorded significantly higher sugar yield (7.58 to 7.99 t ha^{-1}) compared to control (LM_5) (6.12 t ha^{-1}) (Table 51). The improvement in sugar yield of liquid manures (LM_1 to LM_4) was due to higher tuber yield (74.15 to 75.68 t ha^{-1}) and quality characters viz., brix (21.84 to 22.15%), sucrose (16.21 to 16.64%) and commercial beet sugar (CBS) (10.19 to 10.54%). Beulah (2001) reported that, the quality parameters viz., crude fibres, protein, ascorbic acid, carotene content and shelf life were higher under organic manure applied with panchagavya spray in rice. Similar improvement in keeping quality of onion and sugarcane was reported by Natarajan (2002) with application of panchagavya.

All the liquid manures (LM_1 to LM_4) recorded significantly higher gross returns (Rs. 99780 to 101831 ha^{-1}), net returns (Rs. 50703 to 52154 ha^{-1}) and B:C (2.05 to 2.07) compared to control (LM_5) (Rs. 92115, 43112 ha^{-1} and 1.89, respectively) (Table 52). The variation in net returns and B:C was mainly due to variation in gross returns and cost of cultivation. Yadav and Lourduraj (2006b) opined that spraying of panchagavya recorded significantly higher gross returns (Rs. 37608 ha^{-1}), net returns (Rs. 17822 ha^{-1}) and B:C (1.92) as compared to without panchagavya spray (Rs. 34612 ha^{-1} , Rs. 15586 ha^{-1} and 1.84, respectively) in rice.

5.3.3 Interaction effect of sources of nitrogen and liquid manures on performance of sugar beet

Integrated nitrogen management by using organic manures, green manures and along with chemical nitrogen would go a long way in maximizing production per unit area, without affecting the soil fertility and productivity. In order to sustain the soil fertility and to reap rich harvest of sugar beet yield, it is imperative that the conjunctive use of inorganic along with organic sources of nutrients has to be given more importance to meet nutrient requirement of crop throughout the cropping period.

The tuber yield of sugar beet differed significantly due to interaction of sources of nitrogen and liquid manures (Table 49 and Fig. 17). Among the treatment combinations, application of 100 per cent RDN (120 kg ha^{-1}) through inorganic fertilizer (IF) along with foliar spray of VW (20%) and CU (10%) at 30 and 60 DAS (SN_1LM_4) recorded significantly higher tuber yield (80.13 t ha^{-1}) than application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure

spray (SN₅LM₅) (67.16 t ha⁻¹). The per cent increase in tuber yield with SN₁LM₄ was to the tune of 19.31 over SN₅LM₅. Application of inorganic fertilizer along with organic manure and liquid manures might have resulted in better availability of nutrients mainly nitrogen. Higher quantity and readily available nitrogen throughout the crop growth since major quantity of nitrogen was in inorganic form which promoted growth and development of sugar beet. Further, beneficial effect of liquid manures (vermiwash and cow urine) which act as growth regulator and enhanced the availability of nutrients to crop. The beneficial effect of liquid organic manures was mainly attributed to the presence of large quantities of IAA and GA which are physiologically active in photosynthesis and other processes which promoted growth of sugar beet and hence resulted in increased tuber yield. The better availability of nutrients could be attributed to increased microbial activity and soil enzymatic activity (Channagoudra, 2012). Yadav and Lourduraj (2006a) opined that application of recommended dose of NPK through fertilizers along with panchagavya spray resulted in significantly higher grain yield (5946 kg ha⁻¹) in maize. The results obtained are also in line with the work of Yadahalli (2008). The variations in tuber yield of sugar beet can also be attributed to variations in nutrient uptake by sugar beet (Fig. 18) (Channagoudra, 2012). The lower tuber yield in SN₅LM₅ might be attributed to insufficient quantity of easily available nutrients.

Tuber yield is the manifestation of yield attributing characters. Significant increase in tuber yield could be traced back to the significant increase in the yield components such as tuber weight, tuber length and tuber girth (Table 48 and Fig. 19). Significantly higher tuber weight (1251.39 g plant⁻¹), tuber length (40.25 cm) and tuber girth (27.90 cm) was recorded with application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) over application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (776.69 g plant⁻¹, 30.82 cm and 19.76 cm, respectively). The results corroborate the findings of Sanwal *et al.* (2007).

The differences in various yield components which led to significant yield differences could be traced back to significant variations in dry matter production and its accumulation in leaves and tuber (Table 47, 46 and 45). Among the treatment combinations, application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher TDMP (226.46 g plant⁻¹). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ (224.80, 223.80, 222.22, 219.48, 218.36 and 220.38 g plant⁻¹, respectively) treatments were found on par with SN₁LM₄. Significantly lower TDMP was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (194.50 g plant⁻¹) (Fig. 20). Shwetha (2007) observed that significantly higher total dry matter production of soybean with RDF + FYM and organic manures in combination with foliar spray of beejamrut + jeevamrut + panchagavya. Similar such results were earlier reported by Yadahalli (2008) in chilli.

The higher TDMP in SN₁LM₄ could also be related to higher photosynthetically active assimilatory surface area. Photosynthetic capacity of a plant depends upon plant height (Table 40), number of leaves per plant (Table 41), leaf area (Table 42) and dry matter accumulation in leaves (Table 45) at peak stage of crop growth (120 DAS). The higher growth parameters in SN₁LM₄ enabled the plant to trap higher quantity of solar energy with higher leaf surface area convert into chemical energy. The results are in line with findings of Yadahalli (2008).

Tuber yield and yield attributing characters of sugar beet are the reflections of dry matter accumulation in tuber (Table 46). Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher DMA in tuber (199.39 g plant⁻¹) over application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) (187.58 g plant⁻¹). Results are in concurrence with the findings of Shwetha (2007) and Yadahalli (2008). The higher dry matter accumulation in tuber may be due to higher photosynthetic ability of the crop as reflected through higher dry matter accumulation in green foliage and higher translocation of metabolites from leaves to tuber during reproductive phase of crop growth.

Photosynthetic capacity of plants is a function of photosynthetically active leaf area which is indicated by leaf area index (LAI) and leaf area duration (LAD) (Table 43 and 44; Fig. 21 and 22). In the present study, the maximum LAI was recorded at 120 DAS (8.22) in SN₁LM₄ over SN₅LM₅ (6.00). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₂LM₁, SN₂LM₂ and SN₂LM₄ (8.08, 7.98, 7.87, 7.63, 7.53 and 7.70, respectively) treatments were found on par with SN₁LM₄. Similar to LAI, SN₁LM₄ recorded significantly higher LAD between 120 to harvest (302.56 days) when compared to SN₅LM₅ (198.18 days). However, SN₁LM₁, SN₁LM₂ and SN₁LM₃ (296.76, 291.69 and 286.64 days, respectively)

treatments were found on par with SN₁LM₄. The results obtained are in line with the work of Yadahalli (2008).

Among the treatment combinations, SN₁LM₄ recorded significantly higher sugar yield (9.28 t ha⁻¹) than SN₅LM₅ (5.85 t ha⁻¹) (Table 51). Significantly higher sugar yield of SN₁LM₄ was due to increase in tuber yield (80.13 t ha⁻¹) and quality characters viz., brix (22.86 %), sucrose (17.87 %) and commercial beet sugar (CBS) (11.59 %).

Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher gross and net returns (Rs. 107831 and 64528 ha⁻¹, respectively) (Table 52 and Fig. 23). However, SN₁LM₁, SN₁LM₂, SN₁LM₃, SN₁LM₅, SN₂LM₁, SN₂LM₂, SN₂LM₃, SN₂LM₄, SN₃LM₁ and SN₃LM₄ remained on par with former treatment combination. Significantly lower gross and net returns were recorded in SN₅LM₅ (Rs. 90378 and 38013 ha⁻¹, respectively). The B:C followed the trend observed in net returns. Significantly higher B:C was observed in all the treatment combinations involving SN₁ and SN₂ with different levels of liquid manures except SN₂LM₅. On the other hand, significantly lower B:C of 1.72 was recorded in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅). The variations in net returns and B:C could be attributed to the variations in gross returns and cost of cultivation. Channagoudra (2012) reported that crop residue (50%) + vermicompost (50%) equivalent to RDF with lucerene green manure with jeevamrutha @ 500 l ha⁻¹ recorded significantly higher net returns and B:C (Rs. 59531 ha⁻¹ and 2.86, respectively) over other combinations.

Results of practical utility

Based on the results of investigation the following results have the practical utility.

1. Sole sugarcane and sugarcane + sugar beet in 1:1 RP recorded significantly higher cane yield compared to sugarcane + sugar beet in 1:2 and 1:3 RP.
2. Sole cultivars of sugar beet viz, Cauvery and Shubhra recorded significantly higher tuber and sugar yield than intercropped treatments. In intercropping system cultivars Cauvery and Shubhra in 1:3 and 1:2 row proportions recorded significantly higher tuber and sugar yield than 1:1 RP.
3. Sugarcane + sugar beet (irrespective of sugar beet cultivars) in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield, LER, ATER, SPI, total sugar yield, net returns when compared to 1:1 RP, but B:C was significantly higher in 1:1 RP.
4. Application of 100 per cent RDN (120 kg ha⁻¹) through inorganic fertilizer (IF) along with foliar spray of vermiwash (VW) (20 %) and cow urine (CU) (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher tuber (80.13 t ha⁻¹), sugar yield (9.28 t ha⁻¹), net returns (Rs. 60770 ha⁻¹) and B:C ratio (2.29) than other treatment combinations. However, application of 75 per cent RDN through IF + 25 per cent RDN through vermicompost and poultry manure in equal proportions along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₂LM₄) remained on par with SN₁LM₄.

Future line of work

1. Studies on planting geometry and nutrient management in sugarcane and sugar beet in intercropping system.
2. Response of sugar beet to different levels of nitrogen through combination of organic manures, green manures along with chemical fertilizer.
3. Response of sugarcane + sugar beet for simultaneous planting/ sowing.

SUMMARY AND CONCLUSIONS

The two field experiments namely 1. Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2. Performance of sugar beet to sources of nitrogen and liquid manures were conducted at Agricultural Research Station (ARS), Madhurakhandi, University of Agricultural Sciences, Dharwad during the year 2010-11 and 2011-12.

In first experiment, sugar beet cultivars (Cauvery, Shubhra, Magnolia and Calixta) were intercropped with sugarcane grown in three row proportions (1:1, 1:2 and 1:3) along with four sole treatments of sugar beet and one sole treatment of sugarcane. The treatments were laid out in randomized complete block design using three replications.

The second experiment was conducted to study the influence of sources of nitrogen (SN₁, SN₂, SN₃, SN₄ and SN₅) and liquid manures (LM₁, LM₂, LM₃, LM₄ and LM₅) on sugar beet. The experiment was laid out in split plot design with three replications where in sources of nitrogen and liquid manures were assigned to main and subplot, respectively.

In general rainfall during first year was near to average (2001-2010) while, in the second year was very less than the average. As the result, the performance of crops (sugarcane and sugar beet) in terms of growth and yield was better in the first year than second year. The results obtained on various growth, yield and quality parameters of sugarcane and sugar beet of both the experiments were summarized in this chapter.

6.1 Experiment-I: Intercropping of sugar beet cultivars at different row proportions in sugarcane

6.1.1 Performance of sugarcane

Sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP recorded significantly higher cane yield when compared to other intercropped treatments (SC + SB in 1:2 and 1:3 RP). Significantly higher yield attributes *viz.*, number of millable canes, single cane weight, number of internodes, length of internode, diameter of cane and growth attributes such as plant height, number of leaves per plant, leaf area per plant, leaf area index, leaf area duration, dry matter production and its distribution to different plant parts (leaves and stem) were observed in sole sugarcane and sugarcane (SC) + sugar beet (SB) in 1:1 RP. These values were significantly lower in SC + SB in 1:2 and 1:3 RP.

Sugar yield of sugarcane was significantly higher in sole sugarcane and SC + SB in 1:1 RP over other treatments (SC + SB in 1:2 and 1:3 RP). The quality parameters such as brix, sucrose and commercial cane sugar per cent did not showed any significant variations. The nutrients (N, P and K) uptake by sugarcane also followed similar trend as that of cane yield.

6.1.2 Performance of sugar beet

Sole sugar beet cultivars recorded significantly higher tuber yield over intercropping situation (irrespective of sugar beet cultivars). Sole cultivars Cauvery and Shubhra recorded significantly higher tuber yield on pooled basis when compared to other cultivars (Calixta and Magnolia). Significantly lower tuber yield was recorded in sole Magnolia. The nutrients (N, P and K) uptake by sugar beet also followed similar trend as that of tuber yield.

The yield attributing characters such as tuber weight, tuber length and tuber girth were significantly higher with Cauvery and Shubhra. Similarly, growth parameters such as plant height, number of leaves, leaf area, leaf area index, leaf area duration, dry matter production and its distribution to different plant parts (green foliage and tuber) were also higher with Cauvery and Shubhra over other cultivars. Lower value of growth and yield components were observed with sole Magnolia. Similar trend was also noticed with sugar yield and green foliage yield.

Tuber yield of sugar beet decreased significantly due to intercropping with sugarcane irrespective of row ratio as compared to sole sugar beet. In general, among the intercropping systems, intercropping of SC + SB in 1:3 and 1:2 RP (irrespective of sugar beet cultivars) recorded significantly higher tuber yield as compared to 1:1 RP. This was mainly due to higher plant population of sugar beet in 1:3 RP (same as that of sole sugar beet) and 1:2 (66%) as compared to 1:1 row ratio (33%).

Among the intercropping systems, the performance of Cauvery and Shubhra in terms of tuber yield was higher in 1:3 and 1:2 RP than 1:1 RP than Magnolia and Calixta. Significantly higher values

of various growth (plant height, number of leaves, leaf area, LAI, LAD, DMA in leaves (green foliage), DMA in stem and TDMP) and yield (tuber weight, tuber length and tuber girth) parameters were observed with Cauvery and shubhra in 1:3 and 1:2 RP.

Similar to tuber yield, the sugar yield also showed significant variations among the intercropped treatments but was significantly lower when compared with sole crop. Among the intercropped treatments, irrespective of sugar beet cultivars sugar yield increased significantly with increase in the rows of sugar beet from 1:1 to 1:3. Accordingly, significantly higher sugar yield was recorded in 1:3 RP followed by 1:2 RP. But other quality parameters such as brix, sucrose and commercial cane sugar per cent did not showed any significant variations.

6.1.3 Performance of intercropping system

All the intercropping treatments recorded significantly higher sugarcane equivalent yield (SEY) as compared to sole stands. Irrespective of sugar beet cultivars, intercropping treatments namely SC + SB in 1:2 and 1:3 RP recorded significantly higher SEY than SC + SB in 1:1 RP.

Similar to SEY, irrespective of sugar beet cultivars, intercropping treatments namely SC + SB in 1:2 and 1:3 RP recorded significantly higher LER, ATER, SPI and total sugar yield than SC + SB in 1:1 RP.

All the intercropping treatments (except SC + Calixta/ Magnolia in 1:3 RP) recorded significantly higher net returns than sole crops. Intercropping of sugarcane + sugar beet in 1:1 and 1:2 RP recorded significantly higher B:C ratio when compared to 1:3 RP and sole crops.

6.2 Experiment II: Performance of sugar beet to sources of nitrogen and liquid manures

6.2.1 Effect of sources of nitrogen on performance of sugar beet

Sources of nitrogen showed significant influence on performance of sugar beet. Application of 100 per cent RDN (SN_1) through inorganic fertilizer (IF) recorded significantly higher tuber yield than other sources of nitrogen. The lower tuber yield was recorded in application of 100 per cent RDN through vermicompost (VC) (33%), poultry manure (PM) (33%) and green manuring (GM) (33%) in equal proportions (SN_5). Similar trend was also noticed with green foliage yield. The nutrients (N, P and K) uptake by sugar beet also followed similar trend as that of tuber yield.

The growth parameters such as plant height, number of leaves, leaf area, LAI, LAD, TDMP, dry matter accumulation in green foliage and tuber were significantly higher with application of 100 per cent RDN through IF (SN_1). Lower values were observed with application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportions (SN_5). The tuber weight, tuber length and tuber girth of sugar beet also followed similar trend.

Application of 100 per cent RDN through IF (SN_1) recorded significantly higher values of quality parameters such as sugar yield, brix, sucrose and commercial beet sugar per cent. The lower values of quality parameters were noticed in application of 100 per cent RDN through VC (33%), PM (33%) and GM (33%) in equal proportions (SN_5).

6.2.2 Effect of liquid manures on performance of sugar beet

All the liquid manures treatments (LM_1 to LM_4) recorded significantly higher tuber and green foliage yield when compared to control (LM_5). Similar trend was also noticed with quality parameters such as sugar yield, brix, sucrose and commercial beet sugar per cent. The nutrients (N, P and K) uptake by sugar beet also followed the trend of tuber yield.

During both years and on pooled basis, all the liquid manures treatments (LM_1 to LM_4) recorded higher growth parameters such as plant height, number of leaves, leaf area, LAI, LAD, TDMP, dry matter accumulation in green foliage and tuber. Lower values were observed with control (LM_5). Yield attributes of sugar beet followed the trend of growth parameters.

6.2.3 Interaction effect of sources of nitrogen and liquid manures on performance of sugar beet

Performance of sugar beet was significantly influenced due to interaction effect of sources of nitrogen and liquid manures during both years and on pooled basis. The highest tuber yield was obtained with application of 100 per cent RDN (120 kg ha^{-1}) through IF along with foliar spray of VW

(20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄). Significantly lower tuber yield was recorded with application of 100 per cent through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅) compared to SN₁LM₄. Similar trend was also noticed with green foliage yield. The nutrients (N, P and K) uptake by sugar beet also followed similar trend as that of tuber yield. However, application of 75 per cent RDN through IF + 25 per cent RDN through vermicompost and poultry manure in equal proportions along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₂LM₄) remained on par with SN₁LM₄.

Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher growth parameters such as plant height, number of leaves, leaf area, LAI, LAD, TDMP, dry matter accumulation. Significantly lower values was recorded with application of 100 per cent through VC (33%), PM (33%) and GM (33%) with no liquid manure spray (SN₅LM₅). Similar trend was also observed in yield components of sugar beet. However, SN₂LM₄ remained on par with SN₁LM₄. Similar trend was also noticed with quality parameters such as sugar yield, brix, sucrose and commercial beet sugar per cent.

6.3 Economics

Application of 100 per cent RDN (120 kg ha⁻¹) through IF along with foliar spray of VW (20 %) and CU (10 %) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher net returns than rest of the treatments except SN₂LM₄. However, SN₂LM₄ remained on par with SN₁LM₄. The B:C ratio followed the trend observed in net returns. Significantly higher B:C ratio was observed in all the treatment combinations involving SN₁ and SN₂ with different levels of liquid manures except SN₂LM₅. On the other hand, significantly lowest net returns and B:C ratio was recorded in SN₅LM₅.

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*- *Originals not seen*

Appendix I: Prices for inputs and output

Particulars	2010-11	2011-12
Seeds/ setts		
Sugarcane	2300/t	2500/t
Sugar beet	1870/kg	1870/kg
Manures and Fertilizers		
FYM	500/t	500/t
Urea	5.60/ kg	6.0/kg
Di Ammonium Phosphate	10.5/kg	11.0/kg
Muriate of Potash	5.30/kg	6.0/kg
Vermicompost	1.0/kg	1.0/kg
Poultry manure	2.50/kg	2.50/kg
Fermented organics		
Jeevamrutha	1.25/l	1.25/l
Cow urine	1.25/l	1.25/l
vermiwash	5.0/kg	5.0kg
Chemicals		
Karate	475/lit	475/lit
Acephate	540/lit	540/lit
Trichoderma	120/kg	120/kg
ZnSO4	750/kg	750/kg
FeSO4	525/kg	525/kg
Application	110/labour	130/labour
Labor wages		
Men	110	130
Women	100	120
Bullock pair with men	500	500
Tractor rates		
Single bottom plough	1200/acre	1200/acre
Cultivator	1200/acre	1200/acre
Seed drill	250/acre	250/acre
Outputs		
Sugarcane	2200/t	2500/t
Sugar beet	1200/t	1500/t

Appendix IIa: Treatment-wise details of cost of cultivation (Rs. ha⁻¹) during 2010-11 (Experiment-I)

Sl. No.	Treatments Particulars	T ₁	T _{2-T5}	T ₆		T ₇		T ₈		T ₉		T ₁₀		T ₁₁		T ₁₂		T ₁₃		T ₁₄		T ₁₅		T ₁₆		T ₁₇	
		Sole SC	Sole SB	1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP	
		SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB
1.	Deep ploughing by tractor(one time)	2500	2500	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-
2.	Cultivator by tractor (two times)	2500	2500	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-
3	Harrowing by bullock pair (two times)	2500	2500	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-	2500	-
4.	Furrow opening by tractor mounted ridger	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5	Reopening of furrow for sugarcane planting	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-
6.	Seed cost	10350	6720	10350	2218	10350	4435	10350	6720	10350	2218	10350	4435	10350	6720	10350	2218	10350	4435	10350	6720	10350	2218	10350	4435	10350	6720
7.	Cutting & transportation of cane	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-	1800	-
8.	Seed treatment for cane	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-	800	-
9.	Cutting, detashing and planting of sugarcane	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-	2200	-
10.	sowing of sugarbeet	-	1100	-	330	-	660	-	1100	-	330	-	660	-	1100	-	330	-	660	-	1100	-	330	-	660	-	1100
11.	FYM	12500	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000
12.	Transport and Labour for FYM application	500	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500	-	500
13.	N in the form urea	2686	1176	2686	388	2686	776	2686	1176	2686	388	2686	776	2686	1176	2686	388	2686	776	2686	1176	2686	388	2686	776	2686	1176
14.	P ₂ O ₅ in the form of DAP	1712	1365	1712	450	1712	901	1712	1365	1712	450	1712	901	1712	1365	1712	450	1712	901	1712	1365	1712	450	1712	901	1712	1365
15.	K ₂ O in the form of MOP	1678	795	1678	262	1678	525	1678	795	1678	262	1678	525	1678	795	1678	262	1678	525	1678	795	1678	262	1678	525	1678	795
16.	ZnSO ₄	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-
17.	FeSO ₄	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-
18.	Fertilizer application charges	550	550	550	220	550	220	550	550	550	220	550	220	550	550	220	550	220	550	550	550	220	550	220	550	220	550
19.	Top dressing	660	220	660	110	660	110	660	220	660	110	660	110	660	220	660	110	660	110	660	220	660	110	660	110	660	220
20.	Earthing up(one time)	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-
21.	Inter cultivation	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750	2250	750
22.	Hand weeding	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200	1100	2200
	Insecticides																										
23.	Karate	-	475	-	160	-	320	-	475	-	160	-	320	-	475	-	160	-	320	-	475	-	160	-	320	-	475
24.	Acephate	-	540	-	180	-	360	-	540	-	180	-	360	-	540	-	180	-	360	-	540	-	180	-	360	-	540
25.	Trichoderma	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200
26.	Application charges	-	440	-	220	-	330	-	440	-	220	-	330	-	440	-	220	-	330	-	440	-	220	-	330	-	440
27.	Irrigation	3300	1650	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770	3300	770
28.	Harvesting & transportation to factory	23000	9950	21560	4393	20680	7319	19360	7803	21560	4101	20680	6833	19360	7283	21560	3718	20680	6173	19360	6579	21560	3841	20680	6404	19360	6834
	Total			61050	18601	61931	26026	63251	31654	61050	18309	61931	25540	63251	31134	61050	17926	61931	24880	63221	30400	61050	18049	61931	25111	63251	30685
	Grand Total	75661	42831	79773		86317		90625		79481		85831		90105		79098		85171		89401		79221		85402		89656	

SC – Sugarcane

SB – Sugar beet

RP – Row proportion

Appendix IIb: Treatment-wise details of cost of cultivation (Rs. ha⁻¹) during 2011-12 (Experiment-I)

Sl. No.	Treatments 2011-12 Particulars	T ₁		T _{2-T₅}		T ₆		T ₇		T ₈		T ₉		T ₁₀		T ₁₁		T ₁₂		T ₁₃		T ₁₄		T ₁₅		T ₁₆		T ₁₇		
		SC	SB	1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP		1:1 RP		1:2 RP		1:3 RP				
		SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	SC	SB	
1.	Deep ploughing by tractor(one time)	2750	2750	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	
2.	Cultivator by tractor (two times)	2750	2750	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	2750	-	
3.	Harrowing by bullock pair (two times)	2160	2160	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	2160	-	
4.	Furrow opening by tractor mounted ridger	1100	1100	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	1100	-	
5.	Reopening of furrow for sugarcane planting	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	540	-	
6.	Seed cost	11250	6750	11250	2228	11250	4455	11250	6750	11250	2228	11250	4455	11250	6750	11250	2228	11250	4455	11250	6750	11250	2228	11250	4455	11250	6750	11250	6750	
7.	Cutting & transportation of cane	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	2000	-	
8.	Seed treatment for cane	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	900	-	
9.	Cutting, detaching and planting of sugarcane	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	2600	-	
10.	sowing of sugarbeet	-	1300	-	430	-	860	-	1300	-	430	-	860	-	1300	-	430	-	860	-	1300	-	430	-	860	-	1300	-		
11.	FYM	12500	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-	5000	-
12.	Transport and Labour for FYM application	650	650	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	650	-	
13.	N in the form urea	2878	1260	2878	416	2878	832	2878	1260	2878	416	2878	832	2878	1260	2878	416	2878	832	2878	1260	2878	416	2878	832	2878	1260	2878	1260	
14.	P ₂ O ₅ in the form of DAP	1794	1430	1794	472	1794	944	1794	1430	1794	472	1794	944	1794	1430	1794	472	1794	944	1794	1430	1794	472	1794	944	1794	1430	1794	1430	
15.	K ₂ O in the form of MOP	1900	900	1900	297	1900	594	1900	900	1900	297	1900	594	1900	900	1900	297	1900	594	1900	900	1900	297	1900	594	1900	900	1900	900	
16.	ZnSO ₄	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	750	-	
17.	FeSO ₄	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	525	-	
18.	Fertilizer application charges	650	650	650	260	650	260	650	650	650	260	650	260	650	650	650	260	650	260	650	650	650	260	650	260	650	260	650	650	
19.	Top dressing	780	260	780	130	780	130	780	260	780	130	780	130	780	260	780	130	780	130	780	260	780	130	780	130	780	130	780	260	
20.	Earthing up(one time)	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	810	-	
21.	Inter cultivation	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	2430	810	
22.	Hand weeding	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	1300	2600	
	Insecticides																													
23.	Karate	-	475	-	160	-	320	-	475	-	160	-	320	-	475	-	160	-	320	-	475	-	160	-	320	-	475	-	475	
24.	Acephate	-	540	-	180	-	360	-	540	-	180	-	360	-	540	-	180	-	360	-	540	-	180	-	360	-	540	-	540	
25.	Trichoderma	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200	-	400	-	800	-	1200	-	1200	
26.	Application charges	-	520	-	260	-	390	-	520	-	260	-	390	-	520	-	260	-	390	-	520	-	260	-	390	-	520	-	520	
27.	Irrigation	3900	1950	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	3900	920	
28.	Harvesting & transportation to factory	25000	11300	25000	5200	25000	8664	25000	9236	25000	4854	25000	8088	25000	8621	25000	4401	25000	7307	25000	7787	25000	4546	25000	7580	25000	8089	25000	8089	
	Total			69417	19763	69417	27939	69417	33851	69417	19417	69417	26363	69417	33236	69417	18964	69417	26582	69417	32402	69417	19104	69417	26855	69417	32704	32704		
	Grand Total	81917	46895	89180		97356		103268		88834		96780		102653		88381		95999		101819		88526		96272		102121				

SC – Sugarcane

SB – Sugar beet

RP – Roe proportion

Appendix IIIa: Treatment-wise details of cost of cultivation (Rs. ha⁻¹) during 2010-11(Experiment-II)

Particulars	SN ₁ LM ₁	SN ₁ LM ₂	SN ₁ LM ₃	SN ₁ LM ₄	SN ₁ LM ₅	SN ₂ LM ₁	SN ₂ LM ₂	SN ₂ LM ₃	SN ₂ LM ₄	SN ₂ LM ₅	SN ₃ LM ₁	SN ₃ LM ₂	SN ₃ LM ₃	SN ₃ LM ₄	SN ₃ LM ₅
Deep ploughing by tractor	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Harrowing (bullock pair)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Cultivator by tractor (two times)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Sowing by manual dibbling	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Seed cost	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720
FYM 10 t/ha	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Labour for FYM application	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440
Urea	1461	1461	1461	1461	1461	1096	1096	1096	1096	1096	730	730	730	730	730
DAP	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365
MOP	795	795	795	795	795	795	795	795	795	795	795	795	795	795	795
Application charges	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440
Top dressing	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
Organic manures															
Vermicompost						1650	1650	1650	1650	1650	3310	3310	3310	3310	3310
Poultrymanure						2398	2398	2398	2398	2398	4840	4840	4840	4840	4840
Green manuring(glyricidia)															
Jeevamrutha @ 100%	625	600	75	675	0	625	600	75	675	0	625	600	75	675	0
Cowurine @10%															
vermiwash@ 20%		0													
Application charges	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440
Intercultivation	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
Hand weeding	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Insecticides															
Karate	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475
Acephate	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540
Trichoderma	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Application charges	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440
Irrigation	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650
Harvesting and detopping	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050
Total	41410	41385	40860	41460	40785	45093	45068	44543	45143	44468	48830	48805	48280	48880	48205

Contd....

Particulars	SN ₄ LM ₁	SN ₄ LM ₂	SN ₄ LM ₃	SN ₄ LM ₄	SN ₄ LM ₅	SN ₅ LM ₁	SN ₅ LM ₂	SN ₅ LM ₃	SN ₅ LM ₄	SN ₅ LM ₅
Deep ploughing by tractor	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Harrowing (bullock pair)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Cultivator by tractor (two times)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Sowing by manual dibbling	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Seed cost	6720	6720	6720	6720	6720	6720	6720	6720	6720	6720
FYM 10 t/ha	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Labour for FYM application	440	440	440	440	440	440	440	440	440	440
Urea	365	365	365	365	365	365	365	365	365	365
DAP	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365
MOP	795	795	795	795	795	795	795	795	795	795
Application charges	440	440	440	440	440	440	440	440	440	440
Top dressing	220	220	220	220	220	220	220	220	220	220
Organic manures										
Vermicompost	4970	4970	4970	4970	4970	4370	4370	4370	4370	4370
Poultrymanure	7238	7238	7238	7238	7238	6380	6380	6380	6380	6380
Green manuring(glyricidia)						500	500	500	500	500
Jeevamrutha @ 100%	625	600	75	675	0	625	600	75	675	0
Cowurine @10% vermiwash@ 20%										
Application charges	440	440	440	440	440	440	440	440	440	440
Intercultivation	750	750	750	750	750	750	750	750	750	750
Hand weeding	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Insecticides										
Karate	475	475	475	475	475	475	475	475	475	475
Acephate	540	540	540	540	540	540	540	540	540	540
Trichoderma	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Application charges	440	440	440	440	440	440	440	440	440	440
Irrigation	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650
Harvesting and detopping	9050	9050	9050	9050	9050	9050	9050	9050	9050	9050
Total	52523	52498	51973	52573	51898	51200	51175	50650	51250	50575

Appendix IIIb: Treatment-wise details of cost of cultivation (Rs. ha⁻¹) during 2011-12 (Experiment-II)

Particulars	SN ₁ LM ₁	SN ₁ LM ₂	SN ₁ LM ₃	SN ₁ LM ₄	SN ₁ LM ₅	SN ₂ LM ₁	SN ₂ LM ₂	SN ₂ LM ₃	SN ₂ LM ₄	SN ₂ LM ₅	SN ₃ LM ₁	SN ₃ LM ₂	SN ₃ LM ₃	SN ₃ LM ₄	SN ₃ LM ₅
Deep ploughing by tractor	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
Harrowing (bullock pair)	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160
Cultivator by tractor (two times)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Sowing by manual dibbling	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
Seed cost	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750
FYM 10 t/ha	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Labour for FYM application	520	520	520	520	520	520	520	520	520	520	520	520	520	520	520
Urea	1565	1565	1565	1565	1565	1173.75	1173.75	1173.75	1173.75	1173.75	782.5	782.5	782.5	782.5	782.5
DAP	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430
MOP	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900
Application charges	520	520	520	520	520	520	520	520	520	520	520	520	520	520	520
Top dressing	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
Organic manures															
Vermicompost						1650	1650	1650	1650	1650	3310	3310	3310	3310	3310
Poultrymanure						2398	2398	2398	2398	2398	4840	4840	4840	4840	4840
Green manuring(glyricidia)															
Jeevamrutha @ 100%	700	600	75	675	0	700	600	75	675	0	700	600	75	675	0
Cowurine @10%															
vermiwash@ 20%															
Application charges	520	520	520	520	520	520	520	520	520	520	520	520	520	520	520
Intercultivation	810	810	810	810	810	810	810	810	810	810	810	810	810	810	810
Hand weeding	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
Insecticides															
Karate	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475
Acephate	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540
Trichoderma	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Application charges	520	520	520	520	520	520	520	520	520	520	520	520	520	520	520
Irrigation	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950
Harvesting and detopping	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
Total	45170	45070	44545	45145	44470	48826	48726	48201	48801	48126	52537	52437	51912	52512	51837

Contd.....

Particulars	SN ₄ LM ₁	SN ₄ LM ₂	SN ₄ LM ₃	SN ₄ LM ₄	SN ₄ LM ₅	SN ₅ LM ₁	SN ₅ LM ₂	SN ₅ LM ₃	SN ₅ LM ₄	SN ₅ LM ₅
Deep ploughing by tractor	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
Harrowing (bullock pair)	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160
Cultivator by tractor (two times)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Sowing by manual dibbling	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
Seed cost	6750	6750	6750	6750	6750	6750	6750	6750	6750	6750
FYM 10 t/ha	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Labour for FYM application	520	520	520	520	520	520	520	520	520	520
Urea	391.25	391.25	391.25	391.25	391.25	391.25	391.25	391.25	391.25	391.25
DAP	1430	1430	1430	1430	1430	1430	1430	1430	1430	1430
MOP	900	900	900	900	900	900	900	900	900	900
Application charges	520	520	520	520	520	520	520	520	520	520
Top dressing	260	260	260	260	260	260	260	260	260	260
Organic manures										
Vermicompost	4970	4970	4970	4970	4970	4370	4370	4370	4370	4370
Poultrymanure	7238	7238	7238	7238	7238	6380	6380	6380	6380	6380
Green manuring(glyricidia)						500	500	500	500	500
Jeevamrutha @ 100%	700	600	75	675	0	700	600	75	675	0
Cowurine @10%										
vermiwash@ 20%										
Application charges	520	520	520	520	520	520	520	520	520	520
Intercultivation	810	810	810	810	810	810	810	810	810	810
Hand weeding	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
Insecticides										
Karate	475	475	475	475	475	475	475	475	475	475
Acephate	540	540	540	540	540	540	540	540	540	540
Trichoderma	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Application charges	520	520	520	520	520	520	520	520	520	520
Irrigation	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950
Harvesting and detopping	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500
Total	56204	56104	55579	56179	55504	54855	54755	54230	54830	54155

Appendix IV: The nutrient composition of organic and inorganic sources of nutrients

Sl. No.	Particulars	Nutrients (%)		
		Nitrogen	Phosphorus	Potassium
1.	FYM	0.50	0.35	0.50
2	Vermicompost	1.0	0.86	0.98
3.	Poultry manure	2.7	2.01	1.12
4.	Gliricidia	0.50	0.23	0.32
5.	Urea	46	-	-
6.	DAP	18	46	-
7.	MOP	-	-	60

EVALUATION OF SUGAR BEET CULTIVARS AT DIFFERENT ROW PROPORTIONS IN INTERCROPPING WITH SUGARCANE AND ITS NITROGEN MANAGEMENT

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2013

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ABSTRACT

Two field experiments namely 1. Intercropping of sugar beet cultivars with different row proportions in sugarcane and 2. Performance of sugar beet to sources of nitrogen and liquid manures were conducted at Agricultural Research Station (ARS), Madhurakhandi (Dist. Bagalkot), University of Agricultural Sciences, Dharwad during the year 2010-11 and 2011-12. The first experiment consisted of evaluation of sugar beet cultivars (Cauvery, Shubhra, Magnolia and Calixta) with different row proportions (1:1, 1:2 and 1:3) in sugarcane. There were seventeen treatment combinations laid out in randomised complete block design with three replications. The second experiment was conducted to study the influence of sources of nitrogen (SN₁, SN₂, SN₃, SN₄ and SN₅) and liquid manures (LM₁, LM₂, LM₃, LM₄ and LM₅) on sugar beet. The experiment was laid out in split plot design with three replications where in sources of nitrogen and liquid manures were assigned to main and subplot, respectively.

The results of first experiment indicated that sole sugarcane and sugarcane + sugar beet in 1:1 RP recorded significantly higher cane yield (101.39 and 96.66 (Avg. of all cultivars) t ha⁻¹, respectively) and sugar yield (11.07 and 10.55 (Avg. of all cultivars) t ha⁻¹, respectively) compared to sugarcane + sugar beet in 1:2 and 1:3 RP. Sugar beet cultivars Cauvery and Shubhra recorded significantly higher tuber (85.58 and 79.84 t ha⁻¹, respectively) and sugar yield (9.76 and 9.00 t ha⁻¹, respectively) in sole cropping than intercropping treatments. In intercropping system sugar beet cultivars Cauvery and Shubhra in 1:3 and 1:2 row proportions recorded significantly higher tuber and sugar yield than 1:1 RP. Intercropping of sugarcane + sugar beet in 1:2 and 1:3 RP recorded significantly higher sugarcane equivalent yield, LER, ATER, SPI, total sugar yield, net returns when compared to 1:1 RP, but B:C was significantly higher in 1:1 RP.

In second trial, application of 100 per cent RDN (120 kg ha⁻¹) through inorganic fertilizer (IF) along with foliar spray of vermiwash (VW) (20%) and cow urine (CU) (10%) at 30 and 60 DAS (SN₁LM₄) recorded significantly higher tuber (80.13 t ha⁻¹), sugar yield (9.28 t ha⁻¹), net returns (Rs. 64528 ha⁻¹) and B:C (2.49) than other treatment combinations. However, application of 75 per cent RDN through IF + 25 per cent RDN through vermicompost and poultry manure in equal proportions along with foliar spray of VW (20%) and CU (10%) at 30 and 60 DAS (SN₂LM₄) remained on par with SN₁LM₄.