



## A REVIEW

# Agro-techniques for sustainable sugarbeet production

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**Abstract :** The sugarbeet is an important commercial crop for temperate region and long back tropicalized sugarbeet varieties have been emerged out in the country due to the effort of plant breeders. The cultivation of tropical sugarbeet in India is not a new practice but not yet popularized still; the southern states such as Maharashtra and Tamil Nadu have been already succeeded in its cultivation. The cultivation of sugarbeet requires a sound knowledge of sugarbeet agronomy and one should know the agro-techniques to obtain higher yield and sustain the productivity of sugarbeet. Considerable research efforts made by researchers worldwide in developing the production packages and these agro-techniques may motivate the new researcher to think new areas of research in India. Hence, considerable effort has been made here to review the various agro-techniques of sugarbeet with respect to growth, yield, economics and quality and it is the key subject, reviewed and presented below.

**Key Words :** Sugarbeet, Agro-techniques, Good agronomic practices, Tropical sugarbeet

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## INTRODUCTION

Sugarbeet (*Beta vulgaris* L.) is a member of the family Chenopodiaceae. It is main crop of temperate regions where it is grown as a spring or early summer crop (Rinaldi and Vonella, 2006) and it is considered as both drought and salinity tolerant species (Francois and Maas, 1994). It is a biennial sugar producing root crop and ranks second important sugar crop after sugarcane, producing annually about 40 per cent of sugar production all over the world (Leilah *et al.*, 2005). Brazil, India, China and Australia are dominant in sugarcane production while Europe is dominant in sugarbeet production with yearly 45-50 per cent of total world production. It is the

main source of sugar in countries like USSR, USA, France, Germany, Italy, Poland, Turkey, Czechoslovakia, Canada, Syria, Iran, Iraq, Algeria, Israel and Pakistan (FAO).

The yield of sugarbeet in a tropical region varied between 60 to 80 t ha<sup>-1</sup> with 14 per cent to 19 per cent of sugar content (10 t of white sugar ha<sup>-1</sup>) and can be produced within a short life span of five to six months (Chatin, 2004). The average global yield of sugarbeet is 41 t/ha and increasing at the rate of +1.4% per year from 1960 to 2001 (FAO). Growth has even accelerated over the last decade, with yields raising from 33 to 40 t/ha. The yield of sugarcane has also increased, however at a slower rate than sugarbeet, estimated at about + 0.8

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per cent per year. Sugarbeet is mainly produced in Europe and to a lesser extent in Asia and North America (FAO).

In India, genetic and agro-technological improvements have now extended its frontier to higher latitudes of subtropics and also to tropics in Maharashtra as an irrigated winter crop. The northern and the north western regions of sub tropical India comprising Punjab, Haryana, Rajasthan and western Uttar Pradesh and in tropical India comprising Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh and Gujarat are potential areas for winter sugarbeet in the country. It is also cultivated as a catch crop under the situation when sugarcane crop fails due to drought or red rot. The Kashmir valley has a good scope for generation of a beet based sugar industry. However, in 1970's commercial cultivation of sugarbeet was limited to Sriganganagar area of Rajasthan, where it was being grown about 1000 ha for sugar production upto mid-nineties. Coastal-saline tract of Sundarbans in West Bengal has highly suitable for fodder beet production and roots for alcohol purpose, where the crop was not grown usually (Anonymous, 2011).

The important byproducts can be obtained from the sugarbeet are - the beet tops can be fed as a fodder for livestock, tops can also be used as green manure, beets if chopped properly can be used as a concentrated feed for livestock. Beets are major economic part which is utilized for the production of white sugar, alcohol, ethanol and pharmaceutical value (Anonymous, 2011). Sugarbeet has now emerged as commercial field crop because of the favourable characters like - (i) tropical sugarbeet varieties suitable for Tamil Nadu (ii) shorter duration of 5 to 6 months (iii) moderate water requirement of 80–100 cm. (iv) higher sugar content of 12 to 15 per cent (v) improvement of soil conditions because of tuber crop and (vi) suitability for saline and alkali soil (Balakrishnan *et al.*, 2007). Continuous mono-cropping of sugarcane in sugarcane growing belts has led to salinity and reduced yield levels. Since, sugarbeet is salinity tolerant, it is moderate water requiring crop (600-800 mm) compared to sugarcane (2000 mm). Higher brix (18-20), sugar recovery (14-16%), lesser duration (5-6 months) and higher yield levels upto 40 t/ha has made farmers to think about it (Balakrishnan *et al.*, 2007). In this regard there is need to know the agro-techniques to popularize the sugarbeet as a commercial sugar producing crop for its successful cultivation.

### Soil and climate :

All kinds of well drained deep soil (45 cm) with stable and porous soil structure and sandy loam to clayey loam texture are suitable. Optimum pH range is from 6.5 to 8.0 but it can also be grown in saline and alkaline soil, but does poorly in acid soils. The sugarbeet crop requires an optimum temperature range of 20 to 25°C for germination, 30 to 35°C for growth and development and 25 to 35°C for sugar accumulation. A bright sunshine hour during its growth period is very essential for obtaining higher yield (TNAU, Coimbatore) (Anonymous, 2011). Optimum temperature for seed germination is 15°C and for growth and sugar accumulation, it is 21°C. Higher temperatures (<30°C) retard accumulation of sugar but favor rapid growth (Anonymous, 2011).

### Season and agro-climatic zones :

Sugarbeet is cold weather *Rabi* season crop (TNAU, Coimbatore). The highest average beet yield was recorded during *Rabi* season (57.91 t/ha) followed by *Kharif* (44.25 t/ha). Summer season appears not so congenial for sugarbeet cultivation which recorded least yields of 29.47 t/ha (Salimath and Lamani, 2010). They also noticed that Zone 3 (Bijapur and Mudhol) and Zone 8 (Sankeshwar and Nippani) are highly suitable for cultivation of sugarbeet in Northern Karnataka than the other Agro-Climatic Zones tested to obtain higher yields (52.82 and 57.55 t/ha, respectively).

### Time of sowing :

The time of sowing will decide the yield and quality of the beet. The ideal time of sowing in the sub tropics (North India) will preferably in the month of October and harvested in the month of April or May and in the tropical region of south India, little early preferably September 15 to October 15 and harvested in the month of January. First week of February (Feb. 5) is ideal time of sowing to obtain higher root and sucrose yield for Diyarbakir region of Turkey (Tahsin and Halis, 2004). In Riyadh region of Saudi Arabia 15<sup>th</sup> October to 15<sup>th</sup> November is the recommended date for sowing of sugarbeet where the average yield ranges between 116-123 t/ha (Refay, 2010). September 15<sup>th</sup> to October 15<sup>th</sup> is the ideal sowing time for sugarbeet cultivation to obtain the higher crop biometrics at Coimbatore region of Tamil Nadu in India, where the average beet and top yields (80 and 7.7 t ha<sup>-1</sup>, respectively) are ideal with better quality according to Balakrishnan and Selvakumar

(2009).

April 1 to 10, provided the highest root and sugar yield with highest sugar percentage with the Monohikari variety and root yield decreased 0.57 t/ha for each one day delay in planting at Nebraska (Dean *et al.*, 1999). Plants sown on 20 April had greater root and leaf yield compared to other dates of sowing (Maralian *et al.*, 2008). Autumnal beet was more productive than spring for fresh root weight, total dry matter, sucrose yield and water use efficiency. An average saving of about 26 per cent of seasonal irrigation supply (equivalent to about 100 mm) was measured in the three years with the earliest sowing time (Rinaldi and Vonella, 2006). Sugarbeet cultivation during 1<sup>st</sup> Fort Night of October recorded higher yield and quality than the other dates of sowing at Northern Dry Zone of Karnataka (Deshpande, 2013).

#### **Plant varieties/hybrids/genotypes :**

Monogerm varieties are preferred as only one seedling comes out from the glomerule and therefore, singling and thinning operation as is practiced with multigerm variety is not required and therefore, saves labour and time. Sugarbeet breeding and seed productions are performed on hills. The IISR, Lucknow is doing such work at Mukteswar located in Kumaon hills (Uttarakhand). Multigerm varieties that give 3-4 seedlings from a single seed, are sown at 10 kg seed ha<sup>-1</sup>. For a hectare, 3-4 kg seeds of monogerm varieties are sufficient for sowing (Anonymous, 2011). Varieties SZ-35, PAC 6008 and Magnolia were tested at Deccan plateau region of peninsular India, Magnolia recorded higher yield than others. PAC 6008 was better in quality (Deshpande, 2013).

Plant varieties of tropical sugarbeet *viz.*, Ramonskaya-06, IISR Comp-1, Mezzanopoly, LS -6, Tribel, Plant comp-3 and Pant S-10 were tested at Sugarcane Research Station, Jalandhar (PAU, Ludhiana) and found to effective in obtaining higher yield with better quality for Punjab region (Toor and Bains, 1994). Cauvery, Indus and Shubhra are the tropical sugarbeet hybrids produced by Syngenta India Ltd. and are suitable for cultivation in Tamil Nadu (Balakrishnan and Selvakumar, 2008). Posada, Dorotea and HI 0064 are well suited for Belgaum district of Karnataka to obtain higher yields. Dorotea variety which recorded higher brix (16.70%) and top yield was more in HI 0064 (Anonymous, 2004). Gala, Ramela, USC-4 LT 043303, HH-52 No.S LT 52102, HH-79 PC LT 793408, HH-41

No.M, LT 412311 and Sonja M are the few genotypes screened for Sudan region, for obtaining maximum yield upto 80 tonnes ha<sup>-1</sup> and the sugar yield vary from 11-12 t ha<sup>-1</sup> (Elkarouri and Elrayah, 2006).

Nineteen sugarbeet genotypes suitable for powell region of Wyming, the beet yield levels of different sugarbeet genotypes varied between 39 to 49 t/ha, recoverable sugar yield varied upto 14 per cent (7.14 to 8.33 t/ha) and sugar content varied from 159 to 172 g/kg. American crystal 19, Betaseed 9G6915, Holly 50, Hilleshog Mono Hy R<sup>2</sup> and Seedex 91121 are the few best genotypes among them (Lauer, 1997). BETA 4546 and BETA 8749 are the best varieties to obtain higher yield of sugarbeet with better quality and was recommended by University of Wyoming, Powell Research and Extension Center, for Powell region of Wyoming over three years of research (Stevens *et al.*, 2008). Variety Monohikari yields greater than Beta KW3778 (Dean *et al.*, 1999).

#### **Seed treatment :**

Priming seed before sowing reduced the effects of salinity on emergence rates which resulted in significantly larger seedlings in late fall and recorded higher dry matter production under moderate salinity levels (Stephen and Kurt, 2004). Total emergence was greatest in seeds treated with 300 g/l PEG for 3 days (Jerry and Glen, 1991). For protection of seeds from seed and soil borne fungal pathogens, unprocessed seeds may be soaked in 0.25 per cent solution of thiram or 0.1 per cent of carbendazim over night and used for sowing after drying (Anonymous, 2011).

#### **Tillage management :**

Conventional tillage treatment and strip tillage system had significantly recorded higher root and gross sucrose yield than the no tillage treatment in four years of study (Halvorson and Hartman, 1988). Preliminary results from ARS, Kimberly indicate that tillage method (mold board plow, chisel plow, or strip tillage) had no significant effect on beet tonnage or sugar content during the first year. However, if the beets are grown in rotation with other no-till or strip till crops, long term effect of conservation tillage may improve crop production in sugarbeet (Moore *et al.*, 2009). If residues of small grains are fully incorporated in to the soil, early incorporation will reduce immobilization of fertilizer N applications (Moore *et al.*, 2009). In a study near

Kimberly, indicated that, plowing straw into the ground in September increased sucrose percentage and yield with decrease impurities in comparison with November plowing (Smith *et al.*, 1973).

#### Planting methods :

Sowing is done by dibbling manually or by drilling. The seeds are placed rather shallow, about 3 cm deep. The IISR, Lucknow has designed and fabricated hand operated rotary dibbler and planter for making the two operations simultaneous and comfortable. For sowing on ridges, tractor operated sugarbeet ridge planter has been designed and developed. It makes four ridges and plant seeds 2-3 cm deep on the ridges. Another machine, raised bed sugarbeet planter facilitates sowing of seeds by furrow irrigated raised bed method. Seeds are sown on raised bed in two rows maintaining seed to seed distance of 20 cm and row to row distance of 40 cm (Anonymous, 2011). Planting sugarbeet on broad bed and furrows (BBF) recorded significantly higher yield than ridges and furrows (Deshpande, 2013).

Planting of sugarbeet along with sugarcane in paired row system (75-150-75 cm) significantly recorded higher cane yield as well as beet yield compared to planting system 120 cm Row spacing and 150 cm row spacing. This inter cropping is found better in terms of land equivalent ration and cost benefit ratio (Yekkeli, 2010). To maintain the required plant population of 40,000/acre, use 2 pockets designer seeds.

#### Plant density/spacing :

Dean and John (1997) reported that, yields of sugarbeet grown in 35, 56, 76 and 97 cm row widths were compared in multi location field trials at Nebraska. Five target plant populations of 25,000, 40,000, 65,000, 100,000 and 150,000 plants/ha were established for each row spacing tested. Sugarbeet grown in 56 cm row width or less responded with a higher yield than sugarbeet grown in the wider row widths tested. Plant population of 65000/ha was recorded maximum yield. Increasing the plant densities from 28000 to 42000 ha<sup>-1</sup> has significantly increased the root, top and sugar yield in two years of study (Nafei *et al.*, 2010). Narrow spacing of 45x15, 45x20 and 45x25 cm gave significantly higher root yield than the wider intra row spacing of 45x30 and 45x35 cm (Tahsin and Halis, 2004). One pocket contains 20,000 seeds (600g) and the recommended spacing is 50 x 20 cm. The designer seed is dibbled at 2 cm depth

on the top of the ridges at 20 cm apart at one seed/hole (TNAU, Coimbatore).

#### Nutrient management :

Like other root crops, sugarbeet also responds well to fertilizers. It requires continuous and adequate supply of N, P and K for production of good quality roots. Nutrition of sugarbeet varies from place to place depending on soil type, soil nutrients status, cultivar, irrigation facility, etc. Sugarbeet requires 120 kg N + 60 kg P<sub>2</sub>O<sub>5</sub> + 60 kg K<sub>2</sub>O/ha. The P and K are applied based on soil test values. The various sources of N (urea, ammonium sulfate, CAN etc.) are equally effective. The N fertilizers are given in three splits at sowing, thinning and earthing-up in December; beyond this it will deteriorate the quality of root. If the soil is deficient in boron apply borax @ 20 kg/ha where as 30-40 kg Zn/ha for Zn deficient soils (Anonymous, 2011). Root yield was not increased at N rates above 168 kg N ha<sup>-1</sup> following field bean and 202 kg following corn. Sucrose concentration declined from 183 to 175 mg kg<sup>-1</sup> between 67 and 235 kg N ha<sup>-1</sup> following field bean. However, following corn it was increased from 180 to 184 mg kg<sup>-1</sup> between zero and 135 kg N and then declined to 179 mg kg<sup>-1</sup> at 235 kg N. Recoverable sucrose yield was not increased above the 67 kg N rate following field bean, but reached a maximum between 168 and 202 kg N ha<sup>-1</sup> following corn (Donald and Mohammad, 2000). The higher crop biometrics of tropical sugarbeet was recorded with integrated nitrogen management *i.e.* application of 100 per cent N through urea along with FYM and bio-fertilizer treatment (150:75:75 kg NPK ha<sup>-1</sup>) recorded significantly higher values of yield and quality characters *viz.*, beet yield (71 and 89 t ha<sup>-1</sup> during 2005 and 2006, respectively) of tropical sugarbeet and brix (18.2 %) in two years of study (Balakrishnan and Selvakumar, 2008). Adding the highest level of N (285 kg N ha<sup>-1</sup>) and K (114 kg K<sub>2</sub>O ha<sup>-1</sup>) significantly recorded higher root and foliage yield as well as root and foliage dry matter production (Abdel-Motagally and Attia, 2009). Application of 100 mg N kg<sup>-1</sup> soil gave the highest fresh shoot and root weight (94.2 and 425.5 g/pot), respectively.

Application of N and K<sub>2</sub>O @ 160 kg ha<sup>-1</sup> with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> recorded significantly higher root (47.50 t ha<sup>-1</sup>), top (13.41 t ha<sup>-1</sup>) and sugar yield (7.317 t ha<sup>-1</sup>) as compared to other fertilizer levels (Deshpande, 2013). Application of 50 ppm B was the best for achieving

maximum fresh shoot and root yield (127.7 and 565.8 g/plant, respectively) as compared to other boron treatments (Hellal *et al.*, 2009). Sugarbeet was responded well to applied P with the higher levels ranging from 39 to 52 kg P ha<sup>-1</sup> *i.e* in terms of root, top and sugar yield at the early stages of plant growth (60 to 90 days). The response per cent ranges from 242 to 188 per cent over control between 60-90 days, then the response reduced as the growth advances (Kapur and Kanwar, 1990). Higher levels of nitrogen resulted in higher root yield upto 197 kg liquid N ha<sup>-1</sup> for obtaining higher sugar yield (Eckhoff and Flynn, 2008).

Gobarah *et al.* (2011) reported that soil application of 114 kg K<sub>2</sub>O/ha (1/2 at root formation and 1/2 at sugar storing stage) significantly recorded higher root and top yield (84.38 and 37.33 t/ha, respectively). Nafei *et al.* (2010) reported that increasing potassium levels from 0 to 36 kg K<sub>2</sub>O/fed significantly increased the root yield (35.45 and 39.9 t/fed, respectively in the 1<sup>st</sup> and 2<sup>nd</sup> season) and sugar yield (5.58 t/fed). Tawfik *et al.* (2010) concluded that split application of 57 or 114 kg K<sub>2</sub>O/ha in three splits at after thinning, at root formation or at sugar storing stage recorded higher top, root and sugar yield in the 1<sup>st</sup> season (36.75, 81.98 and 15.44 t/ha, respectively) and 2<sup>nd</sup> season (38.57, 90.29 and 18.68 t/ha, respectively). Stallknecht and Gilbertson (2000) observed that 0, 30 and 60 per cent defoliation in sugarbeet and was not affected the root yield of sugarbeet. But, 100 per cent defoliation of sugarbeet at the 8 to 13 leaf stage of growth (mid-June) did not affect root yield in 1992 and 1993, but reduced root yield when applied at the 5 to 8 leaf stage (July 1) of growth during 1991. Balakrishnan (2006) reported that, application of NPK @ 150:75:75 kg ha<sup>-1</sup> was the optimum dose of fertilizer for the tropical sugarbeet production.

### Weed management :

Weed competition in sugarbeet has been estimated to cause an 8 per cent annual loss of sugarbeet value through reduction in yield and quality (Schweizer, 1981). Yield loss depends on weed competitiveness, density and length of time the weeds are allowed to compete and approximately 70 per cent of weeds found in sugarbeet crops are broadleaved species (Schweizer and May, 1993). Broad leaved weeds become most competitive after they begin shading the crop (Wicks and Wilson, 1983). Position of leaf area would be as important as the total area in deciding the competitive outcome

between sugarbeet and weed (Legere and Schreiber, 1989). Weeds are able to grow two to three times taller than sugarbeet by mid-summer and as weed density increases, light becomes more limited and sugarbeet root yields decrease (Schweizer and May, 1993). Sugarbeet cultivars may differ in competitiveness with weeds. Sugarbeet should be kept weed free until the six true-leaf stage. After the six true-leaf stage, the sugarbeet canopy will aid in the suppression of weeds and be more competitive with weeds for light and nutrients.

Weed biomass decreased 60 to 74 per cent when sugarbeet was weeded once in the two true-leaf stage of growth about 4 weeks after planting. Weeds emerging 4 weeks after planting reduced sugarbeet yield by 26 per cent. In plots where hand-hoed, 8 weeks after planting, weed biomass was reduced 97 per cent compared with plots that were not hand-hoed (Wicks and Wilson, 1983). A study conducted in India (Gill and Verma, 1969) showed that row spacing of 40 cm gave the highest yield while that of 50 and 60 cm gave similar yields. In a yield comparison (Yonts and Smith, 1997), 56 cm row spacing produced a greater yield of both roots and sugar than 36 or 76 cm rows. Their study showed that 56 cm row width increased sugar approximately 0.4 t/ha over both 36 and 76 cm rows. Narrower rows, such as 45 cm, are more likely to produce large yields because they help to compensate for poor plant establishment (Anonymous, 1995). Sugarbeet root yield, sugar percentage and purity were higher for sugarbeet planted in 50 cm rows compared with sugarbeet planted in 60 cm rows (O'Connor, 1983).

A large portion of the cost of sugarbeet production is spent in obtaining an adequate stand of weed-free sugarbeets. Careful selection and application of herbicides and planting to stand can reduce the costs considerably. Very good weed control can be obtained with complementary pre-plant incorporated/post-emergence herbicide treatments (Miller and Fornstrom, 1989). Pre-plant application of cycloate + ethofumesate 1.5+1.5 lb *a.i*/acre, post emergence application of desmedipham + phenmedipham 0.6 + 0.6 5 lb *a.i*/acre and both pre and post emergence application of cycloate+ ethofumesate / desmedipham + phenmedipham to the sugarbeet significantly reduced the total weed population down (James and Stephen, 1990).

### Irrigation management :

Sugarbeet requires 500 mm water for its normal

growth and development. Less than 60 per cent available soil moisture results in reduction of root and sucrose yield. Average water consumption by sugarbeet ranges about 0.1 mm per day when the crop emerges, nearly 7 mm per day when the crop canopy completely shades the ground and the tap root is enlarging. Sugarbeet water demand decreases as the older leaves start to die and temperatures start to cool down. Sugarbeet peak water use occurs during 30-day period in late July and August (Efetha, 2011). The crop requires 8-10 irrigations in the subtropics and 10-12 irrigation in the tropics depending upon the weather. Irrigation scheduled at 60-75 mm evaporation gives highest yield of sugarbeet and excessive irrigation is detrimental to root quality (Anonymous, 2011). A study conducted at Tamil Nadu Agricultural University, Coimbatore during 2004-2005 showed that the total water used for the tropical sugarbeet was 810 to 860 mm (Balakrishnan, 2006). Pre-sowing irrigation (seeds germinate in a week), 1<sup>st</sup> irrigation during early establishment stage is mandatory and subsequent irrigation is need based, but crop is sensitive to water stagnation. Stop irrigation one month before harvest (Anonymous, 2004).

The 80 per cent and 100 per cent irrigation through subsurface drip irrigation produced a similar root yield, but the first saved 16.6 per cent irrigation water. Also, 83.3 per cent of applied water may produce 22.2 per cent more yield if water is applied as subsurface drip irrigation rather than surface drip. Subsurface drip irrigation (SDI) gave an additional benefit of 845 Euro/ha<sup>-1</sup> in relation with surface drip, while in 80 per cent treatments, SDI exceeded surface drip by 516 Euro/ha<sup>-1</sup> (Makrantonaki *et al.*, 2002). The hybrid Cauvery coupled with 125 per cent N through drip fertigation was found to be the best for maximizing the yield and economic benefits of tropical sugarbeet. Better growth, higher yield, income benefits, shorter payback period, substantial quantity of water saving (34.2%) and higher water use efficiency are the advantages of the study (Rajasekaran, 2007). Sugarbeet grown under furrow irrigation achieved greatest sucrose yield with available N amounts ranging from 141-197 kg/ha. Under sprinkler irrigation achieved greatest sucrose yield when available N ranged from 112-169 kg/ha. Impurities and sucrose loss to molasses were significantly increased in sprinkler irrigated sugarbeet when N at any rate was applied (Eckhoff and Flynn, 2008). Optimum soil water content is with 70 per cent of field capacity obtained the

root yield of 66.5 t/ha. Sowing on April 20 + irrigation at 70 per cent field capacity recorded higher root and leaf yield (78.50 and 32.03 t/ha, respectively) than the other combinations (Maralian *et al.*, 2008). The optimal irrigation regime produced higher root yield, dry matter and sucrose yield than the reduced one; on the other hand water use efficiency was greater in reduced irrigation regime (Rinaldi and Vonella, 2006). The mean values of sugarbeet yield and sugar content were higher in drip irrigation than with furrow practices (Sharmasarkar *et al.*, 2001).

### Disease management :

Six applications of manganese ethylene bisdithiocarbamate (Maneb) applied from air @ 216 g in 10 gallon of water/acre was effective in controlling the *Cercospora* leaf spot of sugarbeet disease in Colorado (Patren, 1967). In sugarbeet *Rhizoctonia* and *Fusarium* are the aggressive soil borne pathogens and Mycorrhizal and *Trichoderma viridi* inoculation significantly restricted the spread of both soil-borne pathogens in the host root tissues which reduced the severity of disease (Aly and Hussein Manal, 2009). Plant protection with fungicide difenoconazole (0.1%) against *Cercospora* leaf spot significantly reduced the per cent disease incidence after two sprays and obtained the higher beet yield of 101 t/ha and top yield 14 t/ha (Hemachandra, 2007).

Khan and Smith (2005) reported that @ 0.11 kg a.i./ha, pyraclostrobin @ 0.17 kg a.i./ha recorded good leaf spot disease control when compared to other treatments and untreated control. Growing of raddish or mustard as green manure trap crops planted in late summer under sequence cropping reduces the population densities of sugarbeet cyst nematode by six- to eight-fold and the population reductions were 84 per cent to 92 per cent (Hafez, 2011).

The major diseases that affect the sugarbeet crop are *Rhizoctonia* wilt, powdery mildew, *Cercospora* leaf spot, and fusarium yellow. To control *Rhizoctonia* wilt, spot drenching with Bordeaux mixture 1 per cent and for fusarium wilt, drenching the soil with carbendazim @ 0.1 per cent. To control powdery mildew, spraying of wettable powder 0.3 per cent and for *Cercospora* leaf spot, application of mancozeb 0.25 per cent on 10-14 days schedule (TNAU, Coimbatore).

### Insect pest management :

Sugarbeet crop is damaged by insect pests like

cutworm, army-worm, Bihar hairy caterpillar, semilooper, flea beetle and grass hopper. In early stages of crop growth, cutworm may infest the crop. It is, therefore, necessary to apply chlorpyrifos at 1 kg a.i./ha in soil at the time of sowing. Armyworm seriously damages the crop in tropical region. It appears about 100 DAS. Although natural enemies of this pest are present in nature, it should be controlled by single spray of quinolphos (0.05%). Alternatively population of armyworm can be contained by placing 5 pheromone traps in a ha for attracting male adults, releasing *Trichogramma chilonis* at 50,000 parasitized eggs/ha through tricho cards, making grass heaps near sugarbeet field for inviting larvae of the pests and placing bird perches for birds to feed on the larvae. In sub tropics, Bihar hairy caterpillar, flea beetle and armyworm occasionally infest the crop (Anonymous, 2011).

The major insect pests observed on sugar beet crop in Southern India are defoliator, *Spodoptera litura*, cut worms, hairy caterpillar, aphids, grass hoppers, loopers, weevils and wire worms and non-insect pests like rodents, slugs and snails also observed (Prabhakar and Chaudhary, 2009). To control aphids, spray *Neem* oil 3 per cent or dimethoate 2ml/l with teepol 0.5 ml/l, for tobacco caterpillar, spray endosulfon 2ml/l or carbaryl 2g/l of water (Balakrishnan *et al.*, 2007).

The major insect pests that affect the sugarbeet crop are aphids, tobacco caterpillar and diamond backmoth. Integrated pest management programme has to be adopted to control these insect pests. To control aphids, spray *Neem* oil 3 per cent or dimethoate 2ml/l with teepol 0.5 ml/l, for tobacco caterpillar, spray endosulfon 2ml/l or carbaryl 2g/l of water (TNAU, Coimbatore).

### Time of harvesting :

The sugarbeet crop matures in about 5 to 6 months. The yellowing of lower leaf whorls of matured plant and tuber brix reading of 15 to 18 per cent indicate the maturity of beet tuber for harvest. The harvested beet tubers should be handled as gently as possible to remove soil and trash to minimize the beet breakage and bruising to get quality beet tuber. The average yield of beet tuber is 30 to 35 tonnes per acre (TNAU, Coimbatore). Pinch-wheel beet harvesting machines recover 1-2 tons of beets more per acre than spike-wheel harvesters due to the method of root extraction. Also, pinch-wheel harvesters can be used to harvest fields a few days earlier after the

last irrigation than spike wheel harvesters can (Herman, 2004).

The highest sugarbeet raw seed yield (1164 kg/ha) in Firozkooh and maximum grain weight (14.748 mg) was obtained by planting seed-bearing plants in March 18 and harvesting them 45 days after 50 per cent flowering in seed crop (Nikpanah *et al.*, 2010). Late harvesting (187 days after emergence) resulted in greater yield of root, sugar content and white sugar yield than earlier harvesting (Heidari *et al.*, 2008).

### Conclusion :

The above reviewed agro-techniques will provide the sound knowledge about the cultivation aspects, which will help researchers/ scientific community in thinking new areas of sugarbeet research for tropical and sub tropical regions of the country, which can be referred as an “on-coming revolution in global sugar, ethanol and alcohol production”.

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